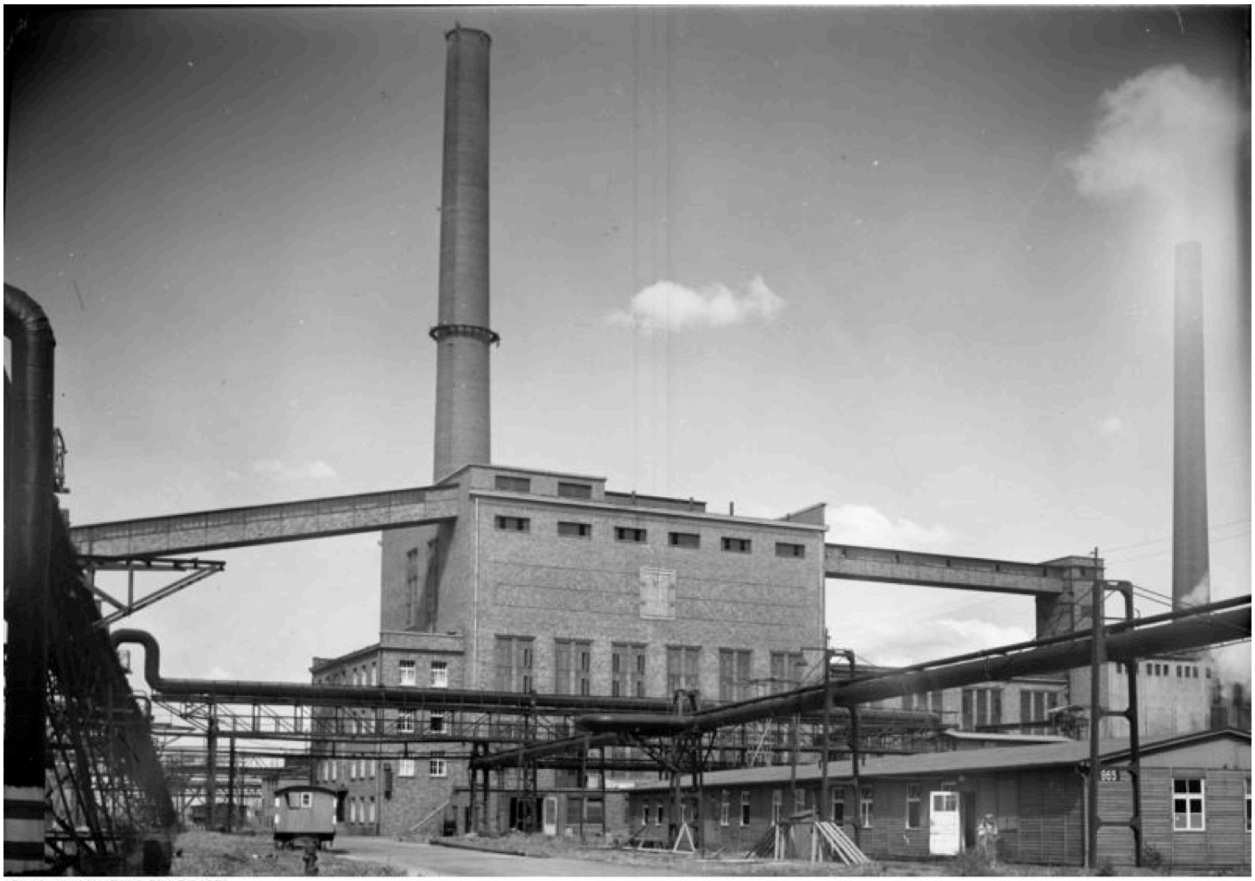
There was a
heavy water production plant
at I.G. Farben Bitterfeld



Bundesarchiv, DH 2 Bild-F-01956
Foto: Wolter | September 1959

Figure D.496: There was a heavy water production plant at I.G. Farben Bitterfeld during the war [Karlsch 2005, p. 110; Sadovsky 2011b]. (This is a later photograph showing part of the Bitterfeld chemical production complex.)

7. I.G. Farben Halle

7 June 1946. Recruitment of German Scientists; Heavy Water Production at Halle. Strategic Services Unit, Top Secret report [NARA RG 319, Entry NM3-85M, Box 51, Folders 926136–926139].

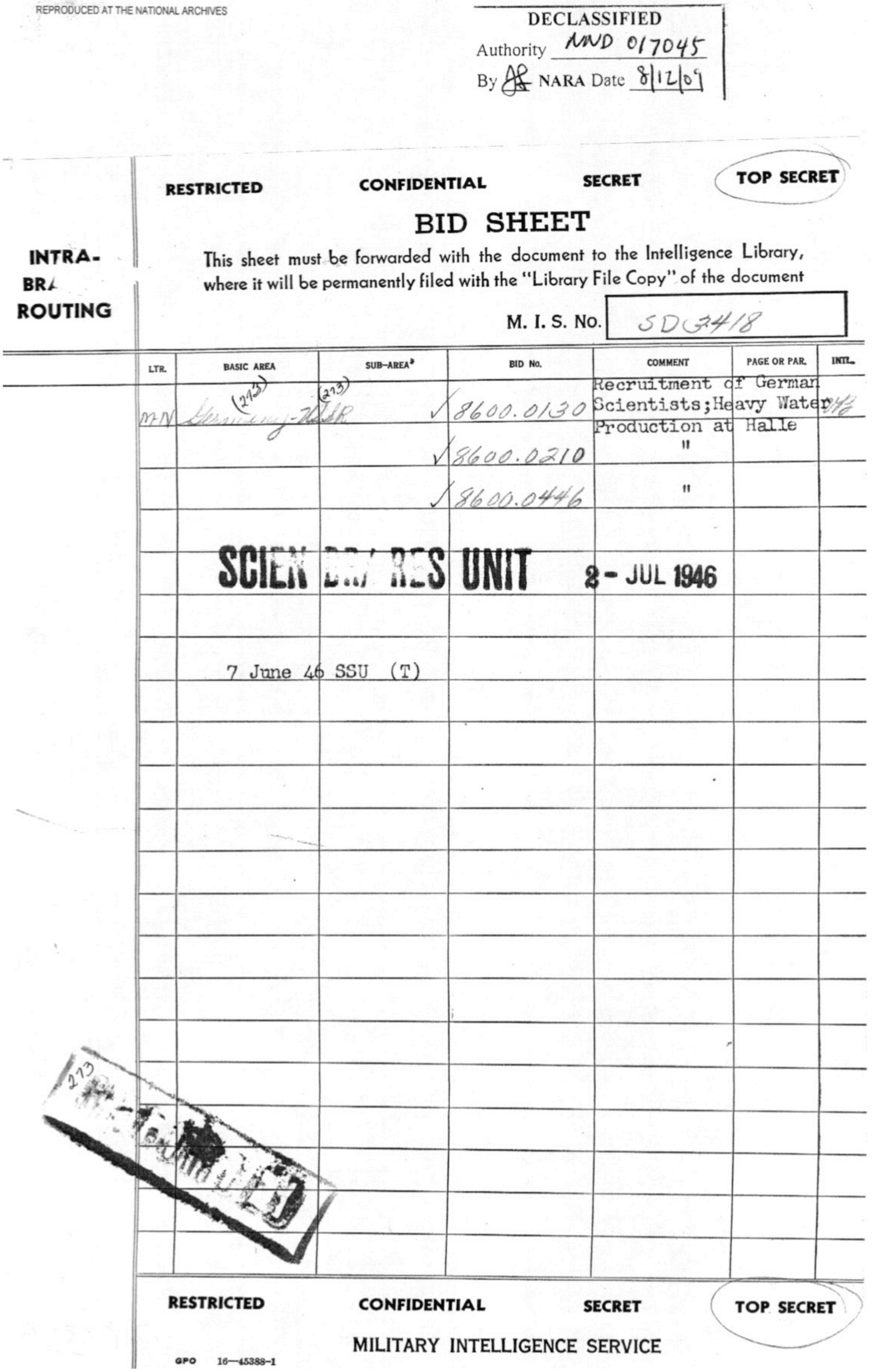
[See pp. 4053–4054.]

U.S. intelligence card catalog [NARA RG 319, Entry A1-84E, Box 124].

[See p. 4055.

U.S. intelligence cover pages and card catalog entries show that there was a heavy water production plant at Halle, but documents about the plant are still classified and unavailable to the public. Why?

Halle is close to Leuna/Merseburg. It is possible that the referenced Halle heavy water plant was the same as one of the Leuna Werke heavy water plants, but most likely it was a separate plant. That entire region was covered with chemical plants.]



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BID SHEET

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INTRA-BR ROUTING

M. I. S. No. SD3418

LTR.	BASIC AREA	SUB-AREA*	BID No.	COMMENT	PAGE OR PAR.	INTL.
MN	(273) Germany-	(273) USSR	✓ 8600.0130	Recruitment of German Scientists; Heavy Water Production at Halle		
			✓ 8600.0210	"		
			✓ 8600.0446	"		

SCIEN [illegible] RES UNIT 2 - JUL 1946

7 June 46 SSU (T)

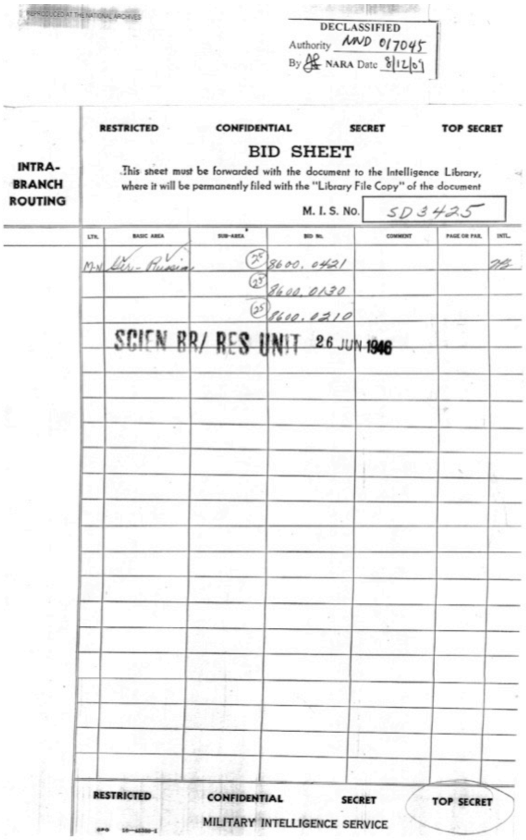
273 [illegible]

RESTRICTED CONFIDENTIAL SECRET TOP SECRET

MILITARY INTELLIGENCE SERVICE

GPO 16—45388-1

Figure D.497: A U.S. intelligence cover page shows that there was a heavy water production plant at Halle, but documents about the plant are still classified and unavailable to the public [NARA RG 319, Entry NM3-85M, Box 51, Folders 926136–926139].



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INTRA-BRANCH ROUTING

BID SHEET

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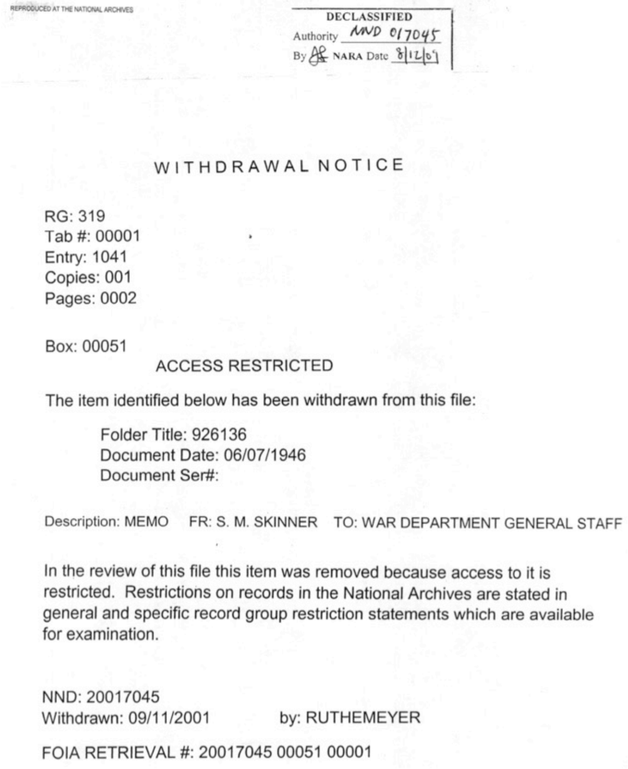
M. I. S. No. SD3425

LTR.	BASIC AREA	SUB-AREA	BID No.	COMMENT	PAGE OR PAR.	INTL.
M-N	Ger.-Russian	(25)	8600.0421			
		(25)	8600.0130			
		(25)	8600.0210			

SCIEN BR/ RES UNIT 26 JUN 1946

RESTRICTED CONFIDENTIAL SECRET [✓ TOP SECRET]

MILITARY INTELLIGENCE SERVICE



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Folder Title: 926136
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Description: MEMO FR: S. M. SKINNER TO: WAR DEPARTMENT GENERAL STAFF

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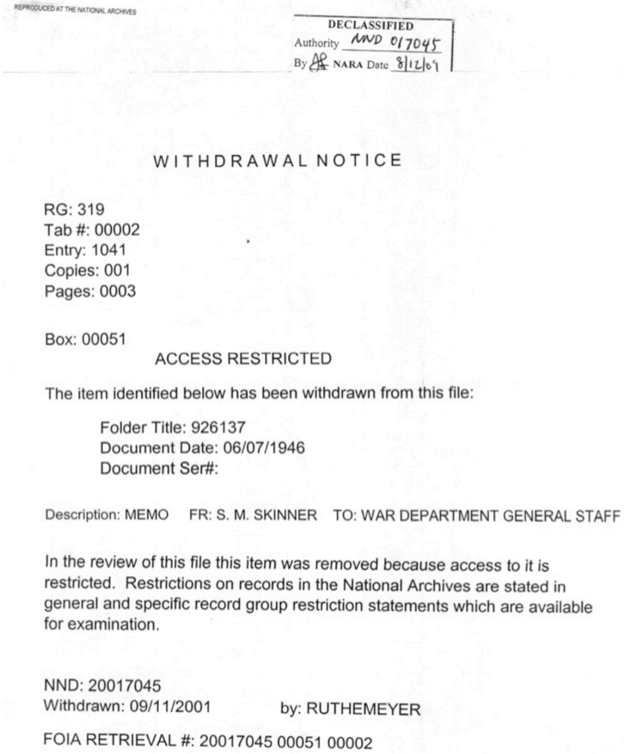

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Document Date: 06/07/1946
Document Ser#:

Description: MEMO FR: S. M. SKINNER TO: WAR DEPARTMENT GENERAL STAFF

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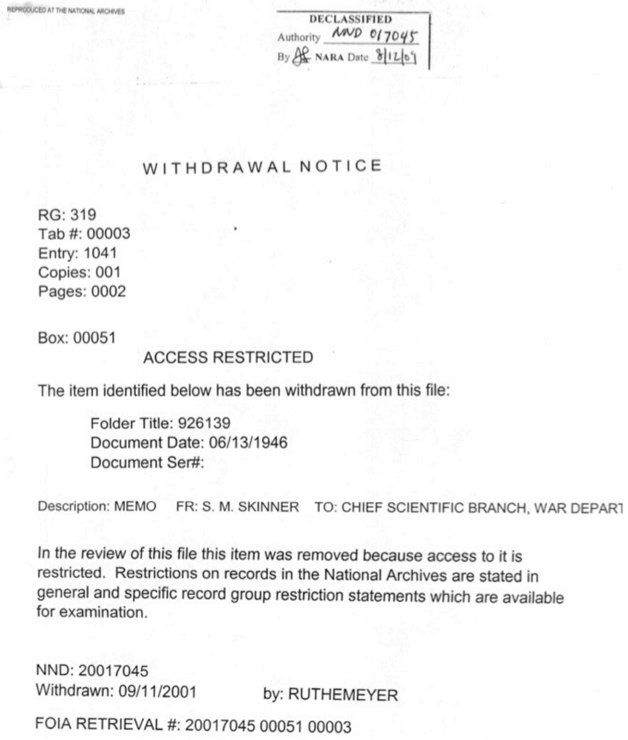

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Authority NND 017045
By NARA Date 8/12/09

WITHDRAWAL NOTICE

RG: 319
Tab #: 00003
Entry: 1041
Copies: 001
Pages: 0002

Box: 00051

ACCESS RESTRICTED

The item identified below has been withdrawn from this file:

Folder Title: 926139
Document Date: 06/13/1946
Document Ser#:

Description: MEMO FR: S. M. SKINNER TO: CHIEF SCIENTIFIC BRANCH, WAR DEPART

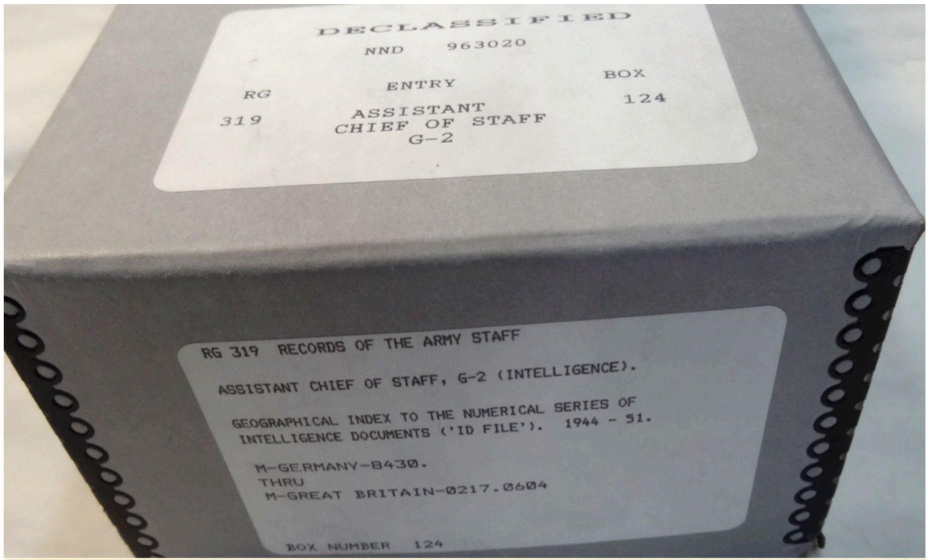
In the review of this file this item was removed because access to it is restricted. Restrictions on records in the National Archives are stated in general and specific record group restriction statements which are available for examination.

NND: 20017045
Withdrawn: 09/11/2001 by: RUTHEMEYER

FOIA RETRIEVAL #: 20017045 00051 00003

Figure D.498: A U.S. intelligence cover page shows that there was a heavy water production plant at Halle, but documents about the plant are still classified and unavailable to the public [NARA RG 319, Entry NM3-85M, Box 51, Folders 926136–926139].

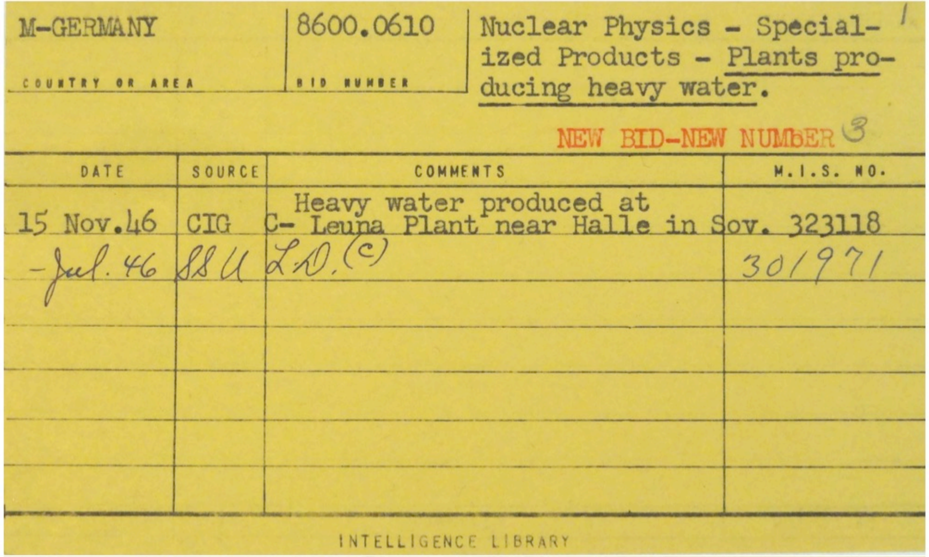
DECLASSIFIED
Authority NND 963020



DECLASSIFIED
NND 963020

RG 319
ENTRY ASSISTANT CHIEF OF STAFF G-2
BOX 124

RG 319 RECORDS OF THE ARMY STAFF
ASSISTANT CHIEF OF STAFF, G-2 (INTELLIGENCE).
GEOGRAPHICAL INDEX TO THE NUMERICAL SERIES OF INTELLIGENCE DOCUMENTS ('ID FILE'). 1944 - 51.
M-GERMANY-8430.
THRU
M-GREAT BRITAIN-0217.0604
BOX NUMBER 124



COUNTRY OR AREA	BID NUMBER	
M-GERMANY	8600.0610	Nuclear Physics - Specialized Products - Plants producing heavy water. 1

NEW BID-NEW NUMBER 3

DATE	SOURCE	COMMENTS	M.I.S. NO.
15 Nov.46	CIG	Heavy water produced at C- Leuna Plant near Halle in Sov.	323118
-Jul. 46	SSU	L.D.(c)	301971

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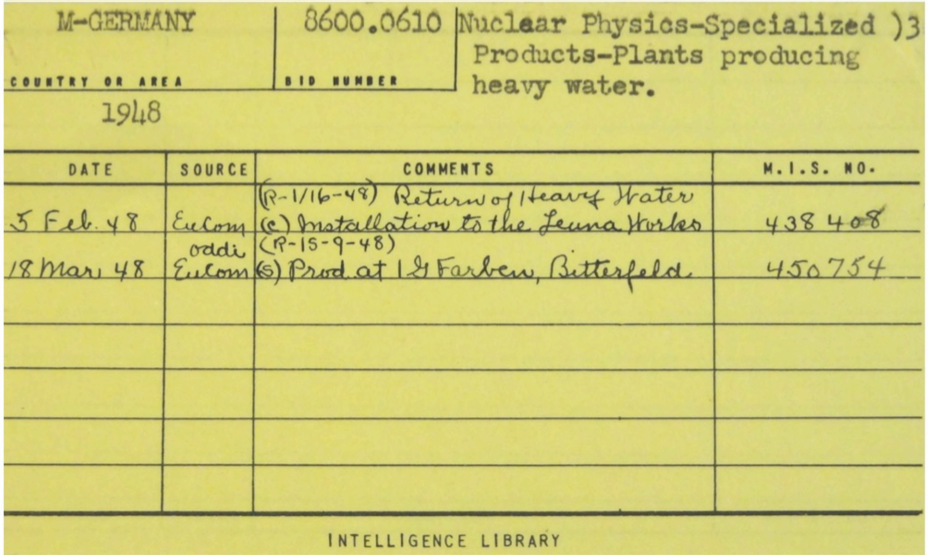


COUNTRY OR AREA	BID NUMBER	
M-GERMANY	8600.0610	Nuclear Physics-Specialized Products-Plants producing heavy water.)3

1948

DATE	SOURCE	COMMENTS	M.I.S. NO.
5 Feb. 48	Eucom	(R-1/16-48) Return of Heavy Water (c) Installation to the Leuna Works	438408
18 Mar. 48	oddi Eucom	(R-15-9-48) (S) Prod. at I G Farben, Bitterfeld.	450754

INTELLIGENCE LIBRARY

NARA RG 319,
Entry A1-84E, Box 124

Figure D.499: A U.S. intelligence card catalog shows that there were heavy water production plants at Halle, Leuna, and Bitterfeld, but documents about the plants are still classified and unavailable to the public [NARA RG 319, Entry A1-84E, Box 124].

8. Kiel

Charles Chamberlain. Reveal Allied Capture of Nazi Atom Factory. *Chicago Daily Tribune.* 9 August 1945 p. 4. http://archives.chicagotribune.com/1945/08/09/page/4/article/reveal-allied-capture-of-nazi-atom-factory/

KIEL, Germany, Aug. 8 (AP)—The largest heavy water plant in Germany, where Nazi scientists were working feverishly to perfect an atomic bomb, was captured almost intact by the allies three months ago in a heavily wooded section four miles from Kiel.

Cobwebs of plastic pipes connected eight huge vats holding thousands of gallons of plain water for processing into heavy water.

I stumbled onto the factory two weeks after it was taken over by American and British technicians. Altho they gave me freedom to roam around the grounds, I was called on the carpet the next day for entering without authority from high officials and was required to pledge not to reveal what I had seen until it was released. Altho the race to perfect the bomb was led by American and British experts, the Germans had made great strides and were catching up. The war against Germany ended just in time.

**Charles Chamberlain. Allies Beat Nazis By Narrow Margin in Atomic Race. *Harrisburg Telegraph.* 9 August 1945 p. 6.
https://www.newspapers.com/article/harrisburg-telegraph/1961441/**

KIEL, Germany, Aug. 9, (AP)—A race against time was won by the Allies by a narrow margin three months ago when the largest heavy water plant in Germany, where Nazi scientists labored furiously to perfect an atomic bomb, was captured intact.

It may now be disclosed that the Allies were so concerned over possible German progress with the bomb that they planned a bold mass parachute attack on Kiel as early as last March to take the experimental station, just outside this base.

The plan was dropped only after the successful Allied crossing of the Rhine, this correspondent learned.

The Kiel plant, captured almost intact three months ago and turned over to British and American specialists, was buried in a camouflaged concrete vault on a wooded hillside and contained eight vats for the manufacture of "D-2O," or heavy water—used in one of the possible processes for producing atomic bombs.

Cobwebs of connecting plastic pipes and files recording the experiments were destroyed by sabotage before the Allies arrived.

The extent of the Nazis' atomic discoveries remains a top secret. But they were making great strides and were catching up. The European war ended just in time.

Among the secret weapons in production at the factory were acoustics torpedoes driven by "ingolene," a fuel described by some sources as 800 times as powerful as high octane gasoline.

[See also:

Charles Chamberlain. Germans' Bomb Plant Located: Nazis Worked Hard on Atomic Device. *San Bernardino Sun.* 12 August 1945 p. 3. https://cdnc.ucr.edu/cgi-bin/cdnc?a=d&d=SBS19450812.1.3

Charles Chamberlain. Atom Race Won By Extremely Narrow Margin. *Ogden Standard Examiner.* 13 August 1945 p. 9. https://newspaperarchive.com/ogden-standard-examiner-aug-13-1945-p-9/

According to Chamberlain, "the largest heavy water plant in Germany" was located approximately four miles from central Kiel, was part of a larger factory that also produced torpedoes, and was hidden in a large concrete bunker buried in an adjacent "heavily wooded hillside." See pp. 4059–4061 for the likely location. Can any remains of this heavy water plant be found now?

As Chamberlain stated, many World War II German torpedoes were powered by "Ingolene," or concentrated hydrogen peroxide. Concentrated hydrogen peroxide was also used as propellant for some rockets and was indeed quite potent, though not far more powerful than gasoline. Chamberlain appears to have heard incorrect information on that point.

Chamberlain specifically remarked that the heavy water plant used a large amount of plastic pipe. While plastic pipe is very common now, it was relatively new and much less common at that time (see p. 643). It would have been used to avoid problems with corrosion and to keep the heavy water as pure as possible.

Chamberlain mentioned that the heavy water plant was partially damaged and its files destroyed or removed by Germans before Allied forces reached the plant.

Chamberlain also reported (based on what he saw and what he heard from Allied forces at the Kiel heavy water plant) that "Nazi scientists were working feverishly to perfect an atomic bomb" and that "The extent of the Nazis' atomic discoveries remains a top secret. But they were making great strides." Chamberlain made it clear that his description of the advanced state of the German nuclear program came directly from Allied investigators, not just his own opinions: "the Allies were so concerned over possible German progress with the bomb that they planned a bold mass parachute attack on Kiel as early as last March to take the experimental station."

The sequence of events behind Chamberlain's reports appears to be:

1. Chamberlain said that he "stumbled onto the factory two weeks after it was taken over by American and British technicians," so he probably discovered it in early or mid-May 1945.

2. Chamberlain was promptly reprimanded by Allied officials for even visiting the heavy water plant—he "was called on the carpet the next day for entering without authority from high officials." That censorship explains why Chamberlain did not publish any articles about the heavy water plan in May 1945.

3. In Allied countries, nuclear-related news articles were commonly censored during the war, up until the public announcement of the Hiroshima bombing. After widespread media reports about Hiroshima and the unveiling of the U.S. nuclear program, Chamberlain presumably thought he could finally report what he had learned in May 1945 regarding the German nuclear program. That explains why his first articles on this topic appeared in August 1945.

4. While it had become permissible to reveal (some) information about the U.S. nuclear program, apparently most details about the former German nuclear program were still closely guarded and publicly denied. Since Chamberlain's reports of this otherwise secret Kiel heavy water production facility and his description of the advanced state of the German nuclear program somehow slipped through censorship and got published in August 1945, he was likely reprimanded for a second and final time by government censors and/or his own newspaper employers. He does not seem to have ever mentioned the Kiel heavy water plant again.

5. In fact, when Chamberlain published an article about the Vemork heavy water plant in February 1946 (p. 4058), he made no mention of the Kiel heavy water plant that he had seen with his own eyes, even though it would have been relevant to the article. He also downplayed the state of the German nuclear program that he himself had reported only six months earlier was quite advanced.

6. The existence of the Kiel heavy water plant and Allied plans to attack it in March 1945 because the German nuclear program was so advanced appear to be historical facts that Allied governments buried in 1945 and that remain buried to this day.]

Charles Chamberlain. Germans Failed to Split Atom: Experiments With Heavy Water Futile. *Council Bluffs Nonpareil* (Council Bluffs, Iowa). 9 February 1946 p. 1. https://www.newspapers.com/article/the-daily-nonpareil/1957966/

MINDEN Germany, (AP)—German experiments with heavy water in attempts to split the atom during the war were unsatisfactory Prof. Otto Hahn, Germany's Nobel prize winning atomic scientist said Saturday.

'In itself heavy water is not an effective radio-active substance, but is used as an auxiliary for the splitting of uranium atoms,' he explained. 'We expected to need heavy water, but it was not so. Americans have proved that this can be done more simply and effectively by using carbon.'

Heavy water plants were built by the Nazis in Norway for atomic bomb research work. British and Norwegian commandos in a highly successful raid blew them up.

(Heavy water has a specific gravity greater than ordinary water. Its hydrogen content is of atomic weight two, rather than atomic weight one).

Another atom scientist in the British occupation zone of Germany—Prof. Paul Harteck of the Kaiser Wilhelm institute of physics in Berlin—said that the light rays thrown out during the enormous explosion of an atomic bomb added greatly to the destructive force.

'The splitting of the atom causes a temperature of more than 10,000,000 degrees and aerial allure which destroy everything,' Harteck said.

This frees an amount of light which is beyond the visible spectrum. Only a few people know that the reflection of beams of light on solid bodies also exerts a mechanical pressure. This pressure is so small where our normal light is concerned that it is not noticed. The amount of light freed by an atomic bomb is so great it destroys walls.

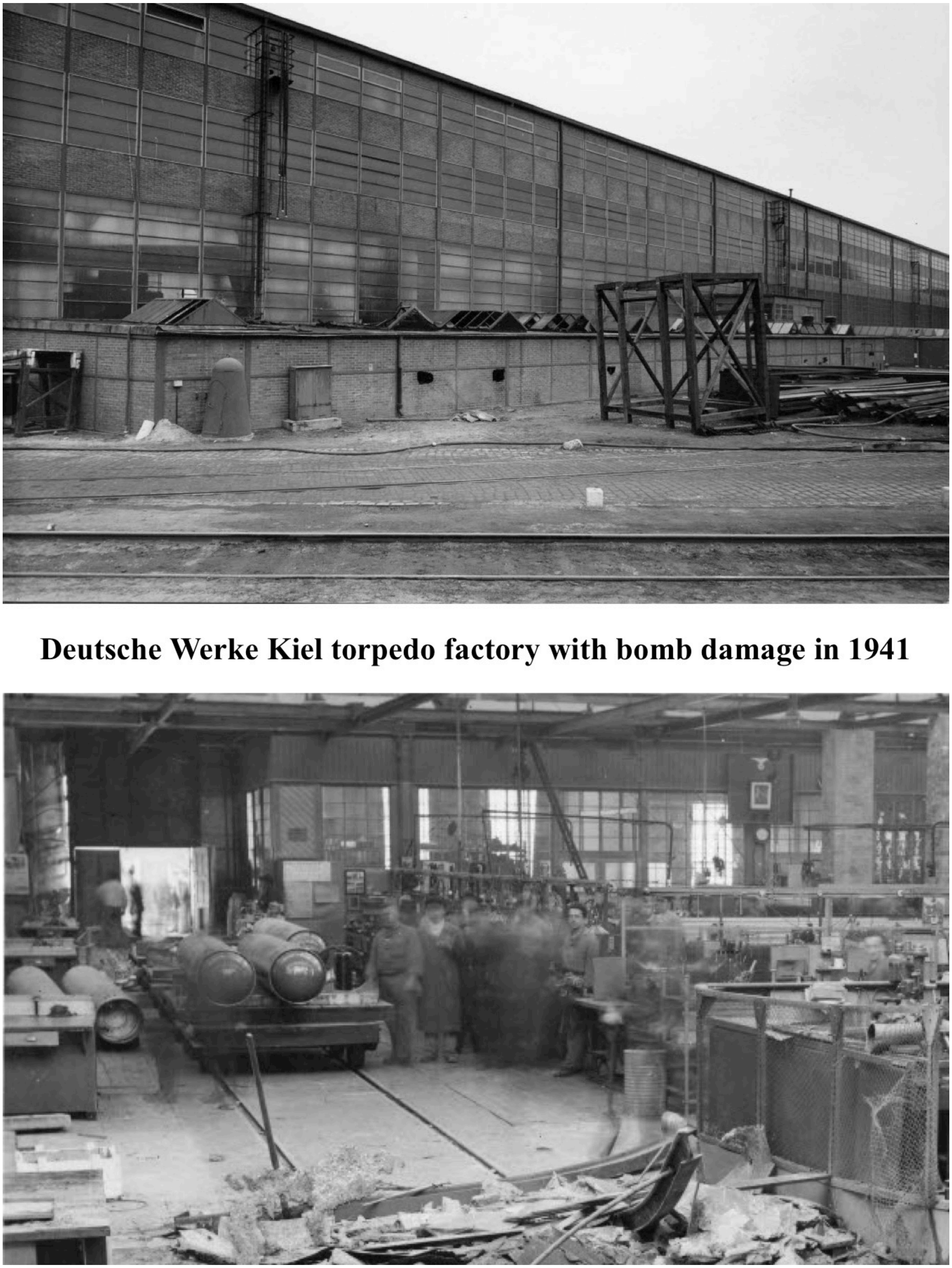


Figure D.500: The Deutsche Werke Kiel torpedo factory (shown here with bomb damage in 1941) was approximately four miles north of central Kiel, and is likely the location that Charles Chamberlain described.

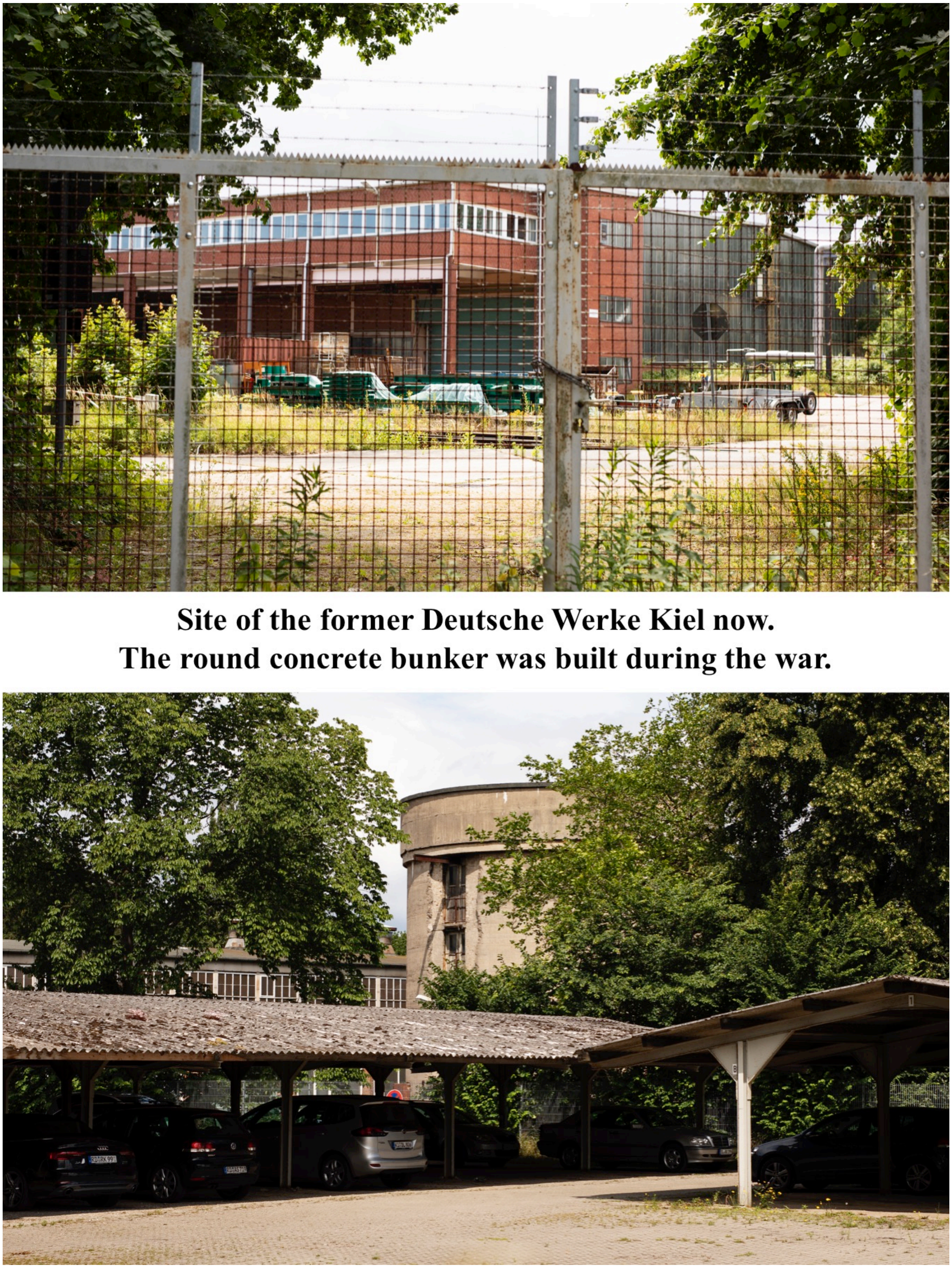


Figure D.501: Site of the former Deutsche Werke Kiel now. The round concrete bunker (lower photo) was built during the war. Other bunkers are known to have been built, but have been demolished or paved over.

Figure D.502: There is a heavily wooded hillside immediately adjacent to the former Deutsche Werke Kiel, exactly as Charles Chamberlain described. Are the remains of the heavy water bunker in this area?

9. Dräger Werke, Lübeck

OSS London. 5 December 1944. Report T-2805-a. [NARA RG 77, Entry UD-22A, Box 171, Folder 32.7003-3 GERMANY: US Wartime Positive Int. (Nov. 44–June 45)]

Original No. T-2805-a

Report from Sweden

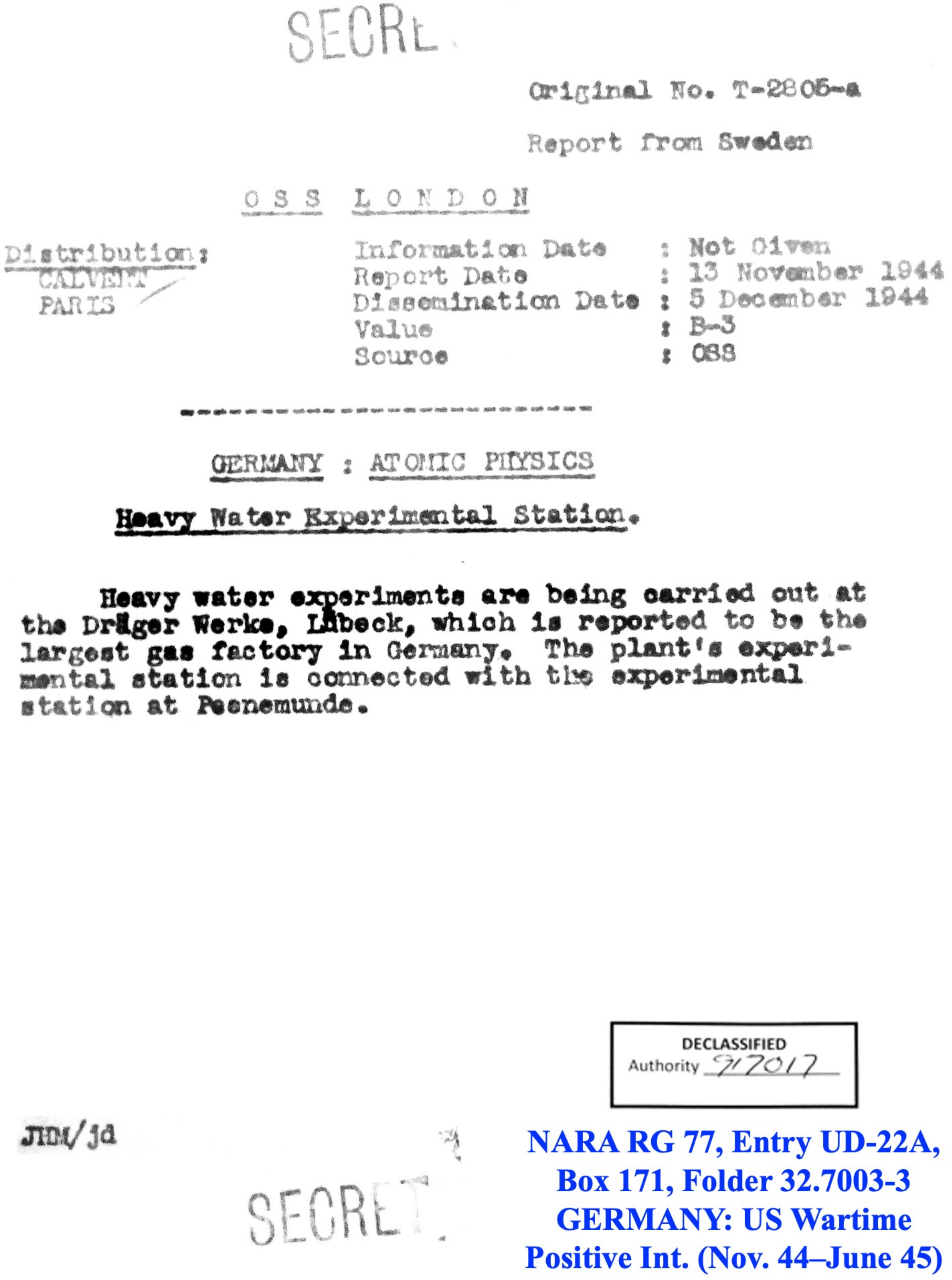
OSS LONDON

Distribution:	Information Date	:	Not Given
CALVERT	Report Date	:	13 November 1944
PARIS	Dissemination Date	:	5 December 1944
	Value	:	B-3
	Source	:	OSS

GERMANY : ATOMIC PHYSICS

Heavy Water Experimental Station.

Heavy water experiments are being carried out at the Dräger Werke, Lübeck, which is reported to be the largest gas factory in Germany. The plant's experimental station is connected with the experimental station at Peenemünde.



SECRE

Original No. T-2805-a

Report from Sweden

OSS LONDON

Distribution:
CALVERT
PARIS

Information Date	: Not Given
Report Date	: 13 November 1944
Dissemination Date	: 5 December 1944
Value	: B-3
Source	: OSS

GERMANY : ATOMIC PHYSICS

Heavy Water Experimental Station.

Heavy water experiments are being carried out at the Dräger Werke, Lübeck, which is reported to be the largest gas factory in Germany. The plant's experimental station is connected with the experimental station at Peenemunde.

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NARA RG 77, Entry UD-22A, Box 171, Folder 32.7003-3 GERMANY: US Wartime Positive Int. (Nov. 44–June 45)

Figure D.503: Report of a heavy water production plant at Lübeck. OSS London. 5 December 1944. Report T-2805-a. [NARA RG 77, Entry UD-22A, Box 171, Folder 32.7003-3 GERMANY: US Wartime Positive Int. (Nov. 44–June 45)]

10. Müggenberg

Karl Cohen to Francis J. Smith. 23 February 1945. Subject: Status of Enemy Separation Projects. [NARA RG 77, Entry UD-22A, Box 166, Folder 32.22-1—GERMANY—Research—TA—(1943–June 1946)]

Heavy Water Production

About the only enemy activity at all comparable in scale to ours. Harteck appears to be leading this work. Methods considered in 1941 meeting were electrolysis, chemical exchange with platinum catalysts, distillation of water and low temperature distillation of liquid hydrogen. 1942 conference goes over same questions. Wirtz, Clusius Bonhoffer participated in discussions. Production of the order of tons/year are envisaged.

Factories: Rjukan (now dismantled) Müggenberg, I. G. Farben

[This is Karl Cohen's summary of some German letters and reports that had been found by Alsos in Strassburg/Strasbourg in late 1944.]

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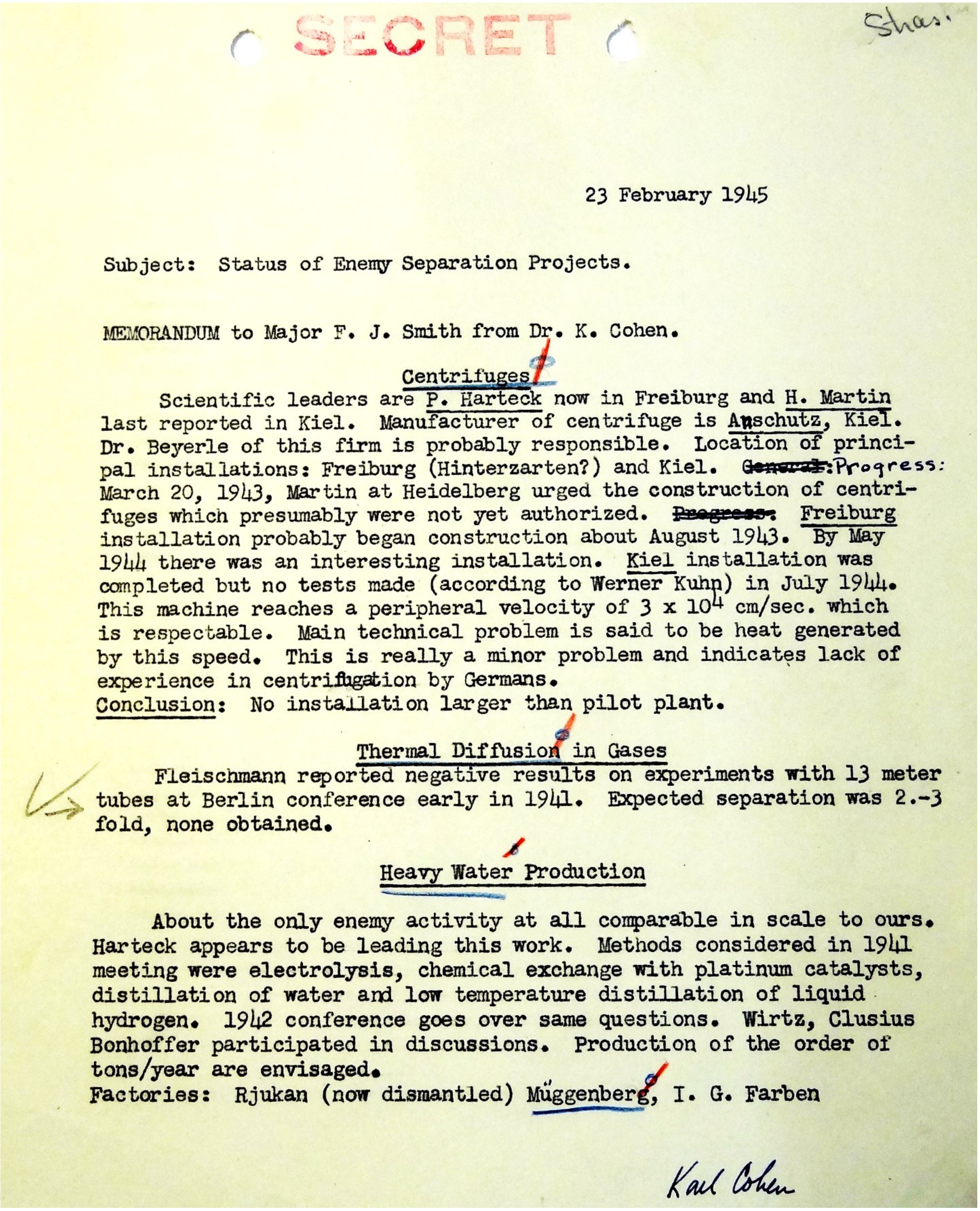
Authority 917017

NARA RG 77, Entry UD-22A, Box 166, Folder 32.22-1—GERMANY—Research—TA—(1943–June 1946)



SECRET

Shas.

23 February 1945

Subject: Status of Enemy Separation Projects.

MEMORANDUM to Major F. J. Smith from Dr. K. Cohen.

Centrifuges

Scientific leaders are P. Harteck now in Freiburg and H. Martin last reported in Kiel. Manufacturer of centrifuge is Anschutz, Kiel. Dr. Beyerle of this firm is probably responsible. Location of principal installations: Freiburg (Hinterzarten?) and Kiel. ~~General:~~ Progress: March 20, 1943, Martin at Heidelberg urged the construction of centrifuges which presumably were not yet authorized. ~~Progress:~~ Freiburg installation probably began construction about August 1943. By May 1944 there was an interesting installation. Kiel installation was completed but no tests made (according to Werner Kuhn) in July 1944. This machine reaches a peripheral velocity of 3×10^4 cm/sec. which is respectable. Main technical problem is said to be heat generated by this speed. This is really a minor problem and indicates lack of experience in centrifugation by Germans.

Conclusion: No installation larger than pilot plant.

Thermal Diffusion in Gases

Fleischmann reported negative results on experiments with 13 meter tubes at Berlin conference early in 1941. Expected separation was 2.-3 fold, none obtained.

Heavy Water Production

About the only enemy activity at all comparable in scale to ours. Harteck appears to be leading this work. Methods considered in 1941 meeting were electrolysis, chemical exchange with platinum catalysts, distillation of water and low temperature distillation of liquid hydrogen. 1942 conference goes over same questions. Wirtz, Clusius Bonhoffer participated in discussions. Production of the order of tons/year are envisaged.

Factories: Rjukan (now dismantled) Müggenberg, I. G. Farben

Karl Cohen

Figure D.504: Report of a heavy water production plant at Müggenberg. Karl Cohen to Francis J. Smith. 23 February 1945. Subject: Status of Enemy Separation Projects. [NARA RG 77, Entry UD-22A, Box 166, Folder 32.22-1—GERMANY—Research—TA—(1943–June 1946)]

11. Griesheim

Report on Interrogation of PW MAYER. 14 July 1944. [NARA RG 77, Entry UD-22A, Box 171, Folder 32.7003-2 GERMANY: US Wartime Positive Int. (July–Oct. 44)]

1. SUBJECT PW is an educated man in his late thirties, a physical chemist by profession and states that he is anti-Nazi and wishes to collaborate. He studied at the Universities of FREIBURG and MUNICH for six years, receiving a degree equivalent to a Doctorate of Philosophy in Chemistry. [...]

7. Manufacture of Hydrogen Peroxide and of Heavy Hydrogen.

[...] PW believes that D2O (Heavy Hydrogen) is manufactured principally at GRIESHEIM ELEKTRON in fairly large quantities for distribution to research and scientific establishments.

[See also pp. 3678–3680.]

Former administration building of
Chemische Fabrik Griesheim-Elektron, Frankfurt am Main

Figure D.505: Former administration building of Chemische Fabrik Griesheim-Elektron, Frankfurt am Main. Griesheim-Elektron reportedly produced large quantities of heavy water during the war. See also pp. 3678–3680. The Griesheim plant appears to have been occupied and tightly controlled by the U.S. military for nearly a year and a half after the war. See for example https://de.wikipedia.org/wiki/Chemische_Fabrik_Griesheim-Elektron and sources cited therein.

12. Berlin and 13. Munich

Mark Walker. 1989. *German National Socialism and the Quest for Nuclear Power, 1939–1949.* Cambridge, UK: Cambridge University Press. p. 145:

Between the electrolysis unit at the Kaiser Wilhelm Institute for Physics and the planned Clusius-Linde plant, large-scale electrolysis was superfluous—something that Harteck had been arguing since 1940. On the other hand, Linde needed one and a half years before full operation could be expected. In late July of 1944 Allied air raids severely damaged the Linde plant in Munich.

G-105. Linde Ice Machine Company. 1941. *Process for Producing Heavy Hydrogen and/or Heavy Water.*

Ordinary hydrogen is cooled, liquified, and continuously rectified. Since HD has a lower vapor pressure than H_2 such an isotope separation is possible. The hydrogen is thus enriched 5%. Catalytic process to split H_2 and D_2. The resulting mixture of $H_2 + HD + D_2$ can be further rectified or it can be oxidized to $H_2O + HDO + D_2O$, and pure D can then be obtained by the usual electrolytic process. Special arrangement for cooling the hydrogen by boiling liquid nitrogen. Diagram showing how rectification can be continuous. Method for removal of impurities.

[See also G-261.]

Klaus and Ann M. Hentschel. 1996. *Physics and National Socialism: An Anthology of Primary Sources.* Basel: Birkhäuser. p. 151:

[I]n 1944 the Linde Company was destroyed in an air raid, partly because it was involved in the production of heavy water (deuterium) for the *Uranverein.* Cf. *75 Jahre Carl v. Linde Gesellschaft für Eismaschinen*, Frankfurt: Brönner, 1954, pp. 123–125, and Walker [1989]a, pp. 144f.

14. Sinigo-Merano and 15. Cotrone, Italy

Per F. Dahl. 1999. *Heavy Water and the Wartime Race for Nuclear Energy.* Philadelphia: Institute of Physics. p. 211:

The only other potential source of heavy water in occupied Europe appeared to be two Montecatini electrolysis plants in Italy—one near Merano and one at Cotrone, with a combined power consumption of 68000 kW, or half that of Vemork. Harteck thought it possible to use the Italian plants for an enrichment to around 1%, whereupon the material could be shipped to Germany for further processing at I G Farben's Leuna works [13-11]. Both Esau and Harteck had personally inspected the Merano plant during the winter 1942–1943, but Esau, for one, was not enthusiastic about the Italian option. [...] At any rate, a Merano-Leuna arrangement was still a fall-back solution, in case of further troubles in Norway.

16. Auschwitz

U.S. Embassy, Warsaw. 12 August 1947. Report No. R-107-47, MIS-390731. Subject: Plants producing heavy water. [NARA RG 319, Entry 85A, Box 2534, Folder 390731–390740]

1. It is believed that no plants designed specially for the production of heavy water exist in Poland. It is reliably reported that the Germans built one such plant near OSWIECIM (Auschwitz) but that it was destroyed or moved out by the SOVIETS in 1945.

[It was "reliably reported" that the Germans had built a heavy water production plant in Poland during the war, and that it was removed by the Soviets.

See p. 4452 for more information.]

17. Heavy water plant near the Schmiedeberg (now Kowary, Poland) uranium mine

[See Witkowski 2013, p. 224.]

18. Breslau/Wrocław

Siegfried Knappe and Ted Brusaw. 1992. *Soldat: Reflections of a German Soldier 1936–1949.* New York: Orion.

[pp. ix-x:] The amount of detail in this narrative is possible because Siegfried Knappe kept a diary from his midteens until he went into Russian captivity on May 2, 1945. Additionally, he smuggled many photographs of his war years from his mother's home in East Germany when he tricked the East Germans into allowing him to go to West Germany upon his release from Russian captivity in December 1949. During approximately 450 hours of interviews, we used these photographs to help trigger his memory as we covered every episode of his war years many times.

Siegfried also had General Weidling's account of the 56th Panzer Korps' part in the fighting from the Oder River to Berlin and the defense of Berlin, which Weidling wrote for the Russians immediately after surrendering. And when Siegfried was released from Russian captivity in December 1949, one of his first acts was to write his own account of the same period and of his Russian captivity as well. Finally, Siegfried had a day-by-day report of his artillery battery's participation in the invasion of France in May 1940, written by his battery commander.

A writer could hardly ask for a more thoroughly documented subject.

Ted Brusaw
Dayton, Ohio
September 1991

[pp. 265–268:] Hitler had declared Breslau a fortress city, which meant that it was to be defended to the last man, even if it was surrounded and totally isolated. The army corps staff in Breslau was the home unit staff for the area, which meant that it was a peacetime staff, and that was why Schörner had wanted officers with extensive combat experience to get the place ready for siege.

The fortress corps staff in Breslau was about seventy people. Because Breslau was the capital of Silesia and had been declared a fortress, the responsibility of the Army Korps Area VIII General Command staff was broader than that of a normal military staff. [...]

I took over the duties of operations officer on January 31. [...]

Schörner had been right: the place was a military mess. All the staff people were handicapped or old, and they had no idea how to fight or how to defend a big city. Defense lines had to be designated, ditches had to be dug, preparations of all kinds had to be made. Wounded coming in from the front had to be accommodated. A factory for making heavy water for atomic experiments had been abandoned east of Breslau, and we had to plan and conduct a counterattack to destroy it and keep its secrets from falling into the hands of the Russians. We were constantly occupied with issuing instructions to civil defense units, decreasing staff personnel, issuing ammunition and supplies, providing weapons, enforcing Schörner's order that no man able to fight was to leave Breslau, keeping refugees supplied and moving, finding engines for hospital trains, keeping utilities operating, preventing looting, preparing landing strips in the city in preparation for the siege—all in addition to normal staff functions like the daily military report to Schörner. [...]

Together with Generalmajor von Ahlfen and his staff, we got things into shape so that Schörner was finally satisfied. On about February 10, the Russian offensive across the Oder River began south of Breslau, near Grottkau, and in the northwest near Steinau. In front of the fortress itself, fairly insignificant combat activity continued at first, but our 609th Division soon became involved in heavy fighting and was pushed back almost to the southern suburbs of Breslau.

On February 11, the 7th Infantry Division, which had successfully completed the operation to retake and destroy the heavy-water plant at Dyhernfurth across the Oder River, sent their vehicles and baggage train into Breslau and pushed south through an enemy that was advancing toward Breslau from the west to form a new front in the area south of Kant. On February 12, two Soviet forces closed the ring around Breslau at Domslau. With that, Breslau had become a fortress under siege.

[Breslau (now Wrocław, Poland) was besieged by the Soviet army beginning in February 1945 but did not surrender until the end of the war. As operations officer for the Breslau-area military staff, in charge of directing and reporting the actions of the German military in that area, Knappe would have been extremely well informed about the topics he discussed. As his interviewer/coauthor Brusaw noted, Knappe's recollections were reviewed thoroughly and were supported by detailed documentation from that time period.

Knappe twice mentioned a heavy water plant in the Breslau area, first saying it was "east of Breslau" and then saying it was at Dyhernfurth (now Brzeg Dolny), which is northwest of Breslau. Perhaps he was referring to two different plants, but it sounds as if he meant the same plant. A heavy water plant would need a plentiful source of water (to find the relatively rare deuterium), so a heavy water plant in the Breslau area would almost certainly be located on the Oder river, which comes from the southeast of Breslau, runs through the city of Breslau, and then flows to the northwest of Breslau. Based on the path of the river, perhaps the most straightforward explanation is that Knappe meant to say the heavy water plant was just east of Dyhernfurth, not Breslau.

It is possible that what Knappe thought was a heavy water plant was actually the relatively well known I.G. Farben/Anorgana Dyhernfurth plant for producing tabun nerve agent. That plant was indeed abandoned yet later sanitized by German forces in a manner similar to what Knappe described.[13] However, there are a number of reasons to think that Knappe's references to a heavy water plant were correct:

- Knappe described the facility as a heavy water plant at least twice (perhaps more times in his interviews with Brusaw when they "covered every episode of his war years many times") and very specifically added that its heavy water was used "for atomic experiments." In his position in the German military, Knappe certainly would have known what chemical weapons were and would have understood the difference.
- There were other reports of heavy water plants in Poland, including a plant near the Schmiedeberg (now Kowary) uranium mine [Witkowski 2013, p. 224] and a plant that was part of or near the I.G. Farben Auschwitz complex (pp. 4069, 4452).
- Uranium gas centrifuges were being produced at a factory in Breslau (p. 4522).
- There were reports of other nuclear facilities in Silesia (pp. 4504–4510), fission reactors in Königsberg (pp. 3928–3933), and a fission bomb test in Poland (Section D.11).
- Multiple weapons plants were often built in close proximity, so locating a heavy water plant near the Dyhernfurth tabun plant (and just upstream of it to the east, to avoid tabun-related contaminants) would be consistent with that German practice. That would also explain why Hitler made defending the Breslau area such a high priority, and why the German military protected Breslau to the end of the war: it was a strategic location for producing both nuclear and chemical (and perhaps other) weapons of mass destruction.]

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[13] Gellermann 1986, pp. 175–176; Gröhler 1989, pp. 9–11; Harris and Paxman 2002, pp. 57–59, 141; Jacobsen 2014, pp. 24–29; Kaszeta 2020, pp. 26–37, 45–51; Tucker 2006, pp. 49–51, 69–72.

19. Weer, Austria

Ferdinand Cap. 23 November 1950. Gutachten [courtesy of Silke Fengler].

Über Einladung von Herrn Oberst GOUSSOT, Innsbruck, hatte ich die Möglichkeit, am 21.XI.50 die Schwere-Wasser-Gewinnungs-Versuchsanlage des Herrn Werd in Wehr [sic: Weer] bei Wattens in Tirol zu besichtigen. Das Prinzip der Anlage besteht in Folgendem: An schwerem Wasser angereichertes Wasser wird den drei (später neun) Zellen der Apparatur zugeführt. In jeder Zelle befindet sich ein Diaphragme, eine Kathode und eine Anode. (Spannung pro Zelle 3 Volt, Gesamtstrom 60 A) Als Elektrolyt dient verdünnt Natronlauge. Die durch die Elektrolyse freigesetzten Gase Wasserstoff und Sauerstoff werden an Paladiumoberflächen katalytisch verbrannt; das entstehende Wasser, das an schwerem Wasser ärmer ist als das in der jeweiligen Zelle elektrolysierte Wasser, wird in die vorhergehende Zelle geleitet; von der ersten Zelle wird es in die Vorkonzentrieranlage geleitet.

Das in jeder Zelle zurückbleibende an schwerem Wasser reichere Wasser wird in die nächstfolgende Zelle überdestilliert—ein einfaches Einleiten ist nicht möglich, da sonst die Konzentration des Elektrolyten stark steigen würde. In weit beim Destillationsprozess gewöhnliches Wasser und schweres Wasser gemeinsam übergehen oder ob hierbei eine kleine (der Apparaturanlage also rückläufige) Trennung eintritt, ist dem Unterzeichneten nicht bekannt und müsste aus Spezialabhandlungen geklärt werden. Sollte eine Verschlechterung der Trennwirksamkeit eintreten so wäre es immerhin wohl möglich durch einen anderen Prozess des überleitens diesen Verlust auszugleichen.

At the invitation of Colonel Colonel GOUSSOT, Innsbruck, I had the opportunity to visit Mr. Werd's heavy water extraction test facility in Wehr [sic: Weer] near Wattens in Tyrol on 21 November 1950. The principle of the plant consists in the following: Water enriched with heavy water is supplied to the three (later nine) cells of the apparatus. Each cell contains a diaphragm, a cathode and an anode. (Voltage per cell 3 volts, total current 60 A) Sodium hydroxide solution diluted serves as electrolyte. The gases hydrogen and oxygen released by the electrolysis are catalytically burned on palladium surfaces; the resulting water, which is poorer in heavy water than the water electrolysed in the respective cell, is led into the preceding cell; from the first cell it is led into the pre-concentration plant.

The water that remains in each cell and is richer in heavy water is distilled into the next cell–a simple discharge is not possible, as otherwise the concentration of the electrolyte would increase sharply. The undersigned does not know whether the distillation process involves the combined use of water and heavy water or whether this results in a small separation (i.e. a retrograde separation of the equipment). Should a deterioration of the separation efficiency occur, it would at least be possible to compensate this loss by another process of transfer.

Der Grundgedanke der Apparatur von Herrn W. ist physikalisch vollkommen einwandfrei. Ob jedoch auf dieser Basis eine Grossproduktion aufgebaut werden kann, wagt der Unterzeichnete nicht zu entscheiden; Entwicklungsarbeiten durchzuführen ist jedoch nicht anzuraten, da diesbezüglich sowohl in Deutschland und Norwegen, als auch in den USA ausgedehnte Untersuchungen bereits vorgenommen wurden. Die Frage nach dem Aufbau einer Grossproduktion kann daher nur nach genauem Studium der einschlägigen Literatur (etwa Monographie von Urey, AEC Reports, FIAT Reports etc.) beantwortet werden. Die von Herrn W. angegebenen Schätzungen über den Strombedarf (rund 1000 kWh für ein Gramm schweres Wasser von 96 % Reinheit) könnten an sich richtig sein, sind aber mit grösster Vorsicht aufzunehmen. Eine Überprüfung ist ohne spezieller Angaben über den Trennfaktor der Elektrolyse nicht möglich.

Jedenfalls müsste ein Vergleich der Wirksamkeit mit den Methoden der NORSK HYDRO, RJUKAN, Norwegen, angestellt werden; auch soll noch auf eine neue, hier noch nicht genügend bekannt gewordene amerikanische chemische Methode (Löslichkeitsmethode) hingewiesen werden, die allem Anschein noch möglicherweise eine grössere Ausbeute verspricht, also die Elektrolysenverfahren.

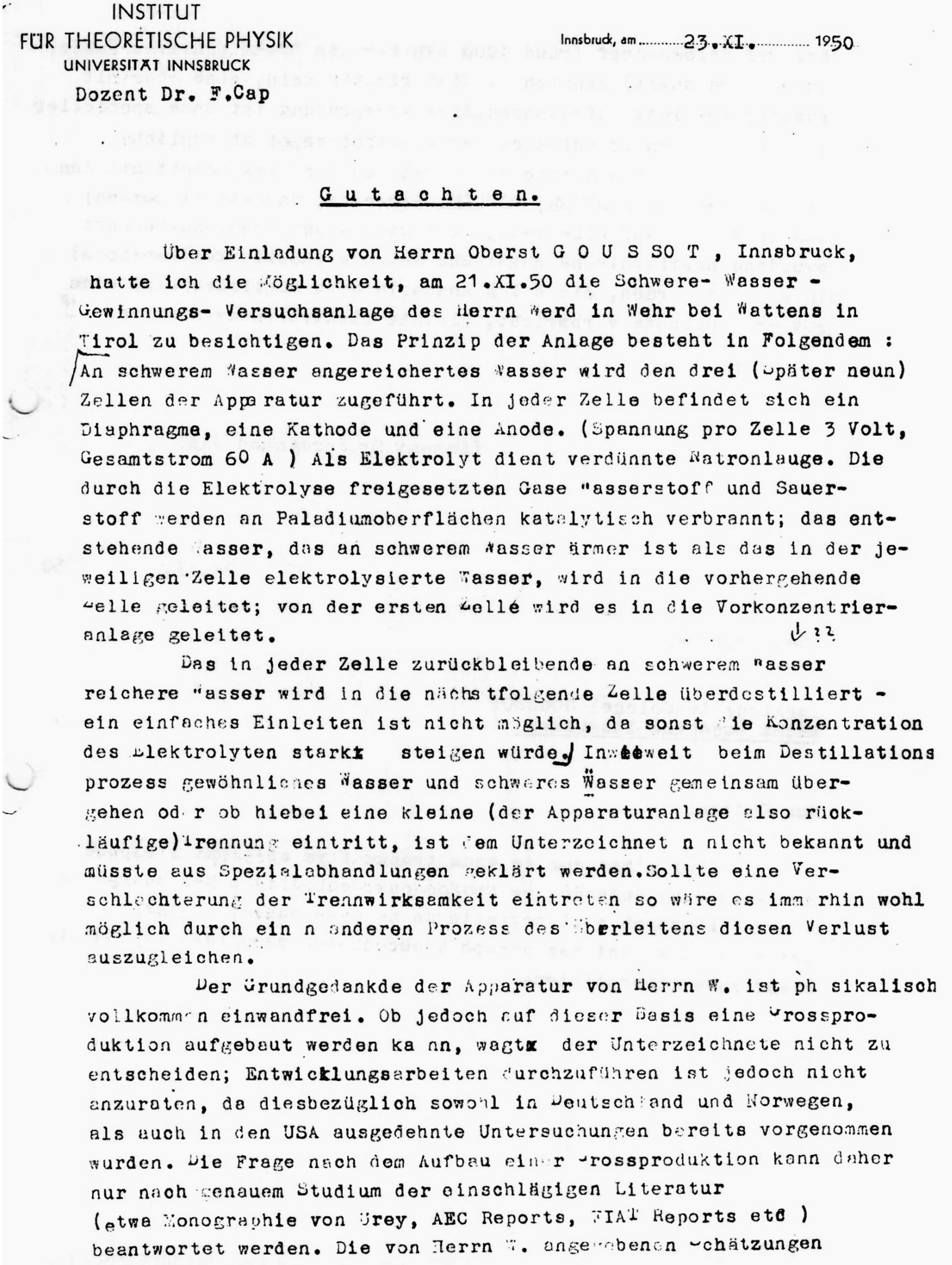
The basic idea of Mr. W.'s apparatus is physically perfect. However, the undersigned does not dare to decide whether a large-scale production can be built on this basis; however, it is not advisable to carry out development work, as extensive investigations have already been carried out in this respect in Germany and Norway, as well as in the USA. The question of setting up a large-scale production can therefore only be answered after a detailed study of the relevant literature (e.g. monograph by Urey, AEC Reports, FIAT Reports etc.). The estimates given by Mr. W. of the electricity requirement (about 1000 kWh for a gram of heavy water of 96 % purity) could be correct in themselves, but must be taken with the greatest caution. A check is not possible without special information about the separation factor of the electrolysis.

In any case, a comparison of the effectiveness with the methods of NORSK HYDRO, RJUKAN, Norway, would have to be made; also, a new American chemical method (solubility method), which has not yet become sufficiently known here, should be pointed out, which to all appearances still possibly promises a higher yield, i.e. the electrolysis methods.

[See also the interview with Ferdinand Cap on pp. 4076–4077. This heavy water plant in the Austrian Alps was apparently quite large and fully operational during the war. It was likely built by or at least for the SS.

This facility was apparently only discovered by outsiders in 1950. It does not seem to be mentioned in any other known documents. Can more information be located in any archives around the world?

If there is so little surviving historical record of this large heavy water production plant, what other wartime heavy water plants (or other nuclear-related facilities) may have existed yet remain unknown today?]



INSTITUT
FÜR THEORETISCHE PHYSIK
UNIVERSITÄT INNSBRUCK
Dozent Dr. F. Cap

Innsbruck, am 23. XI. 1950

Gutachten.

Über Einladung von Herrn Oberst GOUSSOT, Innsbruck, hatte ich die Möglichkeit, am 21.XI.50 die Schwere- Wasser - Gewinnungs- Versuchsanlage des Herrn Werd in Wehr bei Wattens in Tirol zu besichtigen. Das Prinzip der Anlage besteht in Folgendem : An schwerem Wasser angereichertes Wasser wird den drei (später neun) Zellen der Apparatur zugeführt. In jeder Zelle befindet sich ein Diaphragma, eine Kathode und eine Anode. (Spannung pro Zelle 3 Volt, Gesamtstrom 60 A) Als Elektrolyt dient verdünnte Natronlauge. Die durch die Elektrolyse freigesetzten Gase Wasserstoff und Sauerstoff werden an Paladiumoberflächen katalytisch verbrannt; das entstehende Wasser, das an schwerem Wasser ärmer ist als das in der jeweiligen Zelle elektrolysierte Wasser, wird in die vorhergehende Zelle geleitet; von der ersten Zelle wird es in die Vorkonzentrieranlage geleitet.

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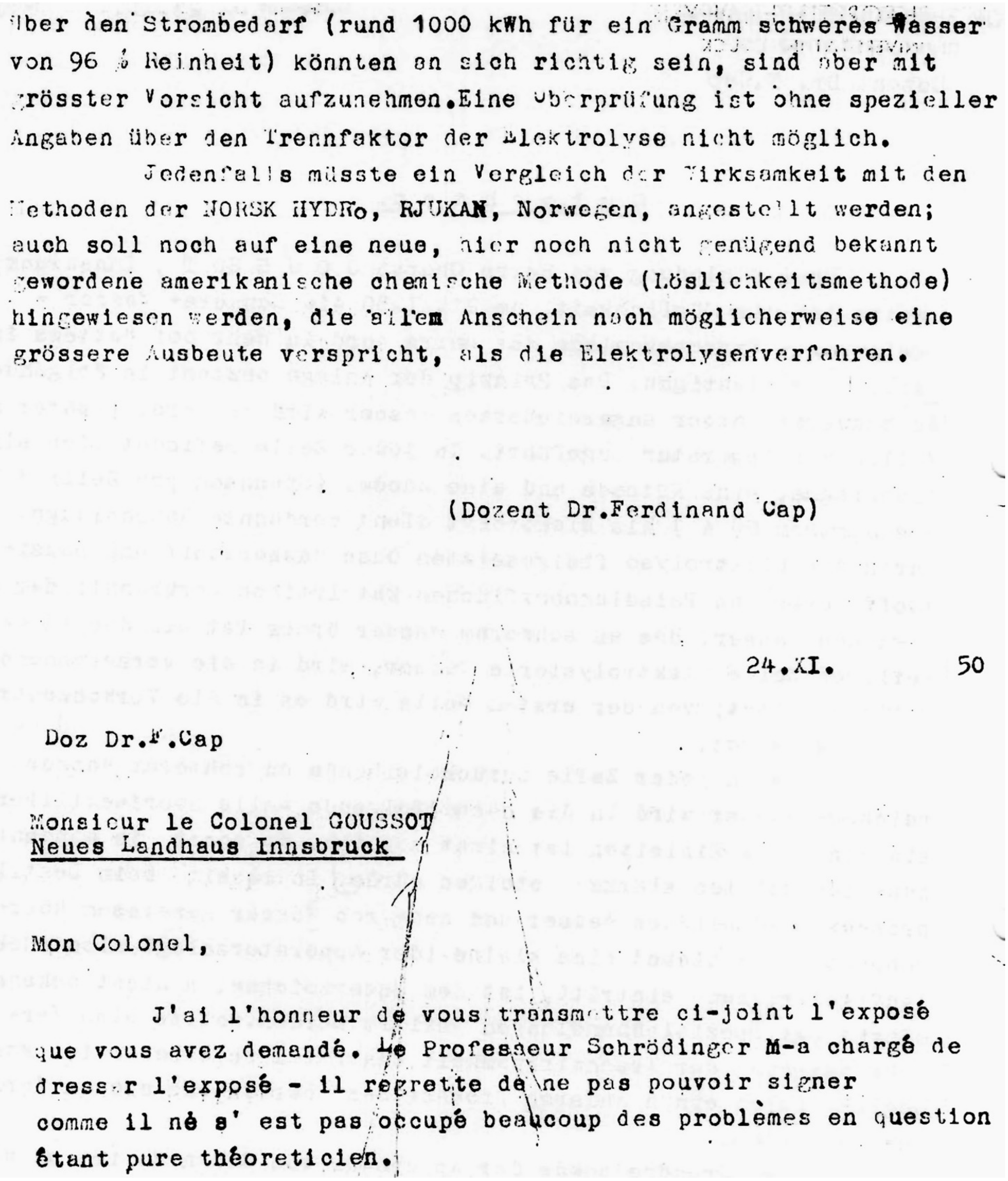
Der Grundgedankde der Apparatur von Herrn W. ist physikalisch vollkommen einwandfrei. Ob jedoch auf dieser Basis eine Grossproduktion aufgebaut werden kann, wagt der Unterzeichnete nicht zu entscheiden; Entwicklungsarbeiten durchzuführen ist jedoch nicht anzuraten, da diesbezüglich sowohl in Deutschland und Norwegen, als auch in den USA ausgedehnte Untersuchungen bereits vorgenommen wurden. Die Frage nach dem Aufbau einer Grossproduktion kann daher nur nach genauem Studium der einschlägigen Literatur (etwa Monographie von Urey, AEC Reports, FIAT Reports etc) beantwortet werden. Die von Herrn W. angegebenen Schätzungen

Figure D.506: Ferdinand Cap. 23 November 1950. Gutachten [courtesy of Silke Fengler].



über den Strombedarf (rund 1000 kWh für ein Gramm schweres Wasser von 96 % Reinheit) könnten an sich richtig sein, sind aber mit grösster Vorsicht aufzunehmen. Eine Überprüfung ist ohne spezieller Angaben über den Trennfaktor der Elektrolyse nicht möglich.

Jedenfalls müsste ein Vergleich der Wirksamkeit mit den Methoden der NORSK HYDRO, RJUKAN, Norwegen, angestellt werden; auch soll noch auf eine neue, hier noch nicht genügend bekannt gewordene amerikanische chemische Methode (Löslichkeitsmethode) hingewiesen werden, die allem Anschein noch möglicherweise eine grössere Ausbeute verspricht, als die Elektrolysenverfahren.

(Dozent Dr.Ferdinand Cap)

24.XI. 50

Doz Dr.F.Cap

Monsieur le Colonel GOUSSOT
Neues Landhaus Innsbruck

Mon Colonel,

J'ai l'honneur de vous transmettre ci-joint l'exposé que vous avez demandé. Le Professeur Schrödinger M-a chargé de dresser l'exposé - il regrette de ne pas pouvoir signer comme il né s' est pas occupé beaucoup des problèmes en question étant pure théoreticien.

Figure D.507: Ferdinand Cap. 23 November 1950. Gutachten [courtesy of Silke Fengler].

Rainer Karlsch. Interview with Ferdinand Cap. 5 February 2009 [courtesy of Rainer Karlsch].

Karlsch: Mich interessiert, wer diese Anlage gebaut hat. Sie erwähnten damals einen Herrn Werdt (W.). Er kann doch unmöglich allein eine solche Anlage Gebaut haben. Wer waren seine Auftraggeber? Natürlich ist es denkbar, dass die SS die Anlage im Zillertal in Auftrag gegeben hat. Gibt es dafür Belege?

Cap: Wer die Anlage gebaut hat, weiss ich nicht, glaube Norsk Hydro. Herr W. war nur Werksleiter und hat mich und Schroedinger geführt.

Karlsch: Prof. Oberkofler schreibt in seiner Studie "Ferdinand Cap und Otto Hittmair. Aus den Pionierjahren der Innsbrucker Theoretischen Physik", Innsbruck 2006, auf S. 27f.: "Auf dringliche Anforderung von Seiten der französischen Besatzungsmacht besichtigte Schrödinger in Begleitung von Cap im November 1950 die von der SS wie in Norwegen auch im Zillertal gebaute Anlage zur Gewinnung von Schwerem Wasser durch Elektrolyse." Mir ist nicht bekannt, dass die SS in Norwegen eine Schwerwasseranlage gebaut hat. Die dortigen Elektrolysezellen der Norsk Hydro (Anteilseigner war die IG Farbenindustrie AG) wurde nach den Entwürfen von Prof. Paul Harteck (Hamburg) und seiner Mitarbeiter 1942 erweitert und im August 1944 demontiert und ins Reichsgebiet geschafft. Mit dem Betrieb der Schwerwasseranlage in Norwegen hatte die SS meines Wissens nichts zu schaffen.

Cap: Harteck und WIRTZ sind mir bekannt. ICH HABE NIE BEHAUPTET DASS DIE SS DIE ANLAGE GEBAUT HAT.

Karlsch: Oder ist noch eine andere Anlage gemeint? Es gab ja nicht nur das Werk in Rjukan, sondern auch noch Anlagen in Saaheim und Nodotten, die sich aber ebenfalls in Regie der Hydro befanden.

Karlsch: I am interested in who built this plant. You mentioned a Mr. Werdt (W.) at that time. He couldn't have built such a plant on his own. Who were his clients? Of course it is conceivable that the SS commissioned the plant in the Zillertal. Is there any evidence of this?

Cap: I don't know who built the plant, Norsk Hydro I believe. Mr. W. was just a plant manager and led me and Schroedinger.

Karlsch: Prof. Oberkofler writes in his study "Ferdinand Cap and Otto Hittmair. From the pioneering years of Innsbruck's Theoretical Physics," Innsbruck 2006, on p. 27f: "On urgent request of the French occupying power Schrödinger, accompanied by Cap, visited in November 1950 the plant for the production of heavy water by electrolysis built by the SS in the Zillertal as in Norway." I do not know that the SS built a heavy water plant in Norway. The electrolysis cells of Norsk Hydro there (the shareholder was IG Farbenindustrie AG) were expanded in 1942 according to the designs of Prof. Paul Harteck (Hamburg) and his employees and dismantled in August 1944 and transported to the territory of the Reich. To my knowledge, the SS had nothing to do with the operation of the heavy water plant in Norway.

Cap: I know Harteck and WIRTZ. I NEVER CLAIMED SS BUILT THE PLANT.

Karlsch: Or is there another plant meant? There was not only the plant in Rjukan, but also plants in Saaheim and Nodotten, which were also directed by Hydro.

Cap: Nein, nur Zillertal mir bekannt.	Cap: No, I only know Zillertal.
[...]	[...]
Karlsch: Die Norsk Hydro scheidet als Bauherr oder Betreiber m.E. aus. Weder in den Unterlagen der Norsk, noch in den Erinnerungen ihrer leitenden Mitarbeiter und auch nicht in den Papieren der IG Farben, damals Hauptaktionär bei der Norsk, findet sich ein Hinweis darauf. Es bleibt also unklar, wer die Auftraggeber für die Anlage waren.	Karlsch: Norsk Hydro is no longer the owner or operator in my opinion. Neither in the documents of Norsk, nor in the memories of its leading employees, nor in the papers of IG Farben, then the main shareholder of Norsk, is there any indication of this. It therefore remains unclear who the contractors for the plant were.
Cap: Leider, offenbar. Ich wäre laut H. W. der Meinung gewesen NORSK HYDRO.	Cap: Unfortunately, apparently. I would have thought, according to Mr. W., NORSK HYDRO.
Karlsch: Können Sie sich daran erinnern, wo genau die Anlage stand?	Karlsch: Can you remember exactly where the plant was located?
Cap: Ziemlich ganz am Ende des Zillertales, nahe einem Gletscher.	Cap: Quite at the end of the Zillertal, near a glacier.
Karlsch: Welche Ausmaße hatten die Elektrolysezellen ungefähr?	Karlsch: What were the approximate dimensions of the electrolysis cells?
Cap: Hunderte Zellen, verschiedene Groesse, kleinere wie Waschbecken, mittlere wie Badewanne.	Cap: Hundreds of cells, different sizes, the smaller like a sink, the medium like a bathtub.
Karlsch: War Herr Werdt Ingenieur oder Physiker?	Karlsch: Was Mr. Werdt an engineer or a physicist?
Cap: Ich würde sagen H. Werdt war Gewerbeschultechniker. Sicher nicht Akademiker.	Cap: I would say Mr. Werdt was a vocational school technician. Certainly not an academic.
Karlsch: Stand er in Verbindung mit der Physiker-Gruppe des Physikalisch-Chemischen Instituts der Universität Innsbruck, die 1944 nach Wattens zur Firma Swarovsky verlegt wurde?	Karlsch: Did he stand in contact with the physicist group of the Physical-Chemical Institute of the University of Innsbruck, which was transferred to Swarovsky in Wattens in 1944?
Cap: Meinen Sie Frau Prof Erika Cremer, die im Krieg beim Berliner "URANVEREIN" war?	Cap: Do you mean Prof. Erika Cremer, who was in the Berlin "URANVEREIN" during the war?

20. B9 Quarz underground complex near Roggendorf and Melk, Austria

Figure D.508: One of the entrances to the B9 Quarz tunnels near Roggendorf and Melk, Austria that may have been involved in heavy water production [Schmitzberger 2004].

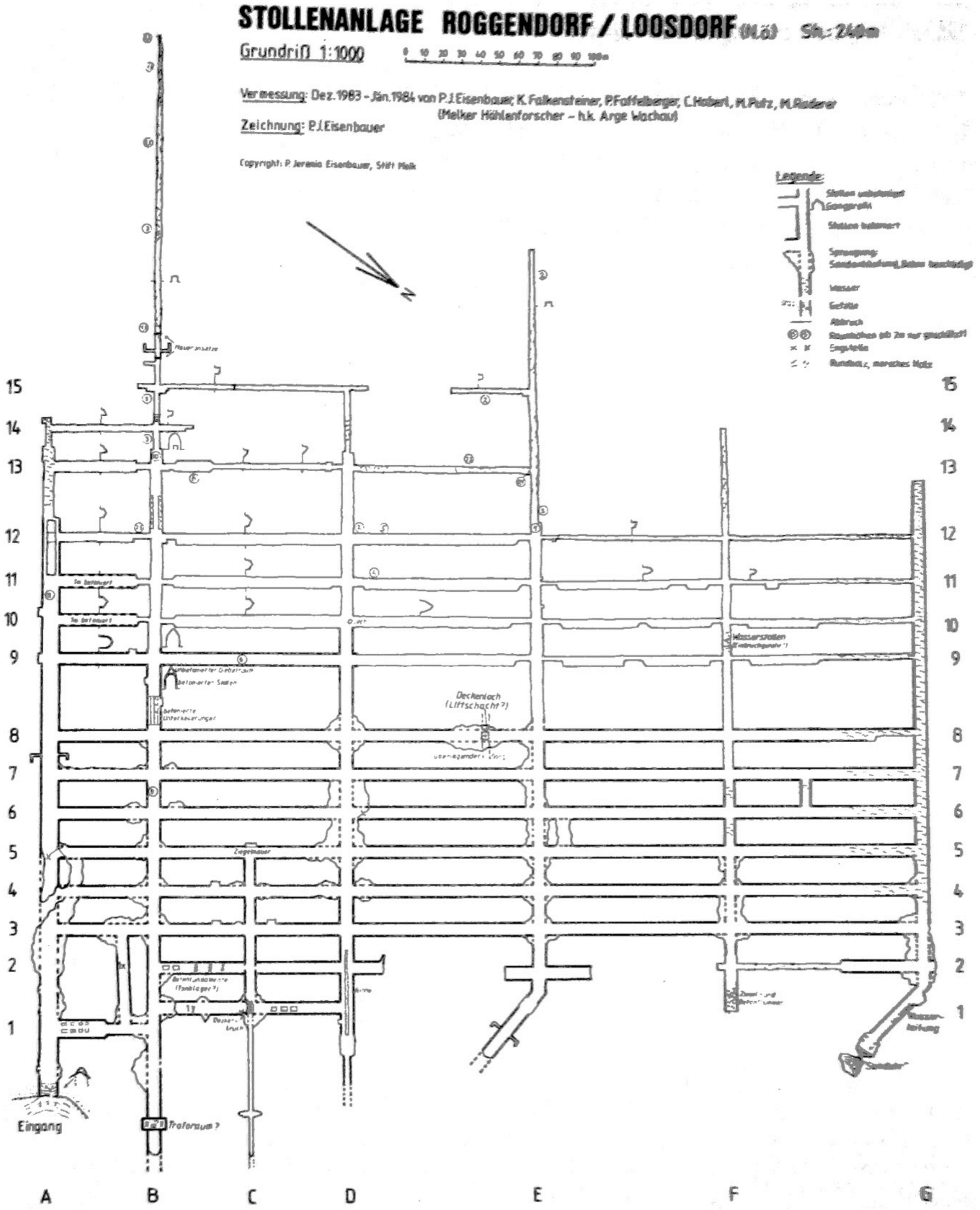


Figure D.509: Map of the B9 Quarz tunnels near Roggendorf and Melk, Austria that may have been involved in heavy water production [Schmitzberger 2004].

21. Degussa plant, Rheinfelden, Austria, and
22. Austrian Chemical Works plant, Weissenstein, Austria

R. W. Kirkman. 28 January 1944. Subject: Carl William Tucker [NARA RG 77, Entry UD-22A, Box 171, Folder 32.7003-1 GERMANY: US Wartime Positive Int. (July 42–June 44)]

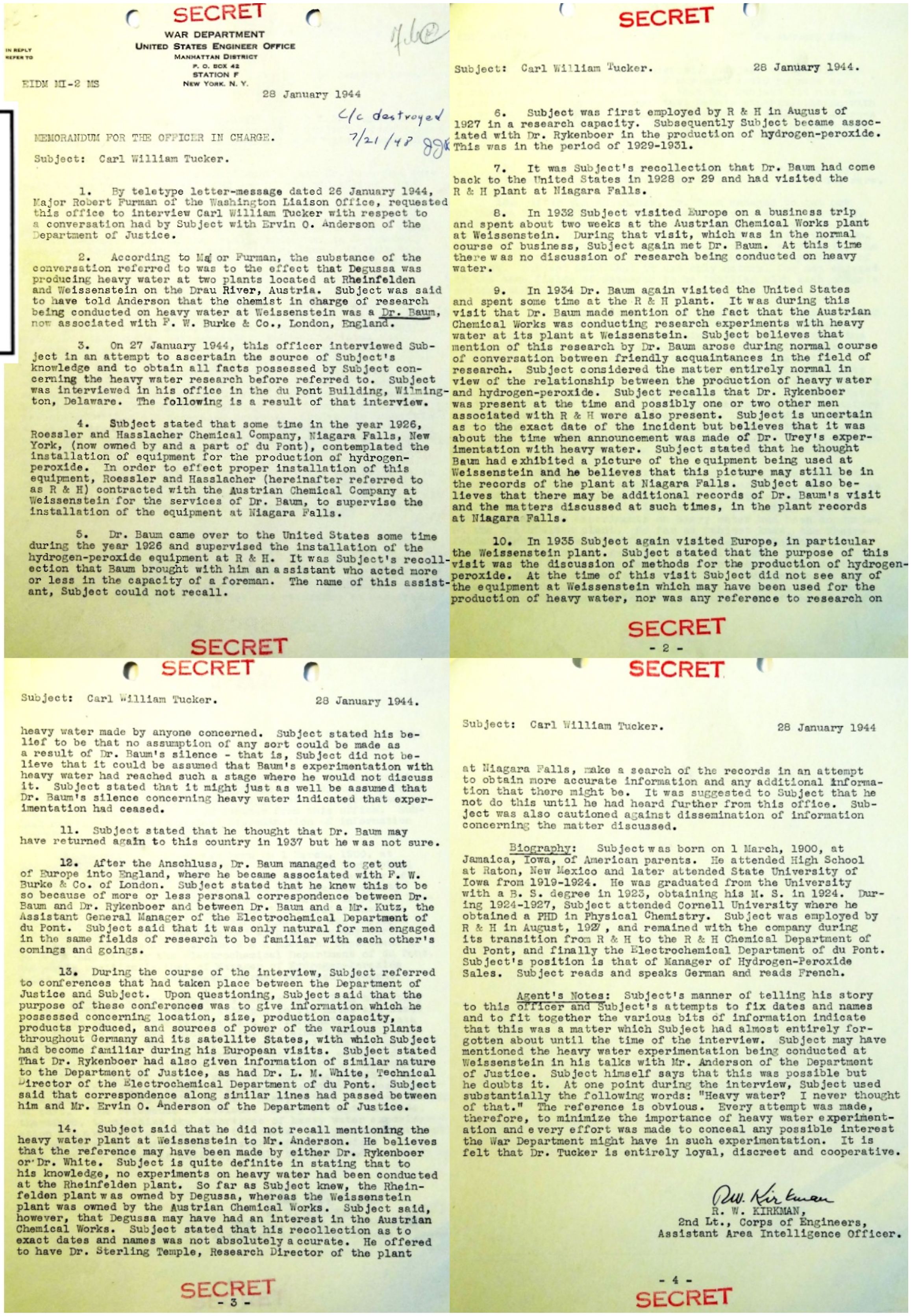
[...] 2. According to Major Furman, the substance of the conversation referred to was to the effect that Degussa was producing heavy water at two plants located at Rheinfelden and Weissenstein on the Drau River, Austria. Subject was said to have told Anderson that the chemist in charge of research being conducted on heavy water at Weissenstein was a Dr. Baum, now associated with F. W. Burke & Co., London, England.

23. Siemens and Halske plant in Lehesten

Monthly Intelligence Summary. February 1945. [NARA RG 77, Entry UD-22A, Box 168, Folder 202.3-1 LONDON OFFICE: Combined Intell Rpts.]

An OSS report states that possible manufacture of long range projectiles is being carried on in a semi-underground installation about 1.5 K.M. north of Lehesten in Germany. T A [Tube Alloy, nuclear] interest in the report arises from the fact that Siemens and Halske are said to be in charge of the plant, and a reference to the breaking down of water by electrolysis at this site. Aerial coverage has been requested.

[For more information, see pp. 3689, 3696.]



DECLASSIFIED
Authority NND 917017

NARA RG 77, Entry UD-22A, Box 171, Folder 32.7003-1
GERMANY: US Wartime Positive Int. (July 42–June 44)

SECRET

WAR DEPARTMENT
UNITED STATES ENGINEER OFFICE
MANHATTAN DISTRICT
P. O. BOX 42
STATION F
NEW YORK, N. Y.

IN REPLY REFER TO
EIDM MI-2 MS

7.6

28 January 1944

C/c destroyed 7/21/48

MEMORANDUM FOR THE OFFICER IN CHARGE.

Subject: Carl William Tucker.

1. By teletype letter-message dated 26 January 1944, Major Robert Furman of the Washington Liaison Office, requested this office to interview Carl William Tucker with respect to a conversation had by Subject with Ervin O. Anderson of the Department of Justice.

2. According to Major Furman, the substance of the conversation referred to was to the effect that Degussa was producing heavy water at two plants located at Rheinfelden and Weissenstein on the Drau River, Austria. Subject was said to have told Anderson that the chemist in charge of research being conducted on heavy water at Weissenstein was a Dr. Baum, now associated with F. W. Burke & Co., London, England.

3. On 27 January 1944, this officer interviewed Subject in an attempt to ascertain the source of Subject's knowledge and to obtain all facts possessed by Subject concerning the heavy water research before referred to. Subject was interviewed in his office in the du Pont Building, Wilmington, Delaware. The following is a result of that interview.

4. Subject stated that some time in the year 1926, Roessler and Hasslacher Chemical Company, Niagara Falls, New York, (now owned by and a part of du Pont), contemplated the installation of equipment for the production of hydrogen-peroxide. In order to effect proper installation of this equipment, Roessler and Hasslacher (hereinafter referred to as R & H) contracted with the Austrian Chemical Company at Weissenstein for the services of Dr. Baum, to supervise the installation of the equipment at Niagara Falls.

5. Dr. Baum came over to the United States some time during the year 1926 and supervised the installation of the hydrogen-peroxide equipment at R & H. It was Subject's recollection that Baum brought with him an assistant who acted more or less in the capacity of a foreman. The name of this assistant, Subject could not recall.

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Subject: Carl William Tucker. 28 January 1944.

6. Subject was first employed by R & H in August of 1927 in a research capacity. Subsequently Subject became associated with Dr. Rykenboer in the production of hydrogen-peroxide. This was in the period of 1929-1931.

7. It was Subject's recollection that Dr. Baum had come back to the United States in 1928 or 29 and had visited the R & H plant at Niagara Falls.

8. In 1932 Subject visited Europe on a business trip and spent about two weeks at the Austrian Chemical Works plant at Weissenstein. During that visit, which was in the normal course of business, Subject again met Dr. Baum. At this time there was no discussion of research being conducted on heavy water.

9. In 1934 Dr. Baum again visited the United States and spent some time at the R & H plant. It was during this visit that Dr. Baum made mention of the fact that the Austrian Chemical Works was conducting research experiments with heavy water at its plant at Weissenstein. Subject believes that mention of this research by Dr. Baum arose during normal course of conversation between friendly acquaintances in the field of research. Subject considered the matter entirely normal in view of the relationship between the production of heavy water and hydrogen-peroxide. Subject recalls that Dr. Rykenboer was present at the time and possibly one or two other men associated with R & H were also present. Subject is uncertain as to the exact date of the incident but believes that it was about the time when announcement was made of Dr. Urey's experimentation with heavy water. Subject stated that he thought Baum had exhibited a picture of the equipment being used at Weissenstein and he believes that this picture may still be in the records of the plant at Niagara Falls. Subject also believes that there may be additional records of Dr. Baum's visit and the matters discussed at such times, in the plant records at Niagara Falls.

10. In 1935 Subject again visited Europe, in particular the Weissenstein plant. Subject stated that the purpose of this visit was the discussion of methods for the production of hydrogen-peroxide. At the time of this visit Subject did not see any of the equipment at Weissenstein which may have been used for the production of heavy water, nor was any reference to research on

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- 2 -

SECRET

Subject: Carl William Tucker. 28 January 1944.

heavy water made by anyone concerned. Subject stated his belief to be that no assumption of any sort could be made as a result of Dr. Baum's silence - that is, Subject did not believe that it could be assumed that Baum's experimentation with heavy water had reached such a stage where he would not discuss it. Subject stated that it might just as well be assumed that Dr. Baum's silence concerning heavy water indicated that experimentation had ceased.

11. Subject stated that he thought that Dr. Baum may have returned again to this country in 1937 but he was not sure.

12. After the Anschluss, Dr. Baum managed to get out of Europe into England, where he became associated with F. W. Burke & Co. of London. Subject stated that he knew this to be so because of more or less personal correspondence between Dr. Baum and Dr. Rykenboer and between Dr. Baum and a Mr. Kutz, the Assistant General Manager of the Electrochemical Department of du Pont. Subject said that it was only natural for men engaged in the same fields of research to be familiar with each other's comings and goings.

13. During the course of the interview, Subject referred to conferences that had taken place between the Department of Justice and Subject. Upon questioning, Subject said that the purpose of these conferences was to give information which he possessed concerning location, size, production capacity, products produced, and sources of power of the various plants throughout Germany and its satellite States, with which Subject had become familiar during his European visits. Subject stated That Dr. Rykenboer had also given information of similar nature to the Department of Justice, as had Dr. L. M. White, Technical Director of the Electrochemical Department of du Pont. Subject said that correspondence along similar lines had passed between him and Mr. Ervin O. Anderson of the Department of Justice.

14. Subject said that he did not recall mentioning the heavy water plant at Weissenstein to Mr. Anderson. He believes that the reference may have been made by either Dr. Rykenboer or Dr. White. Subject is quite definite in stating that to his knowledge, no experiments on heavy water had been conducted at the Rheinfelden plant. So far as Subject knew, the Rheinfelden plant was owned by Degussa, whereas the Weissenstein plant was owned by the Austrian Chemical Works. Subject said, however, that Degussa may have had an interest in the Austrian Chemical Works. Subject stated that his recollection as to exact dates and names was not absolutely accurate. He offered to have Dr. Sterling Temple, Research Director of the plant

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- 3 -

SECRET

Subject: Carl William Tucker. 28 January 1944

at Niagara Falls, make a search of the records in an attempt to obtain more accurate information and any additional information that there might be. It was suggested to Subject that he not do this until he had heard further from this office. Subject was also cautioned against dissemination of information concerning the matter discussed.

Biography: Subject was born on 1 March, 1900, at Jamaica, Iowa, of American parents. He attended High School at Raton, New Mexico and later attended State University of Iowa from 1919-1924. He was graduated from the University with a B. S. degree in 1923, obtaining his M. S. in 1924. During 1924-1927, Subject attended Cornell University where he obtained a PHD in Physical Chemistry. Subject was employed by R & H in August, 1927, and remained with the company during its transition from R & H to the R & H Chemical Department of du Pont, and finally the Electrochemical Department of du Pont. Subject's position is that of Manager of Hydrogen-Peroxide Sales. Subject reads and speaks German and reads French.

Agent's Notes: Subject's manner of telling his story to this officer and Subject's attempts to fix dates and names and to fit together the various bits of information indicate that this was a matter which Subject had almost entirely forgotten about until the time of the interview. Subject may have mentioned the heavy water experimentation being conducted at Weissenstein in his talks with Mr. Anderson of the Department of Justice. Subject himself says that this was possible but he doubts it. At one point during the interview, Subject used substantially the following words: "Heavy water? I never thought of that." The reference is obvious. Every attempt was made, therefore, to minimize the importance of heavy water experimentation and every effort was made to conceal any possible interest the War Department might have in such experimentation. It is felt that Dr. Tucker is entirely loyal, discreet and cooperative.

R. W. Kirkman
R. W. KIRKMAN,
2nd Lt., Corps of Engineers,
Assistant Area Intelligence Officer.

- 4 -
SECRET

Figure D.510: R. W. Kirkman. 28 January 1944. Subject: Carl William Tucker [NARA RG 77, Entry UD-22A, Box 171, Folder 32.7003-1 GERMANY: US Wartime Positive Int. (July 42–June 44)] “According to Major Furman, the substance of the conversation referred to was to the effect that Degussa was producing heavy water at two plants located at Rheinfelden and Weissenstein on the Drau River, Austria.”

24. Bayrische Stickstoffwerke in Piesteritz

H. W. Dix to Francis Smith. Subject: Heavy Water. 26 December 1944. [NARA RG 77, Entry UD-22A, Box 171, Folder 32.7003-3 GERMANY: US Wartime Positive Int. (Nov. 44–June 45)]

This office has received the following comments from our Swedish people and it is dated 22 November 1944 and has a B-2 rating.

> Heavy water is manufactured primarily in Norway by I. G. at Norsk Hydro. However, manufacture in Germany at the Bayrische Stickstoffwerke in Piesteritz or Auschwitz is certainly a possibility.

[For more information, see pp. 4452–4453.]

25. Pardubice/Wesser, Czechia

W. R. Shuler and David C. G. Gattiker. 28 February 1946. Memorandum for the period 17 January 1946 to 28 February 1946 [NARA RG 77, Entry UD-22A, Box 168, Folder 202.3-1 LONDON OFFICE: Combined Intell Rpts.]

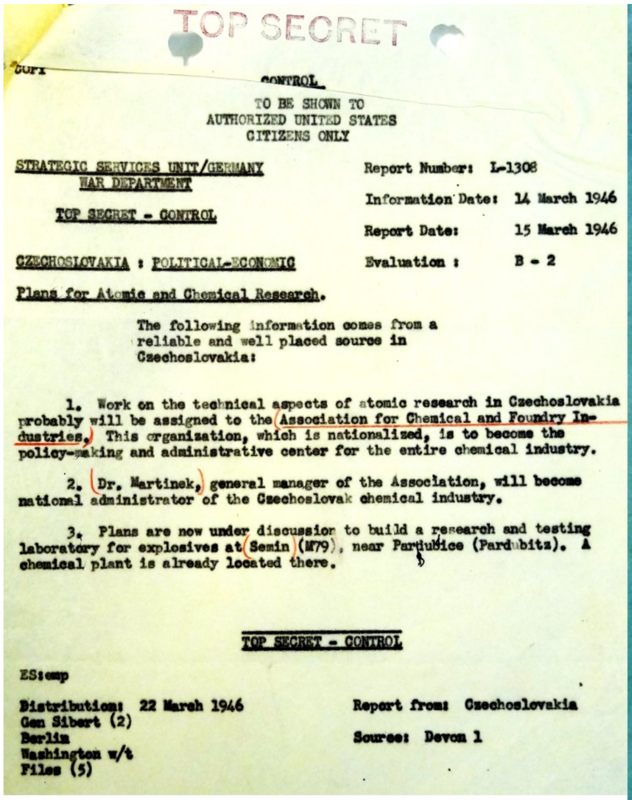
[...] 2. Heavy Water Plant at Wesser: A report has been received of an alleged heavy water plant at Wesser, 17 miles northeast of Pardubice, supposed to be operated by the Russians. Although this report seems unlikely, we would like London to investigate further if possible.

[See document photos on p. 3446. It is unclear exactly what site was meant by "Wesser," but if it was a heavy water plant it was probably on the Elbe river or the Úpa river outside of Pardubice.]

Manhattan Engineering District Foreign Intelligence Unit. March–April 1946 reports on wartime German research facilities near Pardubice that may have been producing heavy water or doing other nuclear-related work [NARA RG 77, Entry UD-22A, Box 175, Folder World].

"Isn't Pardubice the place a heavy water plant was reported?"

[See document photos on p. 4083.]



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STRATEGIC SERVICES UNIT/GERMANY
WAR DEPARTMENT

TOP SECRET - CONTROL

Report Number: L-1308
Information Date: 14 March 1946
Report Date: 15 March 1946
Evaluation : B - 2

CZECHOSLOVAKIA : POLITICAL-ECONOMIC

Plans for Atomic and Chemical Research.

The following information comes from a reliable and well placed source in Czechoslovakia:

1. Work on the technical aspects of atomic research in Czechoslovakia probably will be assigned to the Association for Chemical and Foundry Industries. This organization, which is nationalized, is to become the policy-making and administrative center for the entire chemical industry.

2. Dr. Martinek, general manager of the Association, will become national administrator of the Czechoslovak chemical industry.

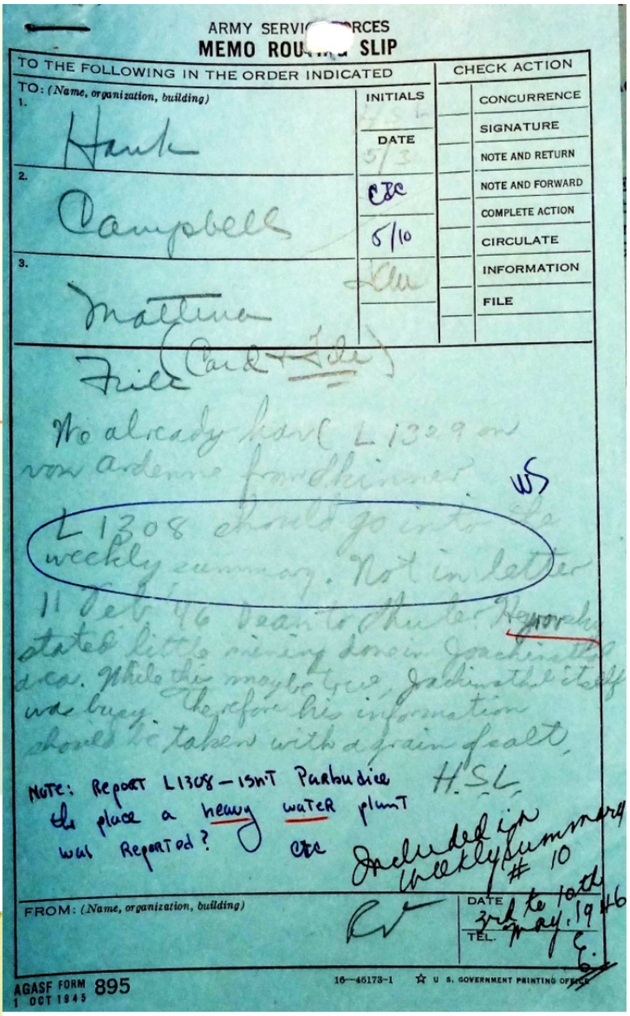
3. Plans are now under discussion to build a research and testing laboratory for explosives at Semin (M79), near Pardubice (Pardubitz). A chemical plant is already located there.

TOP SECRET - CONTROL

ES:emp

Distribution: 22 March 1946
Gen Sibert (2)
Berlin
Washington w/t
Files (5)

Report from: Czechoslovakia
Source: Devon 1



ARMY SERVICE FORCES
MEMO ROUTING SLIP

TO THE FOLLOWING IN THE ORDER INDICATED TO: (Name, organization, building)	INITIALS / DATE		CHECK ACTION
1. Hank	H.S.L. 5/3		CONCURRENCE
2. Campbell	CBC 5/10		SIGNATURE
3. Mattina	Jlu		NOTE AND RETURN
			NOTE AND FORWARD
			COMPLETE ACTION
			CIRCULATE
			INFORMATION
			FILE

File (Card + File)

We already have L 1329 on von Ardenne from Skinner. WS

L 1308 should go into the weekly summary. Not in letter

11 Feb 46 Dean to Shuler: Heyrovsky stated little mining done in Joachimsthal area. While this may be true, Joachimsthal itself was busy. Therefore his information should be taken with a grain of salt. H.S.L.

NOTE: Report L1308 – isn't Parbudice the place a heavy water plant was Reported? etc

Included in Weekly Summary # 10

FROM: (Name, organization, building)

DATE 3rd to 10th May. 1946 E.
TEL.

AGASF FORM 895
1 OCT 1945

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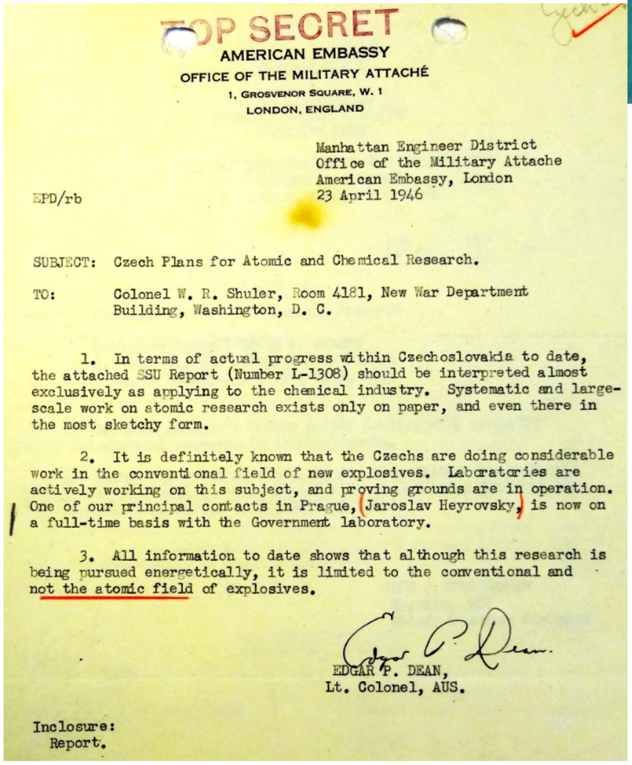


TOP SECRET

AMERICAN EMBASSY
OFFICE OF THE MILITARY ATTACHÉ
1, GROSVENOR SQUARE, W. 1
LONDON, ENGLAND

Manhattan Engineer District
Office of the Military Attache
American Embassy, London
23 April 1946

EPD/rb

SUBJECT: Czech Plans for Atomic and Chemical Research.

TO: Colonel W. R. Shuler, Room 4181, New War Department Building, Washington, D. C.

1. In terms of actual progress within Czechoslovakia to date, the attached SSU Report (Number L-1308) should be interpreted almost exclusively as applying to the chemical industry. Systematic and large-scale work on atomic research exists only on paper, and even there in the most sketchy form.

2. It is definitely known that the Czechs are doing considerable work in the conventional field of new explosives. Laboratories are actively working on this subject, and proving grounds are in operation. One of our principal contacts in Prague, Jaroslav Heyrovsky, is now on a full-time basis with the Government laboratory.

3. All information to date shows that although this research is being pursued energetically, it is limited to the conventional and not the atomic field of explosives.

Edgar P. Dean
EDGAR P. DEAN,
Lt. Colonel, AUS.

Inclosure:
Report.

DECLASSIFIED
Authority NND 917017

NARA RG 77, Entry UD-22A, Box 175, Folder World

Figure D.511: March–April 1946 reports on wartime German research facilities near Pardubice that may have been producing heavy water or doing other nuclear-related work [NARA RG 77, Entry UD-22A, Box 175, Folder World]. "Isn't Pardubice the place a heavy water plant was reported?" See the related report on p. 3446.

26. Other/unspecified heavy water plants

Major B. K. Hough, Jr. to Leslie R. Groves. 9 December 1943. [NARA RG 77, Entry UD-22A, Box 166, Folder 32.22-1—GERMANY—Research—TA—(1943–June 1946)]

[...] In discussing the possible status of German work on the heavy water pile, it was stated that Dr. Urey saw the Norwegian scientist, L. Tronstad, in London about October or November of 1941. It was reported then that the Germans were taking heavy water from Norwegian sources, and it appears likely that they may have performed the critical experiments on cross-section some time before it was done in America. In this connection, Dr. E. P. Wigner of Chicago mentioned to Dr. Urey that he has had reports of heavy water plants now in production in Germany.

[See document photo on p. 4085.]

Samuel Goudsmit to Robert R. Furman. 25 May 1945. [NARA RG GOUDS, Entry UD-7420, Box 6, Folder ALSOS—Reports and Operations]

1. Attached is the RFR correspondence, mainly on Heavy Water and centrifuge installations.

2. Interesting remark on Clusius' letter to Gerlach, 12 February 1945, on bombing of Heavy Water installations.

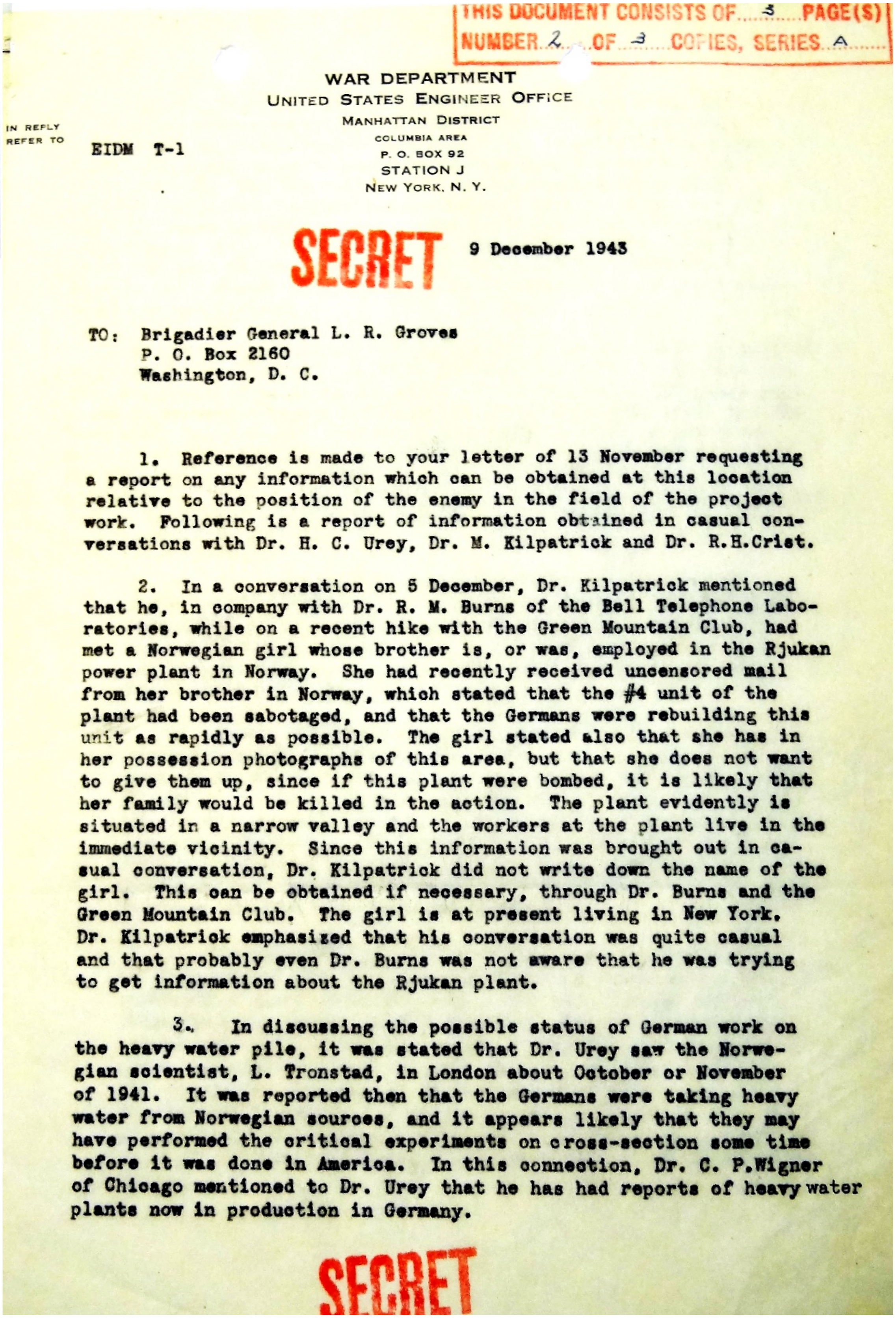
3. Most important are the minutes of the meeting in Stadtilm on 6 February 1945 and the letter at the end of 24 April 1939 about the foundation. The latter is the subject of another report.

4. This file contains intelligence information and should be kept in Paris until further notice.

[See document photo on p. 4086.]

DECLASSIFIED
Authority NND 917017

NARA RG 77, Entry UD-22A, Box 166, Folder 32.22-1--GERMANY--Research--TA--(1943-June 1946)



THIS DOCUMENT CONSISTS OF 3 PAGE(S)
NUMBER 2 OF 3 COPIES, SERIES A

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UNITED STATES ENGINEER OFFICE
MANHATTAN DISTRICT
COLUMBIA AREA
P. O. BOX 92
STATION J
NEW YORK, N. Y.

IN REPLY REFER TO EIDM T-1

SECRET

9 December 1943

TO: Brigadier General L. R. Groves
P. O. Box 2160
Washington, D. C.

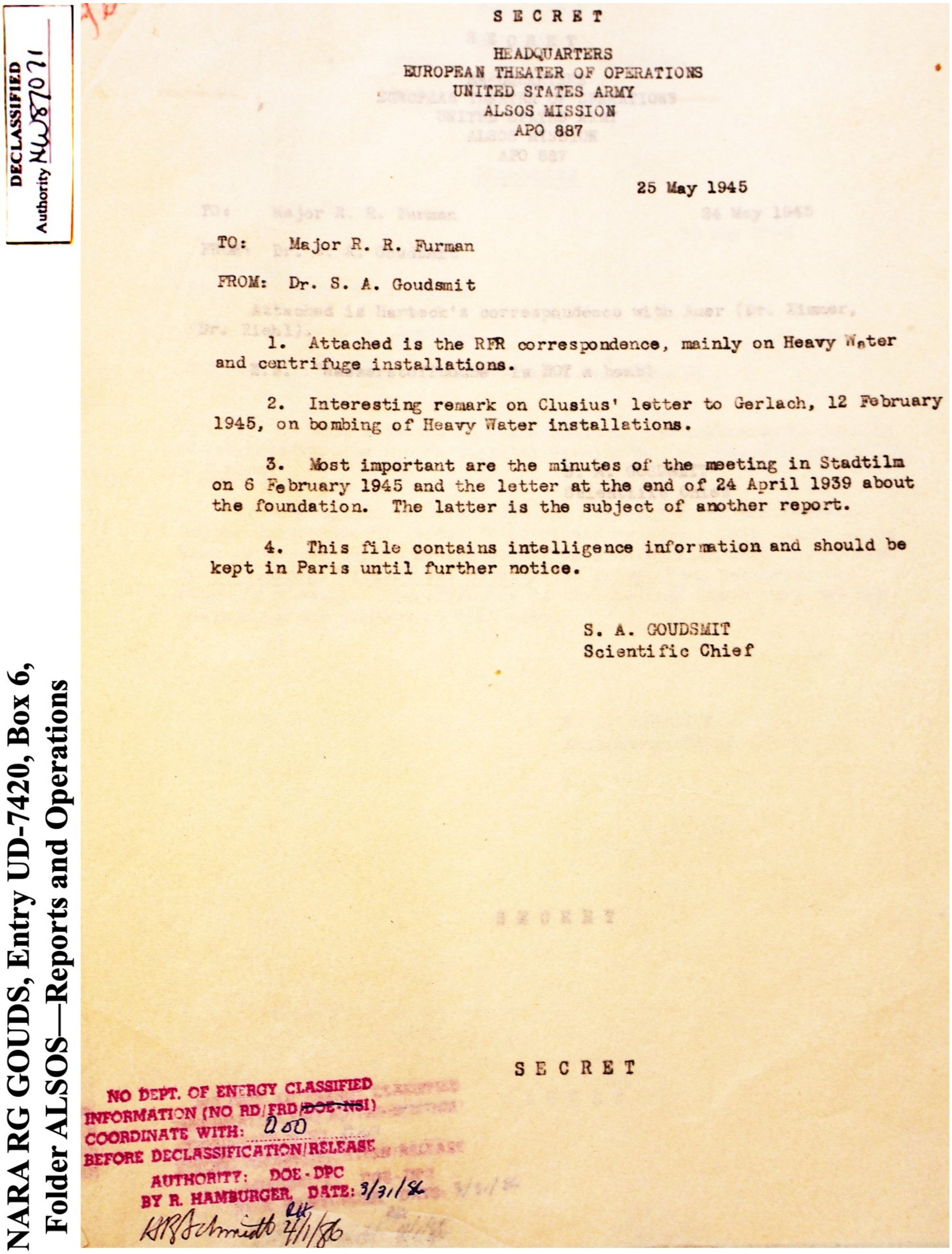
1. Reference is made to your letter of 13 November requesting a report on any information which can be obtained at this location relative to the position of the enemy in the field of the project work. Following is a report of information obtained in casual conversations with Dr. H. C. Urey, Dr. M. Kilpatrick and Dr. R.H.Crist.

2. In a conversation on 5 December, Dr. Kilpatrick mentioned that he, in company with Dr. R. M. Burns of the Bell Telephone Laboratories, while on a recent hike with the Green Mountain Club, had met a Norwegian girl whose brother is, or was, employed in the Rjukan power plant in Norway. She had recently received uncensored mail from her brother in Norway, which stated that the #4 unit of the plant had been sabotaged, and that the Germans were rebuilding this unit as rapidly as possible. The girl stated also that she has in her possession photographs of this area, but that she does not want to give them up, since if this plant were bombed, it is likely that her family would be killed in the action. The plant evidently is situated in a narrow valley and the workers at the plant live in the immediate vicinity. Since this information was brought out in casual conversation, Dr. Kilpatrick did not write down the name of the girl. This can be obtained if necessary, through Dr. Burns and the Green Mountain Club. The girl is at present living in New York. Dr. Kilpatrick emphasized that his conversation was quite casual and that probably even Dr. Burns was not aware that he was trying to get information about the Rjukan plant.

3. In discussing the possible status of German work on the heavy water pile, it was stated that Dr. Urey saw the Norwegian scientist, L. Tronstad, in London about October or November of 1941. It was reported then that the Germans were taking heavy water from Norwegian sources, and it appears likely that they may have performed the critical experiments on cross-section some time before it was done in America. In this connection, Dr. C. P.Wigner of Chicago mentioned to Dr. Urey that he has had reports of heavy water plants now in production in Germany.

SECRET

Figure D.512: Major B. K. Hough, Jr. to Leslie R. Groves. 9 December 1943. [NARA RG 77, Entry UD-22A, Box 166, Folder 32.22-1—GERMANY—Research—TA—(1943–June 1946)] "...about October or November of 1941. It was reported then that the Germans were taking heavy water from Norwegian sources, and it appears likely that they may have performed the critical experiments on cross-section some time before it was done in America. In this connection, Dr. E. P. Wigner of Chicago mentioned to Dr. Urey that he has had reports of heavy water plants now in production in Germany."



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Authority NW87071

S E C R E T

HEADQUARTERS
EUROPEAN THEATER OF OPERATIONS
UNITED STATES ARMY
ALSOS MISSION
APO 887

25 May 1945

TO: Major R. R. Furman

FROM: Dr. S. A. Goudsmit

1. Attached is the RFR correspondence, mainly on Heavy Water and centrifuge installations.

2. Interesting remark on Clusius' letter to Gerlach, 12 February 1945, on bombing of Heavy Water installations.

3. Most important are the minutes of the meeting in Stadtilm on 6 February 1945 and the letter at the end of 24 April 1939 about the foundation. The latter is the subject of another report.

4. This file contains intelligence information and should be kept in Paris until further notice.

S. A. GOUDSMIT
Scientific Chief

S E C R E T

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AUTHORITY: DOE-DPC
BY R. HAMBURGER DATE: 3/31/86

4/1/86

NARA RG GOUDS, Entry UD-7420, Box 6,
Folder ALSOS—Reports and Operations

Figure D.513: Samuel Goudsmit to Robert R. Furman. 25 May 1945 [NARA RG GOUDS, Entry UD-7420, Box 6, Folder ALSOS—Reports and Operations]. “1. Attached is the RFR correspondence, mainly on Heavy Water and centrifuge installations. 2. Interesting remark on Clusius’ letter to Gerlach, 12 February 1945, on bombing of Heavy Water installations. 3. Most important are the minutes of the meeting in Stadtilm on 6 February 1945 and the letter at the end of 24 April 1939 about the foundation. The latter is the subject of another report. 4. This file contains intelligence information and should be kept in Paris until further notice.”

Samuel Goudsmit to Robert R. Furman. 21 May 1945. [NARA RG GOUDS, Entry UD-7420, Box 6, Folder ALSOS—Reports and Operations] [See photo on p. 4088.]

The interest of the SS in nuclear physics is obvious from a letter sent to Harteck as late as the 2nd of April, 1945. This letter is written by an SS Gruppenführer and Generalleutnant der Waffen SS. It comes from the Technical Bureau VIII FEP (probably research development patents) of the SS Führungshauptamt.

The text of the letter is to the effect that the General, whose name is illegible (probably starting with Sp) has ordered SS Standartenoberjunker H. Clasen to accelerate his work on the production of heavy water. For this reason, he asked Harteck, the leader of the heavy water group, to take him into his institute because this work could not easily be continued at the SS institute.

The original address in Berlin is blocked out of the letterhead. The new address is not given, but the mail address is Trebbin Krs. Teltow. [...]

P.S. 22 May 1945—I have today found out that the above mentioned General's name is Schwab.

Samuel A. Goudsmit. 15 June 1945. SUBJECT: Importance Attached to Harteck's Heavy Water Method. [NARA RG 77, Entry UD-22A, Box 166, Folder 32.22-1 GERMANY—Research—TA—(1943–June 1946)]. [See document photo on p. 4089.]

1. The enclosed letters came from the files of the Reichsforschungsrat. They are recent and again show the importance which the Germans placed upon the TA project.

2. First of all, there is a letter from Gerlach to Colonel Geist of the Speer Ministry. The letter is dated December 16, 1944. Here he tells about Harteck's new way of producing heavy water and that they expect to get three tons a year, the cost of the installation to be about 1,300,000 marks. The personnel consists of one engineer, three technicians and twelve laborers, and the price of the ultimate product is estimated at 20 pfennigs a gram. He requests Geist to give permission for proceeding with the production preparation at the highest priority A copy of this letter was sent by Dr. Graue, an administrator in the RFR, to the SS-Standartenführer Sievers, the SS representative in the RFR. An interesting passage is marked in the original of the covering letter. A rough translation is as follows:

> "With this (new procedure) we shall increase further the advantage which we have over the Americans. According to Professor Gerlach, the work in Germany has progressed so far that one may already count upon the possibility of practical results in the near future. You are aware that this would pave the way for a revolution in the whole field of technology and economy. Even if one disregards the possibility of an eventual war application, the support of this work is, nevertheless, absolutely essential."

3. Sievers, in turn, sent a copy of Gerlach's letter to Dr. Ing. Kammler (who was a Lt. General of the Waffen-SS in charge of armaments). In this letter, he literally copied the marked passage of Graue's letter and proposed that the work be done in a cave near Helmstedt because there was slave labor there already.

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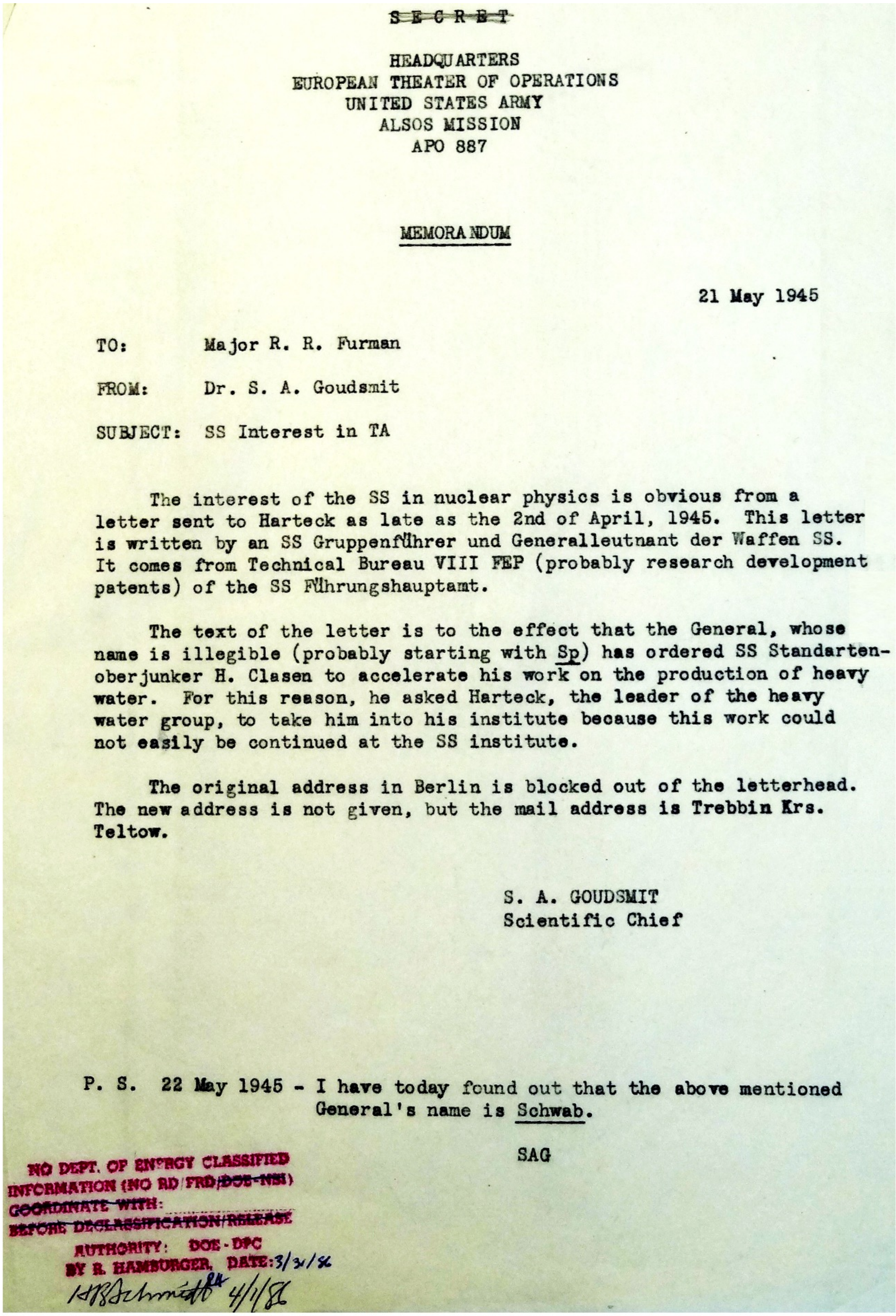
Authority NND 933079



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HEADQUARTERS
EUROPEAN THEATER OF OPERATIONS
UNITED STATES ARMY
ALSOS MISSION
APO 887

MEMORANDUM

21 May 1945

TO: Major R. R. Furman

FROM: Dr. S. A. Goudsmit

SUBJECT: SS Interest in TA

The interest of the SS in nuclear physics is obvious from a letter sent to Harteck as late as the 2nd of April, 1945. This letter is written by an SS Gruppenführer und Generalleutnant der Waffen SS. It comes from Technical Bureau VIII FEP (probably research development patents) of the SS Führungshauptamt.

The text of the letter is to the effect that the General, whose name is illegible (probably starting with Sp) has ordered SS Standartenoberjunker H. Clasen to accelerate his work on the production of heavy water. For this reason, he asked Harteck, the leader of the heavy water group, to take him into his institute because this work could not easily be continued at the SS institute.

The original address in Berlin is blocked out of the letterhead. The new address is not given, but the mail address is Trebbin Krs. Teltow.

S. A. GOUDSMIT
Scientific Chief

P. S. 22 May 1945 - I have today found out that the above mentioned General's name is Schwab.

SAG

NO DEPT. OF ENERGY CLASSIFIED INFORMATION (NO RD/FRD/~~DOE-NSI~~)
~~COORDINATE WITH:~~
~~BEFORE DECLASSIFICATION/RELEASE~~
AUTHORITY: DOE-DPC
BY R. HAMBURGER, DATE: 3/31/86
4/1/86

NARA RG GOUDS, Entry UD-7420, Box 6, Folder ALSOS—Reports and Operations

Figure D.514: Samuel Goudsmit to Robert R. Furman. 21 May 1945 [NARA RG GOUDS, Entry UD-7420, Box 6, Folder ALSOS—Reports and Operations]. “The interest of the SS in nuclear physics is obvious from a letter sent to Harteck as late as the 2nd of April, 1945... It comes from the Technical Bureau VIII FEP... The text of the letter is to the effect that the General... has ordered SS Standartenoberjunker H. Clasen to accelerate his work on the production of heavy water... General’s name is Schwab.”

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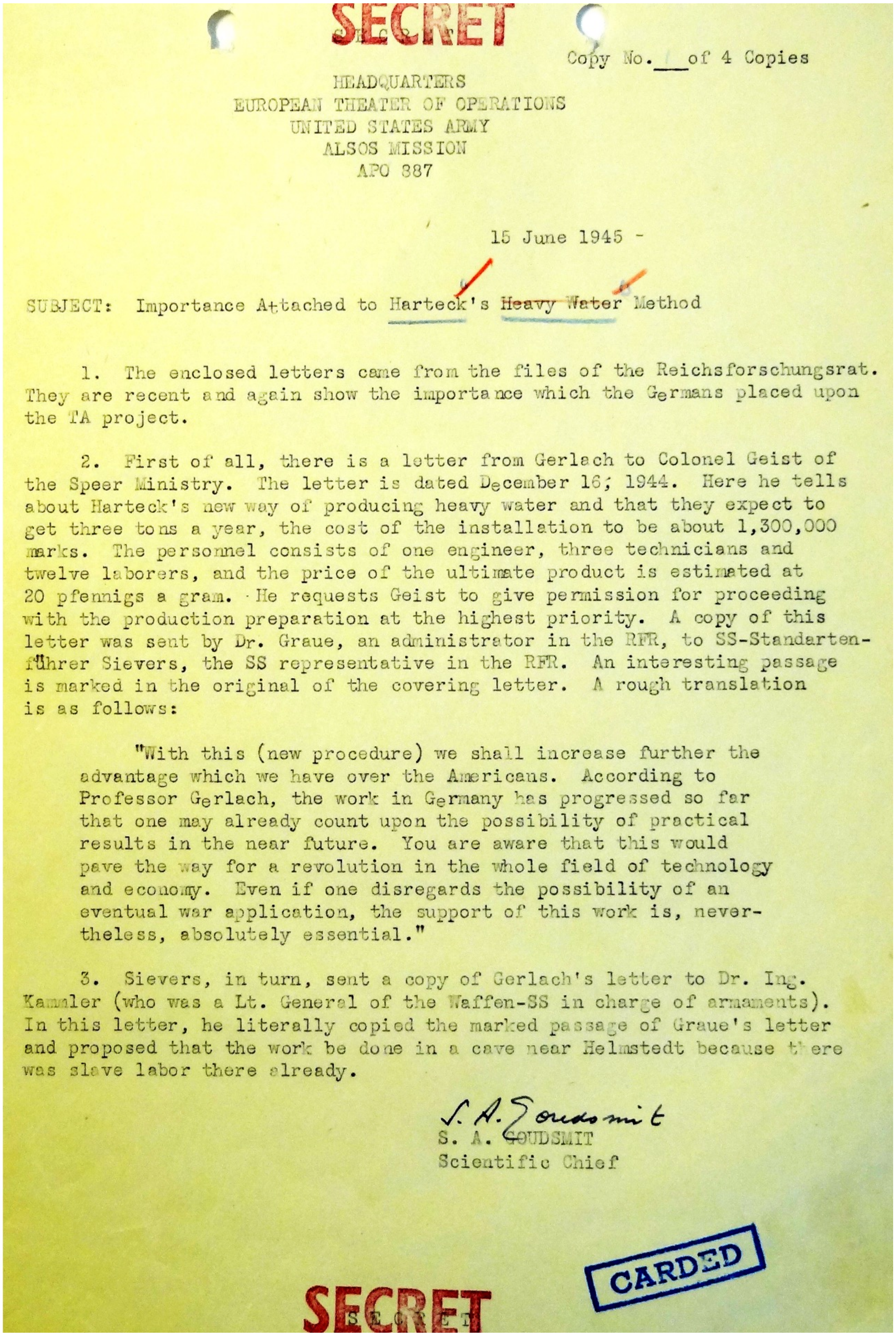
NARA RG 77, Entry UD-22A, Box 166, Folder 32.22-1
GERMANY—Research—TA—(1943--June 1946)



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HEADQUARTERS
EUROPEAN THEATER OF OPERATIONS
UNITED STATES ARMY
ALSOS MISSION
APO 887

15 June 1945 -

SUBJECT: Importance Attached to Harteck's Heavy Water Method

1. The enclosed letters came from the files of the Reichsforschungsrat. They are recent and again show the importance which the Germans placed upon the TA project.

2. First of all, there is a letter from Gerlach to Colonel Geist of the Speer Ministry. The letter is dated December 16, 1944. Here he tells about Harteck's new way of producing heavy water and that they expect to get three tons a year, the cost of the installation to be about 1,300,000 marks. The personnel consists of one engineer, three technicians and twelve laborers, and the price of the ultimate product is estimated at 20 pfennigs a gram. He requests Geist to give permission for proceeding with the production preparation at the highest priority. A copy of this letter was sent by Dr. Graue, an administrator in the RFR, to SS-Standartenführer Sievers, the SS representative in the RFR. An interesting passage is marked in the original of the covering letter. A rough translation is as follows:

> "With this (new procedure) we shall increase further the advantage which we have over the Americans. According to Professor Gerlach, the work in Germany has progressed so far that one may already count upon the possibility of practical results in the near future. You are aware that this would pave the way for a revolution in the whole field of technology and economy. Even if one disregards the possibility of an eventual war application, the support of this work is, nevertheless, absolutely essential."

3. Sievers, in turn, sent a copy of Gerlach's letter to Dr. Ing. Kammler (who was a Lt. General of the Waffen-SS in charge of armaments). In this letter, he literally copied the marked passage of Graue's letter and proposed that the work be done in a cave near Helmstedt because there was slave labor there already.

S. A. Goudsmit
S. A. GOUDSMIT
Scientific Chief

CARDED

SECRET

Figure D.515: Samuel A. Goudsmit. 15 June 1945. SUBJECT: Importance Attached to Harteck's Heavy Water Method. [NARA RG 77, Entry UD-22A, Box 166, Folder 32.22-1 GERMANY—Research—TA—(1943–June 1946)]. See also p. 4088. "The enclosed letters... again show the importance which the Germans placed upon the TA project... There is a letter from Gerlach to Colonel Geist of the Speer Ministry... dated December 16, 1944. Here he tells about Harteck's new way of producing heavy water... Sievers, in turn, sent a copy of Gerlach's letter to Dr. Ing. Kammler (who was a Lt. General of the Waffen-SS in charge of armaments)... and proposed that the work be done in a cave near Helmstedt because there was slave labor there already."

B. Lithium

[Lithium was used for processing ceramics, glass, and metals, but it would also have been extremely useful for producing tritium, neutrons, and/or fusion reactions. The following documents demonstrate large-scale production of lithium, as well as shipment of a large amount of lithium to Japan (along with other nuclear-related materials).

For documentation about wartime German separation of lithium isotopes, for which the only significant applications would be nuclear-related, see p. 4344.]

FIAT 295. *Lithium Extraction and Uses.* p. 9.

[...] Metallgesellschaft produced in 1942:

11637	kilograms	Lithium from	Lithium Mica
1702	”	”	Amblygonite in form of

	1942	1941.
Lithium Carbonate	18987 kgr.	12130 kgr.
Lithium Chloride	12630 ”	13725 ”
Lithium Hydroxide	40506 ”	38003 ”
Lithium Metal	1230 ”	505 ”

Lithium Carbonate and Hydroxide were sold to Merck and other chemical concerns to make medical salts, and Lithium Fluoride. Lithium Hydroxide is also used for storage to batteries. All the Lithium Chloride was used entirely for making Lithium metal. [...]

The amount of Lithium mica received from Metallgesellschaft were:

Year	Tons
1943	530
1st half 1944	293
July-Sept 1944	149

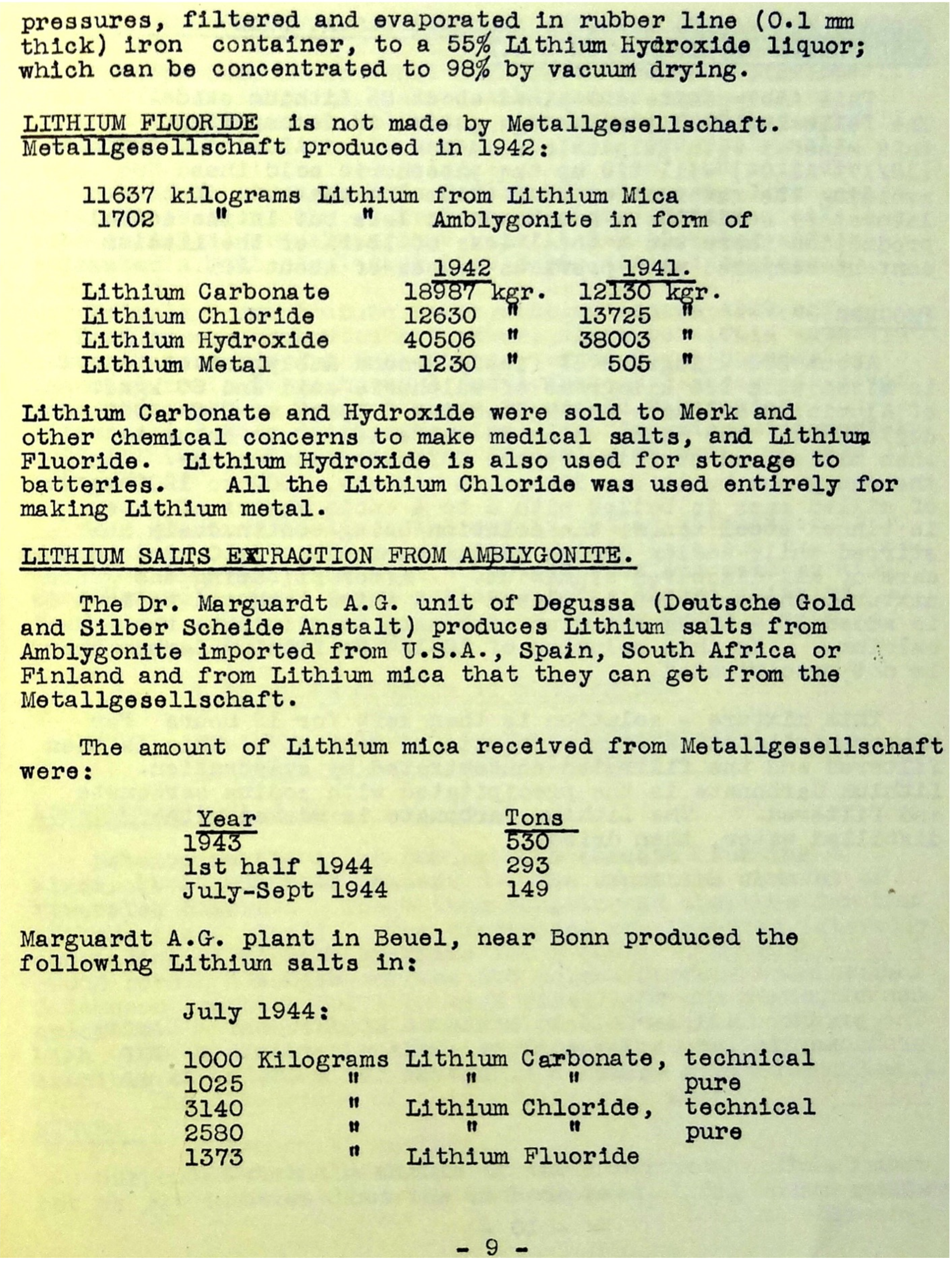
Marguardt A.G. plant in Beuel, near Bonn produced the following Lithium salts in:

July 1944:

1000	Kilograms	Lithium Carbonate,	technical
1025	”	” ”	pure
3140	”	Lithium Chloride,	technical
2580	”	” ”	pure
1373	”	Lithium Fluoride	

[See document photo on p. 4091.]

FIAT 295. ***Lithium Extraction and Uses*****, p. 9**



pressures, filtered and evaporated in rubber line (0.1 mm thick) iron container, to a 55% Lithium Hydroxide liquor; which can be concentrated to 98% by vacuum drying.

LITHIUM FLUORIDE is not made by Metallgesellschaft. Metallgesellschaft produced in 1942:

11637 kilograms Lithium from Lithium Mica
1702 " " Amblygonite in form of

	1942	1941.
Lithium Carbonate	18987 kgr.	12130 kgr.
Lithium Chloride	12630 "	13725 "
Lithium Hydroxide	40506 "	38003 "
Lithium Metal	1230 "	505 "

Lithium Carbonate and Hydroxide were sold to Merk and other chemical concerns to make medical salts, and Lithium Fluoride. Lithium Hydroxide is also used for storage to batteries. All the Lithium Chloride was used entirely for making Lithium metal.

LITHIUM SALTS EXTRACTION FROM AMBLYGONITE.

The Dr. Marguardt A.G. unit of Degussa (Deutsche Gold and Silber Scheide Anstalt) produces Lithium salts from Amblygonite imported from U.S.A., Spain, South Africa or Finland and from Lithium mica that they can get from the Metallgesellschaft.

The amount of Lithium mica received from Metallgesellschaft were:

Year	Tons
1943	530
1st half 1944	293
July-Sept 1944	149

Marguardt A.G. plant in Beuel, near Bonn produced the following Lithium salts in:

July 1944:

1000 Kilograms	Lithium Carbonate,	technical
1025 "	" "	pure
3140 "	Lithium Chloride,	technical
2580 "	" "	pure
1373 "	Lithium Fluoride	

- 9 -

Figure D.516: FIAT 295. *Lithium Extraction and Uses.* p. 9.

FIAT 750. *Rare and Minor Metals.* pp. 8–9.

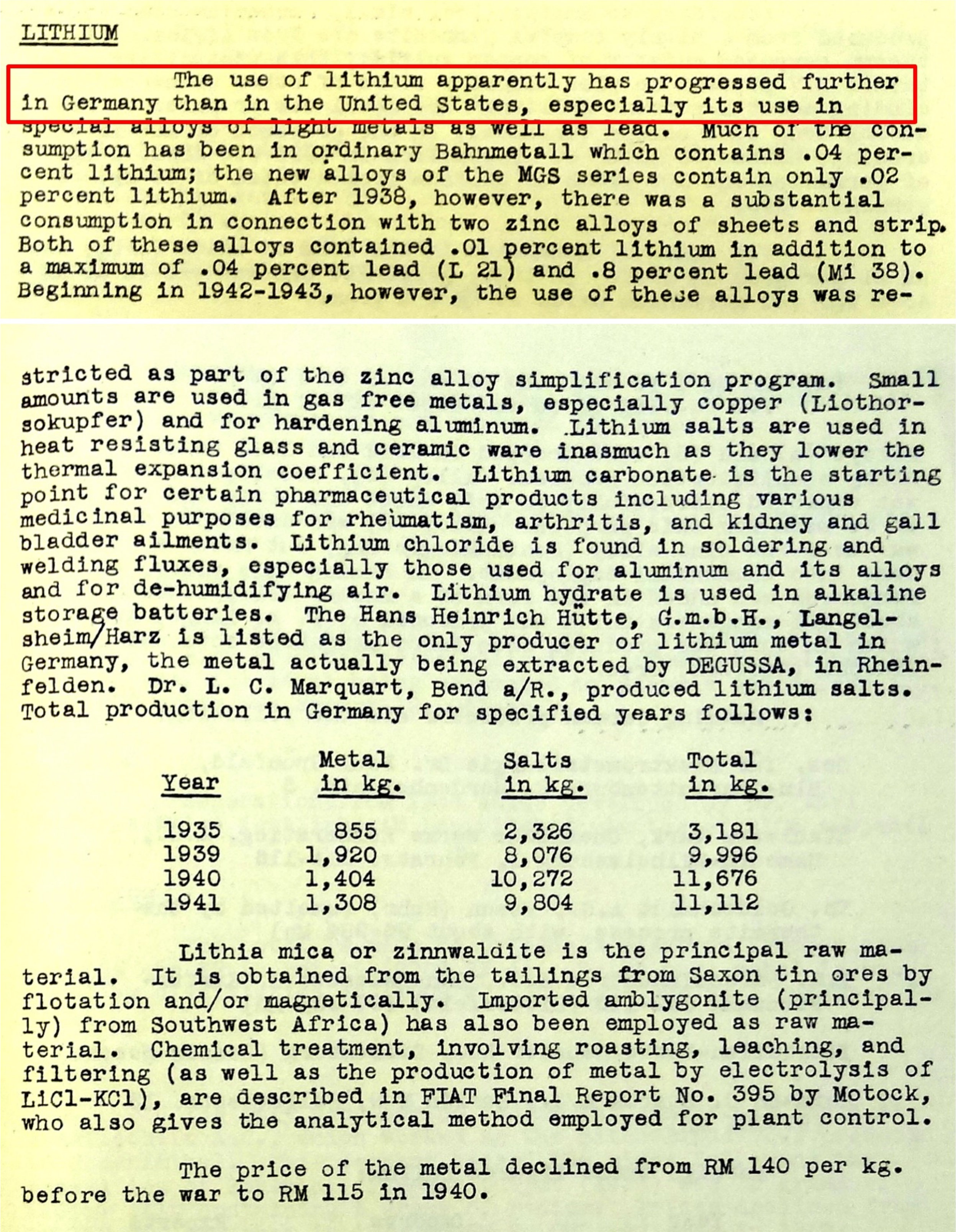
The use of lithium apparently has progressed further in Germany than in the United States, especially its use in special alloys of light metals as well as lead. [...] Lithium salts are used in heat resisting glass and ceramic ware inasmuch as they lower the thermal expansion coefficient. Lithium carbonate is the starting point for certain pharmaceutical products[...] Lithium chloride is found in soldering and welding fluxes[...] Lithium hydrate is used in alkaline storage batteries. [...] Total production in Germany for specified years follows:

Year	Metal in kg.	Salts in kg.	Total in kg.
1935	855	2,326	3,181
1939	1,920	8,076	9,996
1940	1,404	10,272	11,676
1941	1,308	9,804	11,112

[...] The price of the metal declined from RM 140 per kg. before the war to RM 115 in 1940.

[See document photo on p. 4093.]

FIAT 750. *Rare and Minor Metals*, pp. 8-9



LITHIUM

The use of lithium apparently has progressed further in Germany than in the United States, especially its use in special alloys of light metals as well as lead. Much of the consumption has been in ordinary Bahnmetall which contains .04 percent lithium; the new alloys of the MGS series contain only .02 percent lithium. After 1938, however, there was a substantial consumption in connection with two zinc alloys of sheets and strip. Both of these alloys contained .01 percent lithium in addition to a maximum of .04 percent lead (L 21) and .8 percent lead (Mi 38). Beginning in 1942-1943, however, the use of these alloys was restricted as part of the zinc alloy simplification program. Small amounts are used in gas free metals, especially copper (Liothorsokupfer) and for hardening aluminum. Lithium salts are used in heat resisting glass and ceramic ware inasmuch as they lower the thermal expansion coefficient. Lithium carbonate is the starting point for certain pharmaceutical products including various medicinal purposes for rheumatism, arthritis, and kidney and gall bladder ailments. Lithium chloride is found in soldering and welding fluxes, especially those used for aluminum and its alloys and for de-humidifying air. Lithium hydrate is used in alkaline storage batteries. The Hans Heinrich Hütte, G.m.b.H., Langelsheim/Harz is listed as the only producer of lithium metal in Germany, the metal actually being extracted by DEGUSSA, in Rheinfelden. Dr. L. C. Marquart, Bend a/R., produced lithium salts. Total production in Germany for specified years follows:

Year	Metal in kg.	Salts in kg.	Total in kg.
1935	855	2,326	3,181
1939	1,920	8,076	9,996
1940	1,404	10,272	11,676
1941	1,308	9,804	11,112

Lithia mica or zinnwaldite is the principal raw material. It is obtained from the tailings from Saxon tin ores by flotation and/or magnetically. Imported amblygonite (principally) from Southwest Africa) has also been employed as raw material. Chemical treatment, involving roasting, leaching, and filtering (as well as the production of metal by electrolysis of LiCl-KCl), are described in FIAT Final Report No. 395 by Motock, who also gives the analytical method employed for plant control.

The price of the metal declined from RM 140 per kg. before the war to RM 115 in 1940.

Figure D.517: FIAT 750. *Rare and Minor Metals.* pp. 8–9.

Tokyo to Berlin ULTRA message 1443. 16 January 1945. [**Published in Henshall 2000, p. 57. What is the archival source of this document???**]

NAVAL SECTION
JNA 20 C/S 114/1/2/3
TOO 161920 January 1945
From: TOKYO
Action: BERLIN

ULTRA/ZIP/SJA/1443
MEW/535

Action: BWG [Chief Technical Superintendent].
From: CJR [Naval Technical Directorate].

Your secret telegram No. 848 [SJA/1358: enquires what cargo is to be shipped in submarines proceeding to the Far East].

It is desired to obtain the following material urgently by means of the German transport submarines proceeding to Japan.

2. For Department No. 3: [This line is typed differently than the rest, and there is some blank space here. Was information deleted here, and if so by whom?]

1) Diamond dies (diameter between 0.02 and 0.08 mm., as large a quantity as possible of all kinds).

2) Metallic zirconium (500 kg of a standard of 99.5 per cent or over).

3) Metallic lithium, 500 kg.

4) Neon gas (as much as possible).

5) Insulating material for ultra high frequencies, 10 kg of each kind.

6) 2,000 or more [HASPEKERNE, ? clamp cores].

[Clamp cores/nuclear, or nuclear/core clamps?]

3. For Department No. 5:

1) As many BOSCH fuel pumps models 10 and 6 as possible.

2) 1 polarizing microscope.

3) 10 cam shaft grinders.

4) 10 MAAG gear wheel grinders.

[Were there other related messages? Since zirconium and lithium seem like materials for nuclear work, are the other materials for "Department No. 3" also related to nuclear work? What exactly were the "HASPEKERNE" [Henshall 2000, pp. 56–58]?]

For more information on wartime lithium production and applications, see:

BIOS 1356. *Grinding and Treatment of Minerals.* [Lithium production]

FIAT 786. *The Lithium Electrolytic Cell. (Degussa, Rheinfelde.)*

C. Beryllium

[Beryllium was used for producing certain metal alloys, but it also could have been quite useful as a neutron reflector and multiplier in a fission reactor, electronuclear breeding system, or fission bomb. The following documents illustrate that wartime production of beryllium was sophisticated and on a large scale.]

John E. Vance to Francis J. Smith. 17 July 1945. [NARA RG 77, Entry UD-22A, Box 163, Folder Australia]

1. Major Kelley stated that Madison Square Area had been called upon to furnish increased quantities of beryllium metal. The single source of beryllium metal at this time is the Brush Beryllium Company of Cleveland, Ohio, whose facilities are to be enlarged. However, to assist in meeting the requirements, Major Kelley suggested that it would be extremely valuable if it were possible to acquire beryllium metal discovered in Germany.

2. To be useful to use, the metal should be massive, i.e., should be in pieces rather than in flakes and should contain more than 90% beryllium; it would probably not be advisable to place other specifications on the metal.

H. S. Lowenhaupt to Francis J. Smith. 19 July 1945. [NARA RG 77, Entry UD-22A, Box 163, Folder Australia]

A cable to Major F. J. Smith, 17 May states that considerable beryllium was found in Germany by the AT Group. Whereabouts of this metal is not known at present.

A bill from the files (from Deutsche Gold und Silber Scheideanstalt Vormals Roessler, Degussa, Frankfort am Main, 7 May 1943 to the Heereswaffenamt, Berlin) is for 100 plates made of beryllium or 27.848 kg. at 140.20 marks per kg.

I suggest this firm be contacted by our people to see if they can still supply metallic beryllium, either through purchase, or as plunder.

[See document photos on p. 4097. The U.S. nuclear weapons program needed more beryllium than was being produced in the United States. Postwar U.S. investigators discovered that highly suitable beryllium had been made in large quantities in Germany—and had been shipped to Erich Schumann's Army Ordnance Office (Heereswaffenamt) during the war. The investigators also discovered that "considerable" additional quantities of beryllium had been produced and had disappeared into even more mysterious projects: "Whereabouts of this metal is not known at present."]

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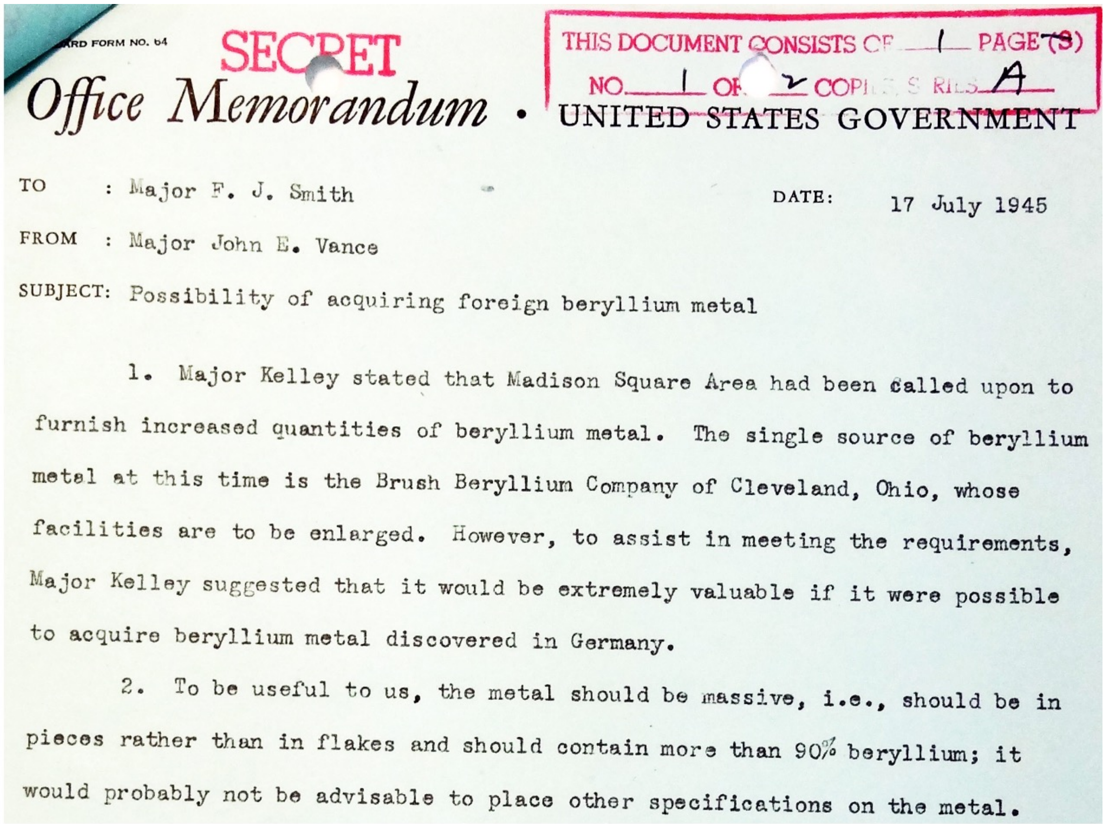
Authority NND 979017



RD FORM NO. 64

SECRET

THIS DOCUMENT CONSISTS OF 1 PAGE(S)
NO. 1 OF 2 COPIES, SERIES A

Office Memorandum • UNITED STATES GOVERNMENT

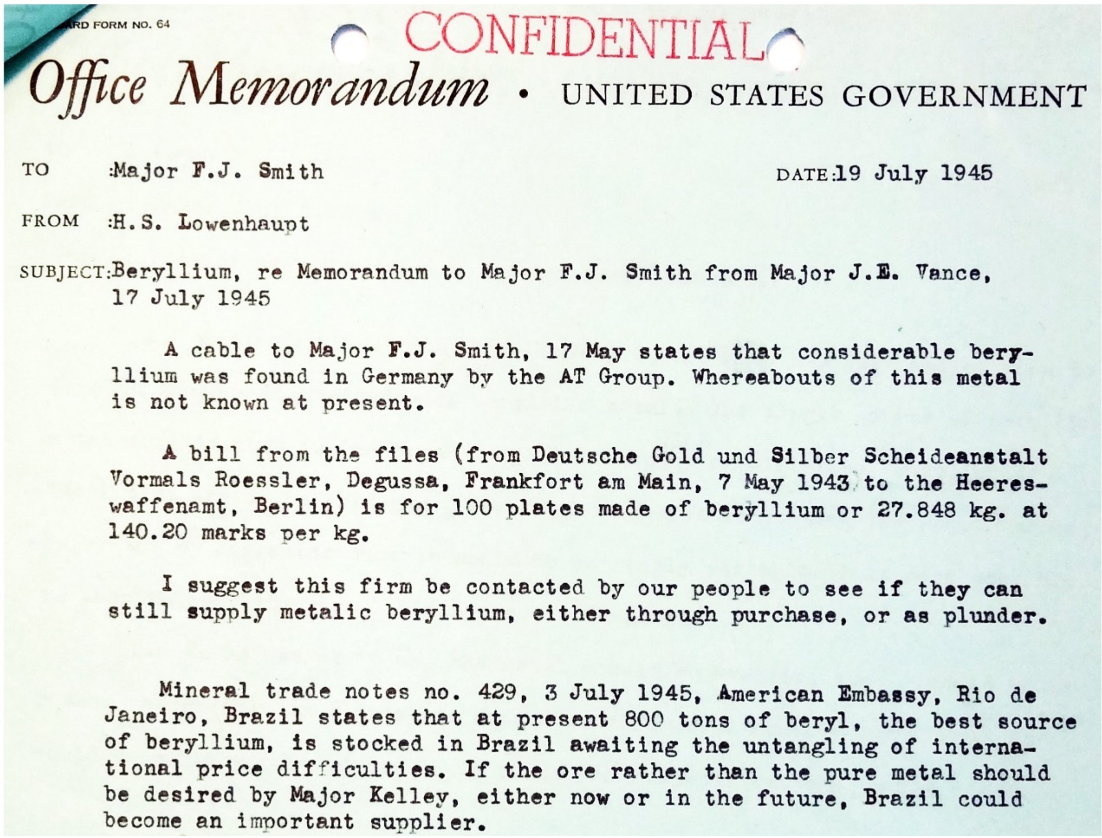
TO : Major F. J. Smith DATE: 17 July 1945

FROM : Major John E. Vance

SUBJECT: Possibility of acquiring foreign beryllium metal

1. Major Kelley stated that Madison Square Area had been called upon to furnish increased quantities of beryllium metal. The single source of beryllium metal at this time is the Brush Beryllium Company of Cleveland, Ohio, whose facilities are to be enlarged. However, to assist in meeting the requirements, Major Kelley suggested that it would be extremely valuable if it were possible to acquire beryllium metal discovered in Germany.

2. To be useful to us, the metal should be massive, i.e., should be in pieces rather than in flakes and should contain more than 90% beryllium; it would probably not be advisable to place other specifications on the metal.



RD FORM NO. 64

CONFIDENTIAL

Office Memorandum • UNITED STATES GOVERNMENT

TO :Major F.J. Smith DATE:19 July 1945

FROM :H.S. Lowenhaupt

SUBJECT:Beryllium, re Memorandum to Major F.J. Smith from Major J.E. Vance, 17 July 1945

A cable to Major F.J. Smith, 17 May states that considerable beryllium was found in Germany by the AT Group. Whereabouts of this metal is not known at present.

A bill from the files (from Deutsche Gold und Silber Scheideanstalt Vormals Roessler, Degussa, Frankfort am Main, 7 May 1943 to the Heereswaffenamt, Berlin) is for 100 plates made of beryllium or 27.848 kg. at 140.20 marks per kg.

I suggest this firm be contacted by our people to see if they can still supply metalic beryllium, either through purchase, or as plunder.

Mineral trade notes no. 429, 3 July 1945, American Embassy, Rio de Janeiro, Brazil states that at present 800 tons of beryl, the best source of beryllium, is stocked in Brazil awaiting the untangling of international price difficulties. If the ore rather than the pure metal should be desired by Major Kelley, either now or in the future, Brazil could become an important supplier.

NARA RG 77, Entry UD-22A, Box 163, Folder Australia

Figure D.518: The U.S. nuclear weapons program needed more beryllium than was being produced in the United States. It discovered that highly suitable beryllium was made in large quantities in Germany—and was shipped to Erich Schumann's Army Ordnance Office (Heereswaffenamt) during the war [NARA RG 77, Entry UD-22A, Box 163, Folder Australia].

BIOS 158. *Production of Beryllia and Beryllium at Degussa Plants.*

Production of Beryllium Oxide and Beryllium at the Degussa Plant in Frankfurt

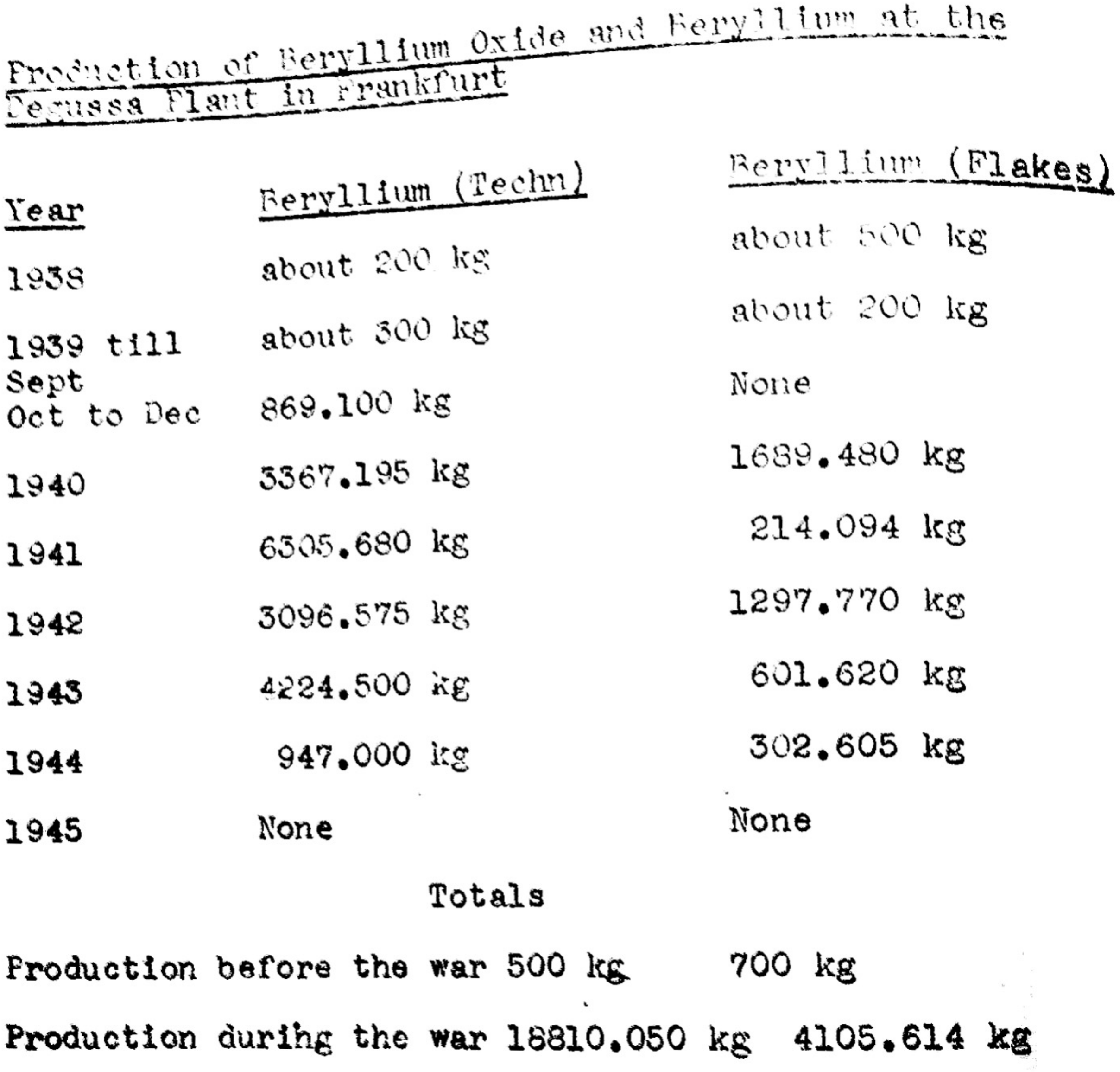
Year	Beryllium (Techn)	Beryllium (Flakes)
1938	about 200 kg	about 500 kg
1939 till Sept	about 300 kg	about 200 kg
Oct to Dec	869.100 kg	None
1940	3367.195 kg	1689.480 kg
1941	6305.680 kg	214.094 kg
1942	3096.575 kg	1297.770 kg
1943	4224.500 kg	601.620 kg
1944	947.000 kg	302.605 kg
1945	None	None
	Totals	
Production before the war	500 kg	700 kg
Production during the war	18810.050 kg	4105.614 kg

[See document photo on p. 4099.]

BIOS 319. *Production of Beryllium "Degussa."*

The whole of our party visited this Factory, spending about three hours with Dr. Völkel, who clearly knew his subject. [...]

Maximum production reached 160/180 Kg. pure beryllium per month.



Production of Beryllium Oxide and Beryllium at the Degussa Plant in Frankfurt

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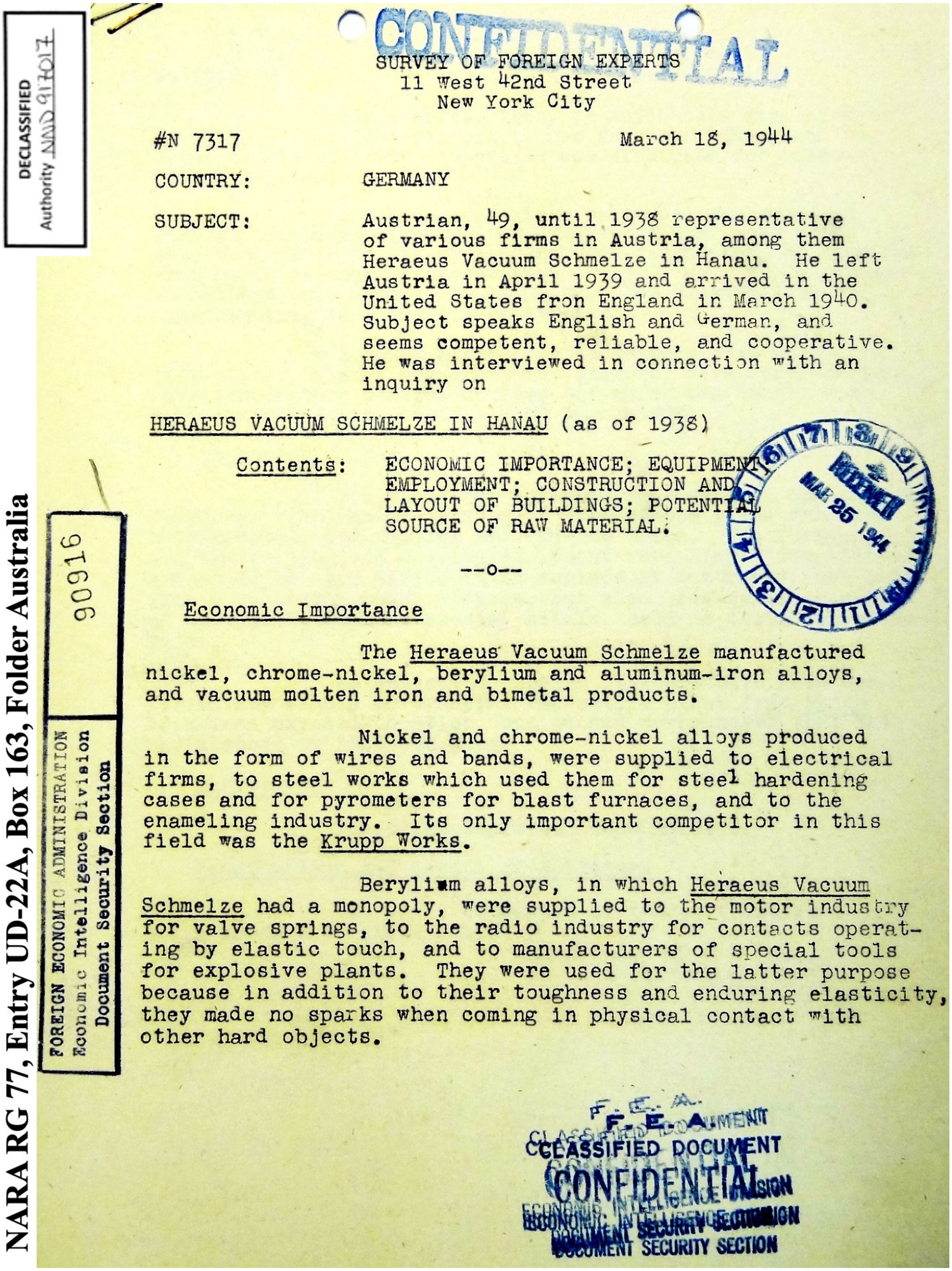
1942	3096.575 kg	1297.770 kg
1943	4224.500 kg	601.620 kg
1944	947.000 kg	302.605 kg
1945	None	None

Totals

Production before the war	500 kg	700 kg
Production durihg the war	18810.050 kg	4105.614 kg

Figure D.519: BIOS 158. *Production of Beryllia and Beryllium at Degussa Plants.*



NARA RG 77, Entry UD-22A, Box 163, Folder Australia

DECLASSIFIED
Authority NND 917017

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SURVEY OF FOREIGN EXPERTS
11 West 42nd Street
New York City

#N 7317

March 18, 1944

COUNTRY: GERMANY

SUBJECT: Austrian, 49, until 1938 representative of various firms in Austria, among them Heraeus Vacuum Schmelze in Hanau. He left Austria in April 1939 and arrived in the United States fron England in March 1940. Subject speaks English and German, and seems competent, reliable, and cooperative. He was interviewed in connection with an inquiry on

HERAEUS VACUUM SCHMELZE IN HANAU (as of 1938)

Contents: ECONOMIC IMPORTANCE; EQUIPMENT; EMPLOYMENT; CONSTRUCTION AND LAYOUT OF BUILDINGS; POTENTIAL SOURCE OF RAW MATERIAL.

RECEIVED
MAR 25 1944

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FOREIGN ECONOMIC ADMINISTRATION
Economic Intelligence Division
Document Security Section

Economic Importance

The Heraeus Vacuum Schmelze manufactured nickel, chrome-nickel, berylium and aluminum-iron alloys, and vacuum molten iron and bimetal products.

Nickel and chrome-nickel alloys produced in the form of wires and bands, were supplied to electrical firms, to steel works which used them for steel hardening cases and for pyrometers for blast furnaces, and to the enameling industry. Its only important competitor in this field was the Krupp Works.

Berylium alloys, in which Heraeus Vacuum Schmelze had a monopoly, were supplied to the motor industry for valve springs, to the radio industry for contacts operating by elastic touch, and to manufacturers of special tools for explosive plants. They were used for the latter purpose because in addition to their toughness and enduring elasticity, they made no sparks when coming in physical contact with other hard objects.

F.E.A.
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DOCUMENT SECURITY SECTION

Figure D.520: Ronald Carroll. 18 March 1944 [NARA RG 77, Entry UD-22A, Box 163, Folder Australia].

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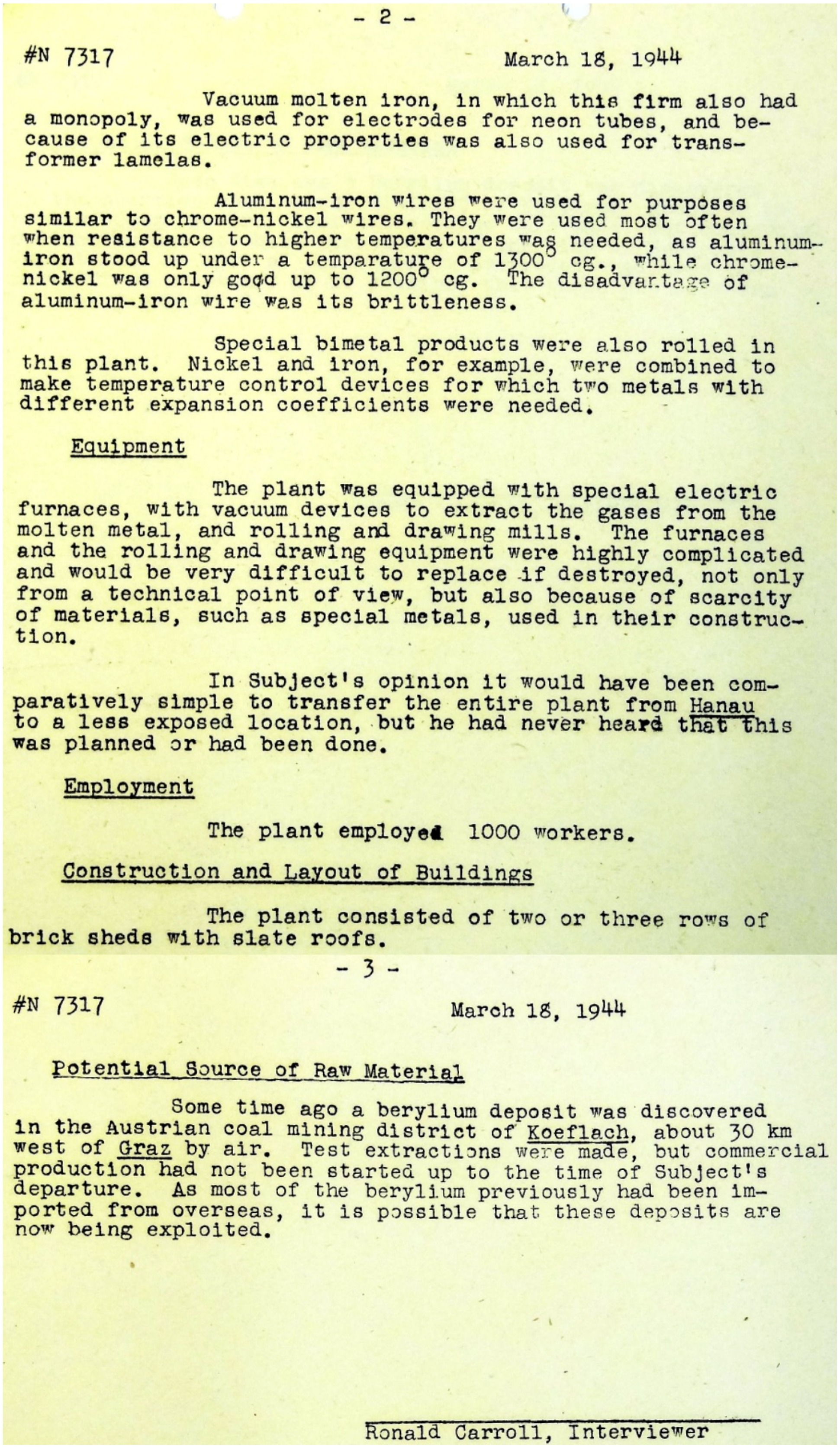
Authority NND 917017

NARA RG 77, Entry UD-22A, Box 163, Folder Australia



- 2 -

#N 7317 March 18, 1944

Vacuum molten iron, in which this firm also had a monopoly, was used for electrodes for neon tubes, and because of its electric properties was also used for transformer lamelas.

Aluminum-iron wires were used for purposes similar to chrome-nickel wires. They were used most often when resistance to higher temperatures was needed, as aluminum-iron stood up under a temparature of 1300° cg., while chrome-nickel was only good up to 1200° cg. The disadvantage of aluminum-iron wire was its brittleness.

Special bimetal products were also rolled in this plant. Nickel and iron, for example, were combined to make temperature control devices for which two metals with different expansion coefficients were needed.

Equipment

The plant was equipped with special electric furnaces, with vacuum devices to extract the gases from the molten metal, and rolling and drawing mills. The furnaces and the rolling and drawing equipment were highly complicated and would be very difficult to replace if destroyed, not only from a technical point of view, but also because of scarcity of materials, such as special metals, used in their construction.

In Subject's opinion it would have been comparatively simple to transfer the entire plant from Hanau to a less exposed location, but he had never heard that this was planned or had been done.

Employment

The plant employed 1000 workers.

Construction and Layout of Buildings

The plant consisted of two or three rows of brick sheds with slate roofs.

- 3 -

#N 7317 March 18, 1944

Potential Source of Raw Material

Some time ago a berylium deposit was discovered in the Austrian coal mining district of Koeflach, about 30 km west of Graz by air. Test extractions were made, but commercial production had not been started up to the time of Subject's departure. As most of the berylium previously had been imported from overseas, it is possible that these deposits are now being exploited.

Ronald Carroll, Interviewer

Figure D.521: Ronald Carroll. 18 March 1944 [NARA RG 77, Entry UD-22A, Box 163, Folder Australia].

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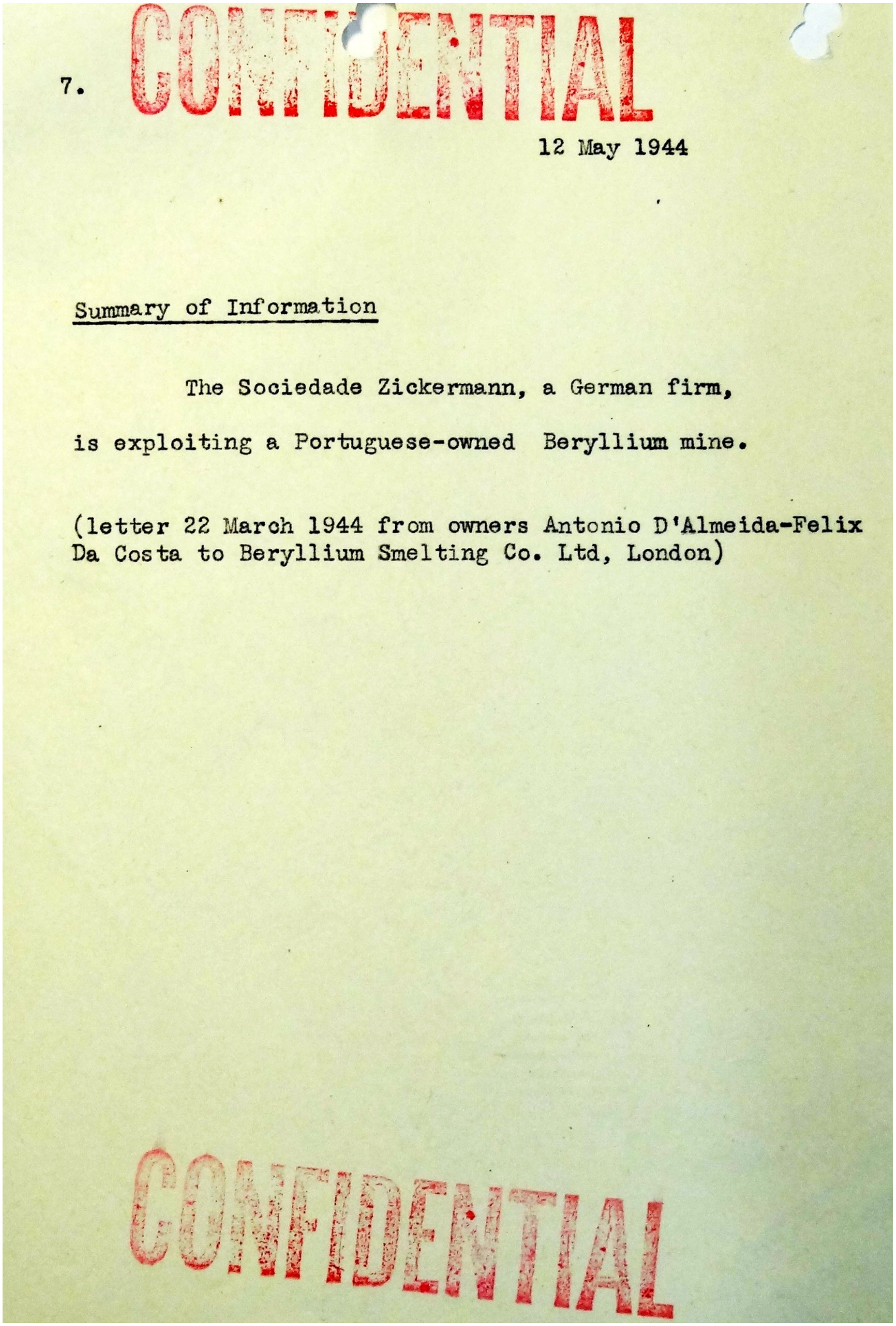
Authority NND 917017



7. CONFIDENTIAL

12 May 1944

Summary of Information

The Sociedade Zickermann, a German firm, is exploiting a Portuguese-owned Beryllium mine.

(letter 22 March 1944 from owners Antonio D'Almeida-Felix Da Costa to Beryllium Smelting Co. Ltd, London)

CONFIDENTIAL

NARA RG 77, Entry UD-22A, Box 170, Folder 32.60-1 GERMANY: Summary Reports (1944)

Figure D.522: 12 May 1944. Summary of Information [NARA RG 77, Entry UD-22A, Box 170, Folder 32.60-1 GERMANY: Summary Reports (1944)].

The following documents are examples of German plans to ship large quantities of beryllium to Japan [Henshall 2000, p. 55]:

Berlin to Tokyo ULTRA message 1201. 22 November 1944. Cargo lost on I-52? [TNA **file number???**] Lists 2590 kg of beryllium alloy for shipment from Germany to Japan.

Berlin to Tokyo ULTRA message 1809. 15 April 1945. Cargo loaded on U-873 [which later surrendered to United States on 11 May 1945]. [TNA **file number???**] Lists 1,402 bars of beryllium alloy for shipment from Germany to Japan.

For more information on wartime beryllium production and applications, see:

BIOS 36. *Magnetic Materials and Beryllium.*

BIOS 441. *The Platinum Metals Industry in Germany.* [Beryllium-platinum alloys.]

BIOS 550. *Investigation of Beryllium Production in Germany and Italy Including Production and Uses of Oxides and Alloys.*

BIOS 945. *Beryllium at Degussa.*

BIOS 1338. *Developments in Magnesium Production and Fabrication.* [Beryllium, zirconium at Degussa; also fluorine and carbon at I.G. Farben.]

BIOS 1660. *A General Survey of the German Non-Ferrous Industry.* [aluminum, beryllium]

CIOS XXVII-95. *Heraeus Vacuumschmelze AG, Hanau.* [Beryllium manufacture.]

FIAT 387. *The German Steel Casting Industry* [Beryllium in steel castings.]

FIAT 522. *The Beryllium Industries of Germany and Italy (1939 to 1945).*

FIAT 617. *The Electrical and Technical Ceramic Industry of Germany.* [Beryllia use in ceramics.]

FIAT 785. *Electrical Contacts.* [Beryllium alloys for contacts.]

G-81. Erwin Fünfer and Walther Bothe. *The Absorption of Thermal Neutrons and the Increase of Fast Neutrons in Beryllium.* 1941.

G-153. Wilhelm Hanle. *Spectroscopic Analysis of Carbon, Aluminum, and Beryllium.* 1942.

JIOA 46. *Data on the German X-Ray Industry.* [Beryllium X-ray windows.]

D. Boron

[Boron was used for producing certain types of glass, ceramics, and metals, but it also would have been very useful as a neutron absorber. The following documents are examples of boron production, applications, and measurement.]

For information on wartime boron production and applications, see for example:

BIOS 676. *German Metallurgical Laboratories for Ferrous Metals with Special Reference to the K. W. Institute for Iron Research.* [KWI measuring boron in steel]

BIOS 925. *Tungsten Carbide Research in Germany.* [Boron carbide for tool tips.]

BIOS 1406. [Boron carbide abrasives manufacture.]

BIOS 1535. *Report on Investigation of Methods of Gaseous Metal Treatment.* [Boron-diffusion treatment of ferrous metals.]

FIAT 617. *The Electrical and Technical Ceramic Industry of Germany.* [Boron carbide and boron nitrate.]

FIAT 738. *The Production of Some Rare Metals and Their Compounds as Practiced by E. Merck, Chemische Fabrik, Darmstadt: Boron, Caesium, Gallium, Germanium, Rubidium.*

FIAT 750. *Rare and Minor Minerals.* [Boron production]

[Unless otherwise noted, text for G-series captured German nuclear reports cited here consists of the English-language abstracts prepared by American scientists who studied the German reports.]

G-35. Wilhelm Hanle. *Investigation of Cadmium Content of Carbon.* 1940.

Spectroscopic tests of charcoal prepared from sugar showed Cd content of about 10^{-7}, certainly less than 3×10^{-7}.

[See document photos on p. 4106.]

G-85. Wilhelm Hanle. *The Determination of Boron and Cadmium in Carbon.* 1941.

Method involves making spectroscopic analysis of C and comparing with C prepared from sugar to which a definite amount of boron nitride has been added. This is better than the usual boric acid because the vaporization of boron nitride compares more closely with that of boron carbide (the usual form of B in C) than does the more easily vaporized boric acid.

Cd content of sugar carbon about 10^{-7}, certainly less than 3×10^{-7}.

Boron content:

Sugar carbon	10^{-6}
Acheson graphite	10^{-4}
Beechwood carbon	10^{-5}
Arc lamp carbon, incandescent	10^{-4}

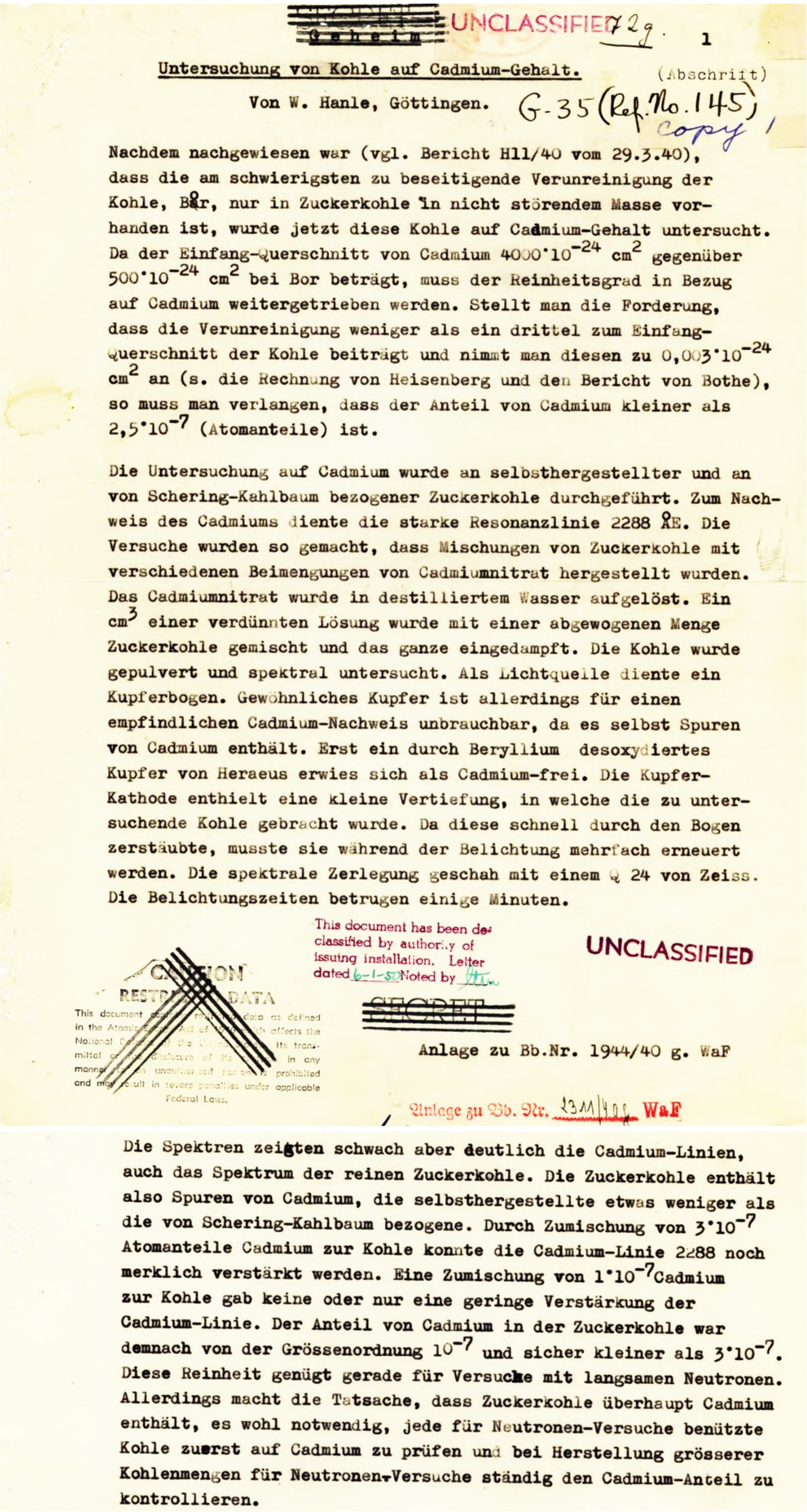
Siemens electrographite used by Bothe for his pile had a boron content between 10^{-5} and 2×10^{-6} atomic parts. The cadmium content was less than 3×10^{-7}.

[See document photos on p. 4107.]

G-153. Wilhelm Hanle. *Spectroscopic Analysis of Carbon, Aluminum, and Beryllium.* 1942.

Graphite used by Bothe, Al used by Döpel and Heisenberg, and Be oxide used by Haxel and Volz submitted for test. B content of graphite lies between 0.6 and 0.8×10^{-5} atoms of B per atom of C. Cd content of Al is less than 10^{-5} mole per mole. B content of Al is also less than 10^{-5} mole per mole. Cd content of Be oxide is less than 10^{-5} mole per mole. B content of Be oxide is less than 10^{-3} and more than 10^{-5} mole per mole.

[See document photos on pp. 4108–4109.]



~~SECRET~~ UNCLASSIFIED 72g. 1

~~Geheim~~

Untersuchung von Kohle auf Cadmium-Gehalt.

(Abschrift)

Von W. Hanle, Göttingen. G-35 (Ref. No. 145) copy 1

Nachdem nachgewiesen war (vgl. Bericht H11/40 vom 29.3.40), dass die am schwierigsten zu beseitigende Verunreinigung der Kohle, Bor, nur in Zuckerkohle in nicht störendem Masse vorhanden ist, wurde jetzt diese Kohle auf Cadmium-Gehalt untersucht. Da der Einfang-Querschnitt von Cadmium $4000 \cdot 10^{-24}$ cm^2 gegenüber $500 \cdot 10^{-24}$ cm^2 bei Bor beträgt, muss der Reinheitsgrad in Bezug auf Cadmium weitergetrieben werden. Stellt man die Forderung, dass die Verunreinigung weniger als ein drittel zum Einfang-Querschnitt der Kohle beiträgt und nimmt man diesen zu $0{,}003 \cdot 10^{-24}$ cm^2 an (s. die Rechnung von Heisenberg und den Bericht von Bothe), so muss man verlangen, dass der Anteil von Cadmium kleiner als $2{,}5 \cdot 10^{-7}$ (Atomanteile) ist.

Die Untersuchung auf Cadmium wurde an selbsthergestellter und an von Schering-Kahlbaum bezogener Zuckerkohle durchgeführt. Zum Nachweis des Cadmiums diente die starke Resonanzlinie 2288 ÅE. Die Versuche wurden so gemacht, dass Mischungen von Zuckerkohle mit verschiedenen Beimengungen von Cadmiumnitrat hergestellt wurden. Das Cadmiumnitrat wurde in destilliertem Wasser aufgelöst. Ein cm^3 einer verdünnten Lösung wurde mit einer abgewogenen Menge Zuckerkohle gemischt und das ganze eingedampft. Die Kohle wurde gepulvert und spektral untersucht. Als Lichtquelle diente ein Kupferbogen. Gewöhnliches Kupfer ist allerdings für einen empfindlichen Cadmium-Nachweis unbrauchbar, da es selbst Spuren von Cadmium enthält. Erst ein durch Beryllium desoxydiertes Kupfer von Heraeus erwies sich als Cadmium-frei. Die Kupfer-Kathode enthielt eine kleine Vertiefung, in welche die zu untersuchende Kohle gebracht wurde. Da diese schnell durch den Bogen zerstäubte, musste sie während der Belichtung mehrfach erneuert werden. Die spektrale Zerlegung geschah mit einem Q 24 von Zeiss. Die Belichtungszeiten betrugen einige Minuten.

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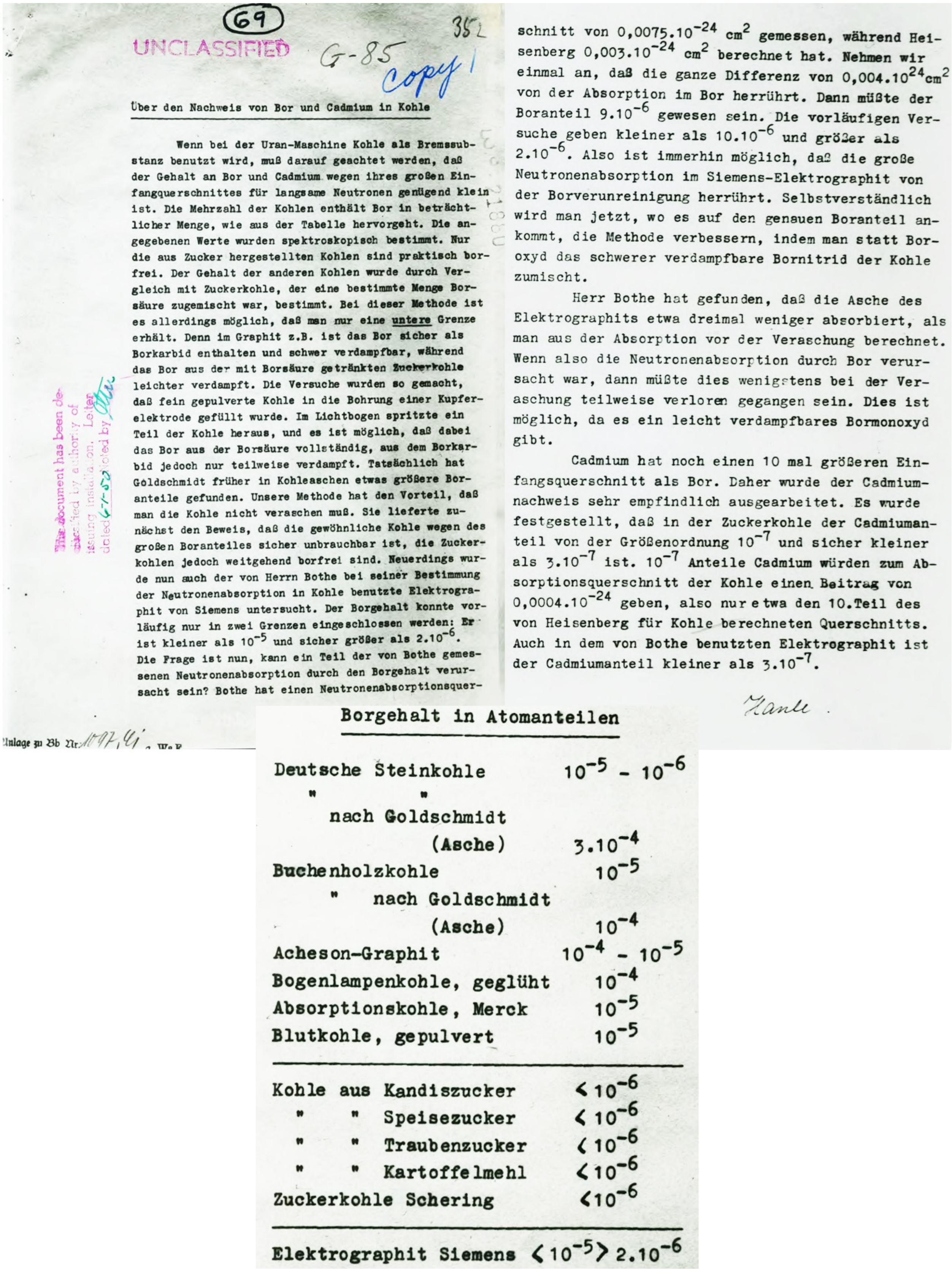
Anlage zu Bb.Nr. 1944/40 g. WaF

Anlage zu Bb. Nr. 2311/40 g. WaF

Die Spektren zeigten schwach aber deutlich die Cadmium-Linien, auch das Spektrum der reinen Zuckerkohle. Die Zuckerkohle enthält also Spuren von Cadmium, die selbsthergestellte etwas weniger als die von Schering-Kahlbaum bezogene. Durch Zumischung von $3 \cdot 10^{-7}$ Atomanteile Cadmium zur Kohle konnte die Cadmium-Linie 2288 noch merklich verstärkt werden. Eine Zumischung von $1 \cdot 10^{-7}$ Cadmium zur Kohle gab keine oder nur eine geringe Verstärkung der Cadmium-Linie. Der Anteil von Cadmium in der Zuckerkohle war demnach von der Grössenordnung 10^{-7} und sicher kleiner als $3 \cdot 10^{-7}$. Diese Reinheit genügt gerade für Versuche mit langsamen Neutronen. Allerdings macht die Tatsache, dass Zuckerkohle überhaupt Cadmium enthält, es wohl notwendig, jede für Neutronen-Versuche benützte Kohle zuerst auf Cadmium zu prüfen und bei Herstellung grösserer Kohlenmengen für Neutronen-Versuche ständig den Cadmium-Anteil zu kontrollieren.

Figure D.523: Wilhelm Hanle. *Investigation of Cadmium Content of Carbon.* 1940. [G-35]



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UNCLASSIFIED

35 2

G-85

copy 1

Über den Nachweis von Bor und Cadmium in Kohle

Wenn bei der Uran-Maschine Kohle als Bremssubstanz benutzt wird, muß darauf geachtet werden, daß der Gehalt an Bor und Cadmium wegen ihres großen Einfangquerschnittes für langsame Neutronen genügend klein ist. Die Mehrzahl der Kohlen enthält Bor in beträchtlicher Menge, wie aus der Tabelle hervorgeht. Die angegebenen Werte wurden spektroskopisch bestimmt. Nur die aus Zucker hergestellten Kohlen sind praktisch borfrei. Der Gehalt der anderen Kohlen wurde durch Vergleich mit Zuckerkohle, der eine bestimmte Menge Borsäure zugemischt war, bestimmt. Bei dieser Methode ist es allerdings möglich, daß man nur eine untere Grenze erhält. Denn im Graphit z.B. ist das Bor sicher als Borkarbid enthalten und schwer verdampfbar, während das Bor aus der mit Borsäure getränkten Zuckerkohle leichter verdampft. Die Versuche wurden so gemacht, daß fein gepulverte Kohle in die Bohrung einer Kupferelektrode gefüllt wurde. Im Lichtbogen spritzte ein Teil der Kohle heraus, und es ist möglich, daß dabei das Bor aus der Borsäure vollständig, aus dem Borkarbid jedoch nur teilweise verdampft. Tatsächlich hat Goldschmidt früher in Kohleaschen etwas größere Boranteile gefunden. Unsere Methode hat den Vorteil, daß man die Kohle nicht veraschen muß. Sie lieferte zunächst den Beweis, daß die gewöhnliche Kohle wegen des großen Boranteiles sicher unbrauchbar ist, die Zuckerkohlen jedoch weitgehend borfrei sind. Neuerdings wurde nun auch der von Herrn Bothe bei seiner Bestimmung der Neutronenabsorption in Kohle benutzte Elektrographit von Siemens untersucht. Der Borgehalt konnte vorläufig nur in zwei Grenzen eingeschlossen werden: Er ist kleiner als 10^{-5} und sicher größer als 2.10^{-6}. Die Frage ist nun, kann ein Teil der von Bothe gemessenen Neutronenabsorption durch den Borgehalt verursacht sein? Bothe hat einen Neutronenabsorptionsquerschnitt von $0{,}0075.10^{-24}$ cm^2 gemessen, während Heisenberg $0{,}003.10^{-24}$ cm^2 berechnet hat. Nehmen wir einmal an, daß die ganze Differenz von $0{,}004.10^{24}$cm^2 von der Absorption im Bor herrührt. Dann müßte der Boranteil 9.10^{-6} gewesen sein. Die vorläufigen Versuche geben kleiner als 10.10^{-6} und größer als 2.10^{-6}. Also ist immerhin möglich, daß die große Neutronenabsorption im Siemens-Elektrographit von der Borverunreinigung herrührt. Selbstverständlich wird man jetzt, wo es auf den genauen Boranteil ankommt, die Methode verbessern, indem man statt Boroxyd das schwerer verdampfbare Bornitrid der Kohle zumischt.

Herr Bothe hat gefunden, daß die Asche des Elektrographits etwa dreimal weniger absorbiert, als man aus der Absorption vor der Veraschung berechnet. Wenn also die Neutronenabsorption durch Bor verursacht war, dann müßte dies wenigstens bei der Veraschung teilweise verloren gegangen sein. Dies ist möglich, da es ein leicht verdampfbares Bormonoxyd gibt.

Cadmium hat noch einen 10 mal größeren Einfangsquerschnitt als Bor. Daher wurde der Cadmiumnachweis sehr empfindlich ausgearbeitet. Es wurde festgestellt, daß in der Zuckerkohle der Cadmiumanteil von der Größenordnung 10^{-7} und sicher kleiner als 3.10^{-7} ist. 10^{-7} Anteile Cadmium würden zum Absorptionsquerschnitt der Kohle einen Beitrag von $0{,}0004.10^{-24}$ geben, also nur etwa den 10.Teil des von Heisenberg für Kohle berechneten Querschnitts. Auch in dem von Bothe benutzten Elektrographit ist der Cadmiumanteil kleiner als 3.10^{-7}.

Hanle

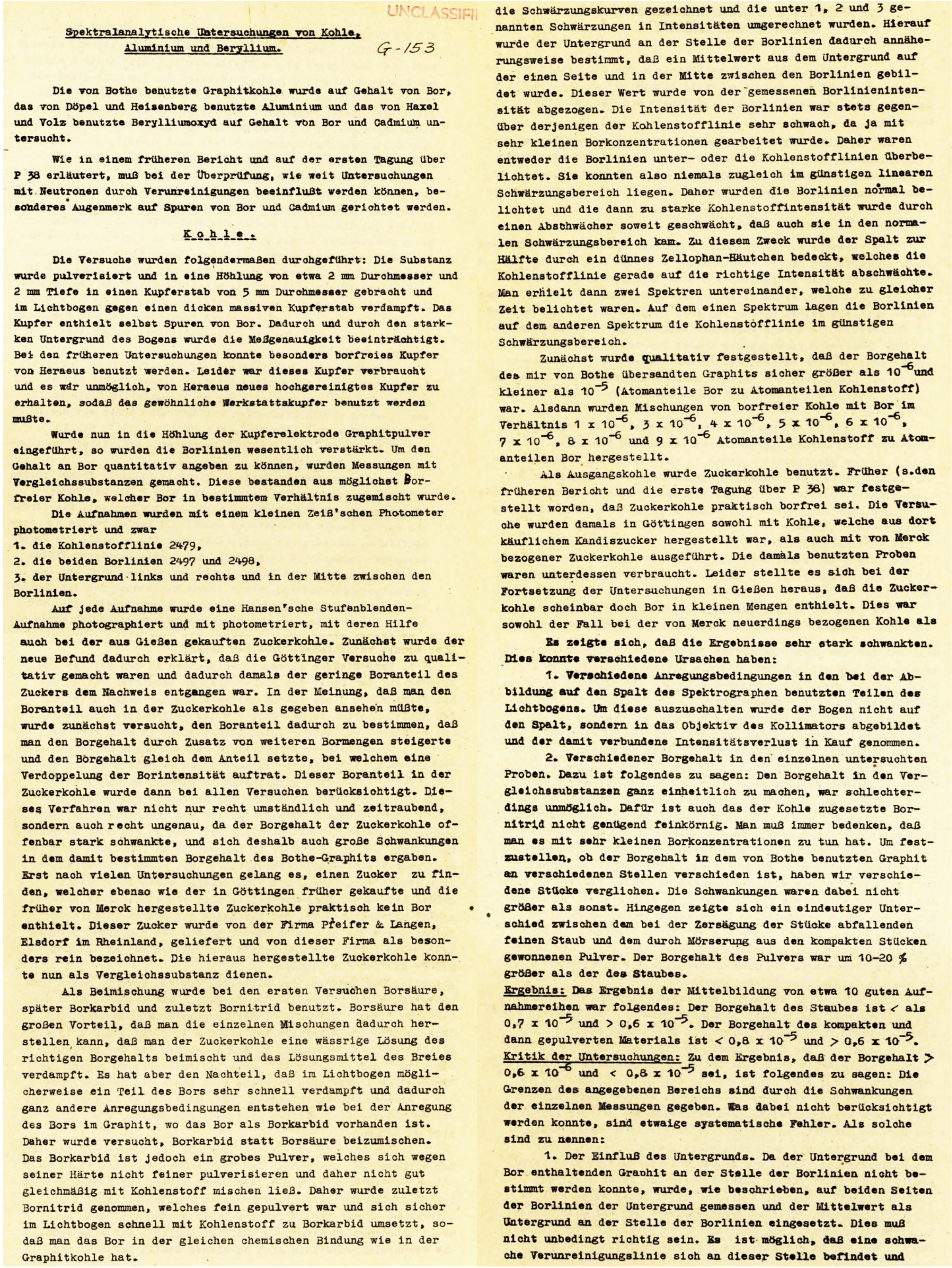
This document has been declassified by authority of issuing installation. Letter dated 6-1-50 Noted by

Anlage zu Bb Nr. 1097/41

Borgehalt in Atomanteilen

Deutsche Steinkohle	10^{-5} - 10^{-6}
" " nach Goldschmidt (Asche)	3.10^{-4}
Buchenholzkohle	10^{-5}
" nach Goldschmidt (Asche)	10^{-4}
Acheson-Graphit	10^{-4} - 10^{-5}
Bogenlampenkohle, geglüht	10^{-4}
Absorptionskohle, Merck	10^{-5}
Blutkohle, gepulvert	10^{-5}
Kohle aus Kandiszucker	$< 10^{-6}$
" " Speisezucker	$< 10^{-6}$
" " Traubenzucker	$< 10^{-6}$
" " Kartoffelmehl	$< 10^{-6}$
Zuckerkohle Schering	$< 10^{-6}$
Elektrographit Siemens	$< 10^{-5} > 2.10^{-6}$

Figure D.524: Wilhelm Hanle. *The Determination of Boron and Cadmium in Carbon.* 1941. [G-85]



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Spektralanalytische Untersuchungen von Kohle, Aluminium und Beryllium.

G-153

Die von Bothe benutzte Graphitkohle wurde auf Gehalt von Bor, das von Döpel und Heisenberg benutzte Aluminium und das von Haxel und Volz benutzte Berylliumoxyd auf Gehalt von Bor und Cadmium untersucht.

Wie in einem früheren Bericht und auf der ersten Tagung über P 38 erläutert, muß bei der Überprüfung, wie weit Untersuchungen mit Neutronen durch Verunreinigungen beeinflußt werden können, besonderes Augenmerk auf Spuren von Bor und Cadmium gerichtet werden.

Kohle.

Die Versuche wurden folgendermaßen durchgeführt: Die Substanz wurde pulverisiert und in eine Höhlung von etwa 2 mm Durchmesser und 2 mm Tiefe in einen Kupferstab von 5 mm Durchmesser gebracht und im Lichtbogen gegen einen dicken massiven Kupferstab verdampft. Das Kupfer enthielt selbst Spuren von Bor. Dadurch und durch den starkken Untergrund des Bogens wurde die Meßgenauigkeit beeinträchtigt. Bei den früheren Untersuchungen konnte besonders borfreies Kupfer von Heraeus benutzt werden. Leider war dieses Kupfer verbraucht und es war unmöglich, von Heraeus neues hochgereinigtes Kupfer zu erhalten, sodaß das gewöhnliche Werkstattskupfer benutzt werden mußte.

Wurde nun in die Höhlung der Kupferelektrode Graphitpulver eingeführt, so wurden die Borlinien wesentlich verstärkt. Um den Gehalt an Bor quantitativ angeben zu können, wurden Messungen mit Vergleichssubstanzen gemacht. Diese bestanden aus möglichst borfreier Kohle, welcher Bor in bestimmtem Verhältnis zugemischt wurde.

Die Aufnahmen wurden mit einem kleinen Zeiß'schen Photometer photometriert und zwar

1. die Kohlenstofflinie 2479,
2. die beiden Borlinien 2497 und 2498,
3. der Untergrund links und rechts und in der Mitte zwischen den Borlinien.

Auf jede Aufnahme wurde eine Hansen'sche Stufenblenden-Aufnahme photographiert und mit photometriert, mit deren Hilfe

auch bei der aus Gießen gekauften Zuckerkohle. Zunächst wurde der neue Befund dadurch erklärt, daß die Göttinger Versuche zu qualitativ gemacht waren und dadurch damals der geringe Boranteil des Zuckers dem Nachweis entgangen war. In der Meinung, daß man den Boranteil auch in der Zuckerkohle als gegeben ansehen müßte, wurde zunächst versucht, den Boranteil dadurch zu bestimmen, daß man den Borgehalt durch Zusatz von weiteren Bormengen steigerte und den Borgehalt gleich dem Anteil setzte, bei welchem eine Verdoppelung der Borintensität auftrat. Dieser Boranteil in der Zuckerkohle wurde dann bei allen Versuchen berücksichtigt. Dieses Verfahren war nicht nur recht umständlich und zeitraubend, sondern auch recht ungenau, da der Borgehalt der Zuckerkohle offenbar stark schwankte, und sich deshalb auch große Schwankungen in dem damit bestimmten Borgehalt des Bothe-Graphits ergaben. Erst nach vielen Untersuchungen gelang es, einen Zucker zu finden, welcher ebenso wie der in Göttingen früher gekaufte und die früher von Merck hergestellte Zuckerkohle praktisch kein Bor enthielt. Dieser Zucker wurde von der Firma Pfeifer & Langen, Elsdorf im Rheinland, geliefert und von dieser Firma als besonders rein bezeichnet. Die hieraus hergestellte Zuckerkohle konnte nun als Vergleichssubstanz dienen.

Als Beimischung wurde bei den ersten Versuchen Borsäure, später Borkarbid und zuletzt Bornitrid benutzt. Borsäure hat den großen Vorteil, daß man die einzelnen Mischungen dadurch herstellen kann, daß man der Zuckerkohle eine wässrige Lösung des richtigen Borgehalts beimischt und das Lösungsmittel des Breies verdampft. Es hat aber den Nachteil, daß im Lichtbogen möglicherweise ein Teil des Bors sehr schnell verdampft und dadurch ganz andere Anregungsbedingungen entstehen wie bei der Anregung des Bors im Graphit, wo das Bor als Borkarbid vorhanden ist. Daher wurde versucht, Borkarbid statt Borsäure beizumischen. Das Borkarbid ist jedoch ein grobes Pulver, welches sich wegen seiner Härte nicht feiner pulverisieren und daher nicht gut gleichmäßig mit Kohlenstoff mischen ließ. Daher wurde zuletzt Bornitrid genommen, welches fein gepulvert war und sich sicher im Lichtbogen schnell mit Kohlenstoff zu Borkarbid umsetzt, sodaß man das Bor in der gleichen chemischen Bindung wie in der Graphitkohle hat.

die Schwärzungskurven gezeichnet und die unter 1, 2 und 3 genannten Schwärzungen in Intensitäten umgerechnet wurden. Hierauf wurde der Untergrund an der Stelle der Borlinien dadurch annäherungsweise bestimmt, daß ein Mittelwert aus dem Untergrund auf der einen Seite und in der Mitte zwischen den Borlinien gebildet wurde. Dieser Wert wurde von der gemessenen Borlinienintensität abgezogen. Die Intensität der Borlinien war stets gegenüber derjenigen der Kohlenstofflinie sehr schwach, da ja mit sehr kleinen Borkonzentrationen gearbeitet wurde. Daher waren entweder die Borlinien unter- oder die Kohlenstofflinien überbelichtet. Sie konnten also niemals zugleich im günstigen linearen Schwärzungsbereich liegen. Daher wurden die Borlinien normal belichtet und die dann zu starke Kohlenstoffintensität wurde durch einen Abschwächer soweit geschwächt, daß auch sie in den normalen Schwärzungsbereich kam. Zu diesem Zweck wurde der Spalt zur Hälfte durch ein dünnes Zellophan-Häutchen bedeckt, welches die Kohlenstofflinie gerade auf die richtige Intensität abschwächte. Man erhielt dann zwei Spektren untereinander, welche zu gleicher Zeit belichtet waren. Auf dem einen Spektrum lagen die Borlinien auf dem anderen Spektrum die Kohlenstofflinie im günstigen Schwärzungsbereich.

Zunächst wurde qualitativ festgestellt, daß der Borgehalt des mir von Bothe übersandten Graphits sicher größer als 10^{-6} und kleiner als 10^{-5} (Atomanteile Bor zu Atomanteilen Kohlenstoff) war. Alsdann wurden Mischungen von borfreier Kohle mit Bor im Verhältnis 1 x 10^{-6}, 3 x 10^{-6}, 4 x 10^{-6}, 5 x 10^{-6}, 6 x 10^{-6}, 7 x 10^{-6}, 8 x 10^{-6} und 9 x 10^{-6} Atomanteile Kohlenstoff zu Atomanteilen Bor hergestellt.

Als Ausgangskohle wurde Zuckerkohle benutzt. Früher (s.den früheren Bericht und die erste Tagung über P 38) war festgestellt worden, daß Zuckerkohle praktisch borfrei sei. Die Versuche wurden damals in Göttingen sowohl mit Kohle, welche aus dort käuflichem Kandiszucker hergestellt war, als auch mit von Merck bezogener Zuckerkohle ausgeführt. Die damals benutzten Proben waren unterdessen verbraucht. Leider stellte es sich bei der Fortsetzung der Untersuchungen in Gießen heraus, daß die Zuckerkohle scheinbar doch Bor in kleinen Mengen enthielt. Dies war sowohl der Fall bei der von Merck neuerdings bezogenen Kohle als

Es zeigte sich, daß die Ergebnisse sehr stark schwankten. Dies konnte verschiedene Ursachen haben:

1. Verschiedene Anregungsbedingungen in den bei der Abbildung auf den Spalt des Spektrographen benutzten Teilen des Lichtbogens. Um diese auszuschalten wurde der Bogen nicht auf den Spalt, sondern in das Objektiv des Kollimators abgebildet und der damit verbundene Intensitätsverlust in Kauf genommen.

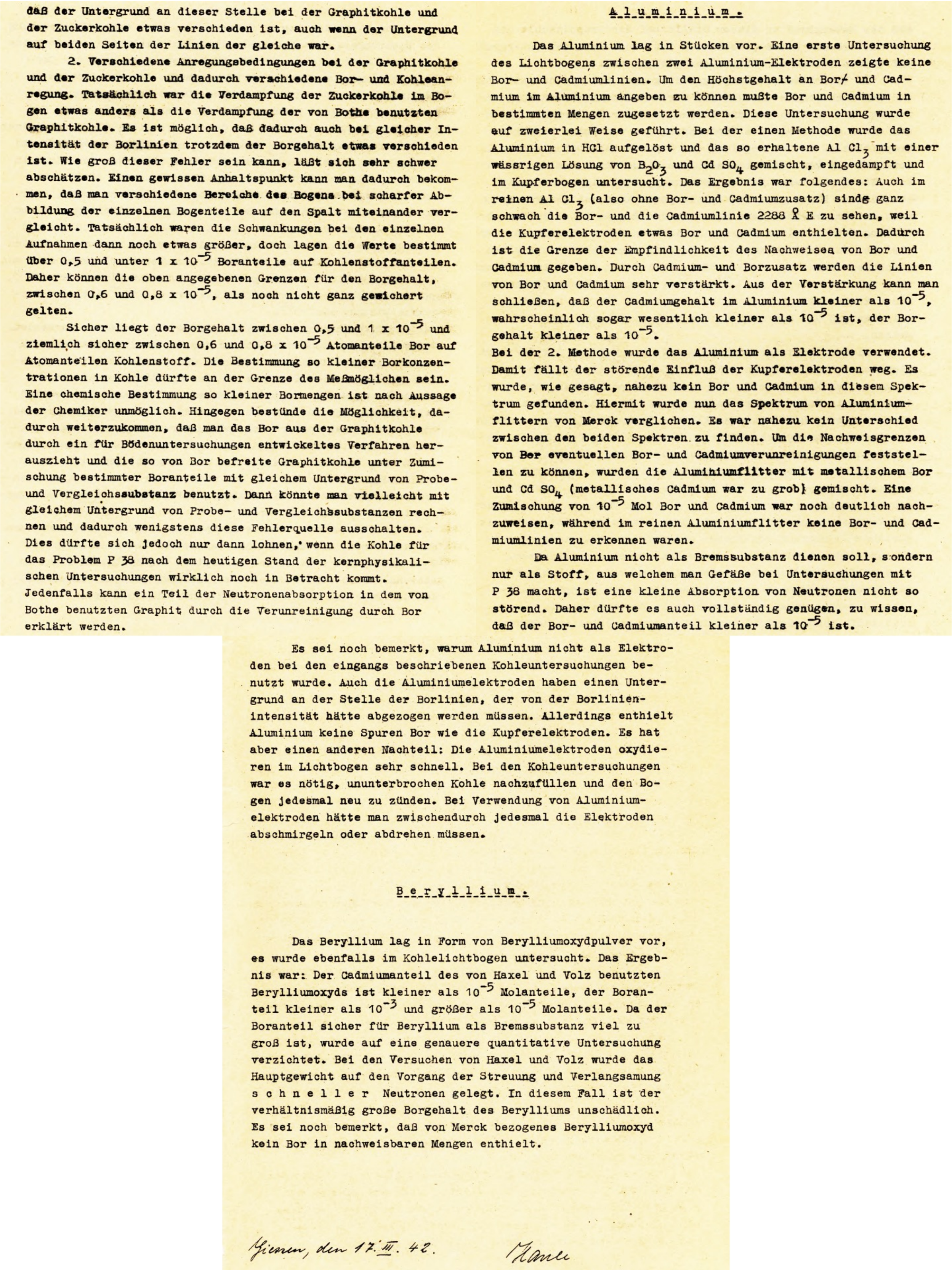
2. Verschiedener Borgehalt in den einzelnen untersuchten Proben. Dazu ist folgendes zu sagen: Den Borgehalt in den Vergleichssubstanzen ganz einheitlich zu machen, war schlechterdings unmöglich. Dafür ist auch das der Kohle zugesetzte Bornitrid nicht genügend feinkörnig. Man muß immer bedenken, daß man es mit sehr kleinen Borkonzentrationen zu tun hat. Um festzustellen, ob der Borgehalt in dem von Bothe benutzten Graphit an verschiedenen Stellen verschieden ist, haben wir verschiedene Stücke verglichen. Die Schwankungen waren dabei nicht größer als sonst. Hingegen zeigte sich ein eindeutiger Unterschied zwischen dem bei der Zersägung der Stücke abfallenden feinen Staub und dem durch Mörserung aus den kompakten Stücken gewonnenen Pulver. Der Borgehalt des Pulvers war um 10–20 % größer als der des Staubes.

<u>Ergebnis:</u> Das Ergebnis der Mittelbildung von etwa 10 guten Aufnahmereihen war folgendes: Der Borgehalt des Staubes ist $<$ als 0,7 x 10^{-5} und $>$ 0,6 x 10^{-5}. Der Borgehalt des kompakten und dann gepulverten Materials ist $<$ 0,8 x 10^{-5} und $>$ 0,6 x 10^{-5}.

<u>Kritik der Untersuchungen:</u> Zu dem Ergebnis, daß der Borgehalt $>$ 0,6 x 10^{-6} und $<$ 0,8 x 10^{-5} sei, ist folgendes zu sagen: Die Grenzen des angegebenen Bereichs sind durch die Schwankungen der einzelnen Messungen gegeben. Was dabei nicht berücksichtigt werden konnte, sind etwaige systematische Fehler. Als solche sind zu nennen:

1. Der Einfluß des Untergrunds. Da der Untergrund bei dem Bor enthaltenden Graphit an der Stelle der Borlinien nicht bestimmt werden konnte, wurde, wie beschrieben, auf beiden Seiten der Borlinien der Untergrund gemessen und der Mittelwert als Untergrund an der Stelle der Borlinien eingesetzt. Dies muß nicht unbedingt richtig sein. Es ist möglich, daß eine schwache Verunreinigungslinie sich an dieser Stelle befindet und

Figure D.525: Wilhelm Hanle. *Spectroscopic Analysis of Carbon, Aluminum, and Beryllium.* 1942. [G-153]



daß der Untergrund an dieser Stelle bei der Graphitkohle und der Zuckerkohle etwas verschieden ist, auch wenn der Untergrund auf beiden Seiten der Linien der gleiche war.

2. Verschiedene Anregungsbedingungen bei der Graphitkohle und der Zuckerkohle und dadurch verschiedene Bor- und Kohleanregung. Tatsächlich war die Verdampfung der Zuckerkohle im Bogen etwas anders als die Verdampfung der von Bothe benutzten Graphitkohle. Es ist möglich, daß dadurch auch bei gleicher Intensität der Borlinien trotzdem der Borgehalt etwas verschieden ist. Wie groß dieser Fehler sein kann, läßt sich sehr schwer abschätzen. Einen gewissen Anhaltspunkt kann man dadurch bekommen, daß man verschiedene Bereiche des Bogens bei scharfer Abbildung der einzelnen Bogenteile auf den Spalt miteinander vergleicht. Tatsächlich waren die Schwankungen bei den einzelnen Aufnahmen dann noch etwas größer, doch lagen die Werte bestimmt über 0,5 und unter 1 x 10^{-5} Boranteile auf Kohlenstoffanteilen. Daher können die oben angegebenen Grenzen für den Borgehalt, zwischen 0,6 und 0,8 x 10^{-5}, als noch nicht ganz gewichert gelten.

Sicher liegt der Borgehalt zwischen 0,5 und 1 x 10^{-5} und ziemlich sicher zwischen 0,6 und 0,8 x 10^{-5} Atomanteile Bor auf Atomanteilen Kohlenstoff. Die Bestimmung so kleiner Borkonzentrationen in Kohle dürfte an der Grenze des Meßmöglichen sein. Eine chemische Bestimmung so kleiner Bormengen ist nach Aussage der Chemiker unmöglich. Hingegen bestünde die Möglichkeit, dadurch weiterzukommen, daß man das Bor aus der Graphitkohle durch ein für Bödenuntersuchungen entwickeltes Verfahren herauszieht und die so von Bor befreite Graphitkohle unter Zumischung bestimmter Boranteile mit gleichem Untergrund von Probe- und Vergleichssubstanz benutzt. Dann könnte man vielleicht mit gleichem Untergrund von Probe- und Vergleichssubstanzen rechnen und dadurch wenigstens diese Fehlerquelle ausschalten. Dies dürfte sich jedoch nur dann lohnen, wenn die Kohle für das Problem P 38 nach dem heutigen Stand der kernphysikalischen Untersuchungen wirklich noch in Betracht kommt. Jedenfalls kann ein Teil der Neutronenabsorption in dem von Bothe benutzten Graphit durch die Verunreinigung durch Bor erklärt werden.

Aluminium.

Das Aluminium lag in Stücken vor. Eine erste Untersuchung des Lichtbogens zwischen zwei Aluminium-Elektroden zeigte keine Bor- und Cadmiumlinien. Um den Höchstgehalt an Bor- und Cadmium im Aluminium angeben zu können mußte Bor und Cadmium in bestimmten Mengen zugesetzt werden. Diese Untersuchung wurde auf zweierlei Weise geführt. Bei der einen Methode wurde das Aluminium in HCl aufgelöst und das so erhaltene $Al\ Cl_3$ mit einer wässrigen Lösung von B_2O_3 und $Cd\ SO_4$ gemischt, eingedampft und im Kupferbogen untersucht. Das Ergebnis war folgendes: Auch im reinen $Al\ Cl_3$ (also ohne Bor- und Cadmiumzusatz) sindg ganz schwach die Bor- und die Cadmiumlinie 2288 Å E zu sehen, weil die Kupferelektroden etwas Bor und Cadmium enthielten. Dadurch ist die Grenze der Empfindlichkeit des Nachweises von Bor und Cadmium gegeben. Durch Cadmium- und Borzusatz werden die Linien von Bor und Cadmium sehr verstärkt. Aus der Verstärkung kann man schließen, daß der Cadmiumgehalt im Aluminium kleiner als 10^{-5}, wahrscheinlich sogar wesentlich kleiner als 10^{-5} ist, der Borgehalt kleiner als 10^{-5}.

Bei der 2. Methode wurde das Aluminium als Elektrode verwendet. Damit fällt der störende Einfluß der Kupferelektroden weg. Es wurde, wie gesagt, nahezu kein Bor und Cadmium in diesem Spektrum gefunden. Hiermit wurde nun das Spektrum von Aluminiumflittern von Merck verglichen. Es war nahezu kein Unterschied zwischen den beiden Spektren zu finden. Um die Nachweisgrenzen von Ber eventuellen Bor- und Cadmiumverunreinigungen feststellen zu können, wurden die Alumihiumflitter mit metallischem Bor und $Cd\ SO_4$ (metallisches Cadmium war zu grob) gemischt. Eine Zumischung von 10^{-5} Mol Bor und Cadmium war noch deutlich nachzuweisen, während im reinen Aluminiumflitter keine Bor- und Cadmiumlinien zu erkennen waren.

Da Aluminium nicht als Bremssubstanz dienen soll, sondern nur als Stoff, aus welchem man Gefäße bei Untersuchungen mit P 38 macht, ist eine kleine Absorption von Neutronen nicht so störend. Daher dürfte es auch vollständig genügen, zu wissen, daß der Bor- und Cadmiumanteil kleiner als 10^{-5} ist.

Es sei noch bemerkt, warum Aluminium nicht als Elektroden bei den eingangs beschriebenen Kohleuntersuchungen benutzt wurde. Auch die Aluminiumelektroden haben einen Untergrund an der Stelle der Borlinien, der von der Borlinienintensität hätte abgezogen werden müssen. Allerdings enthielt Aluminium keine Spuren Bor wie die Kupferelektroden. Es hat aber einen anderen Nachteil: Die Aluminiumelektroden oxydieren im Lichtbogen sehr schnell. Bei den Kohleuntersuchungen war es nötig, ununterbrochen Kohle nachzufüllen und den Bogen jedesmal neu zu zünden. Bei Verwendung von Aluminiumelektroden hätte man zwischendurch jedesmal die Elektroden abschmirgeln oder abdrehen müssen.

Beryllium.

Das Beryllium lag in Form von Berylliumoxydpulver vor, es wurde ebenfalls im Kohlelichtbogen untersucht. Das Ergebnis war: Der Cadmiumanteil des von Haxel und Volz benutzten Berylliumoxyds ist kleiner als 10^{-5} Molanteile, der Boranteil kleiner als 10^{-3} und größer als 10^{-5} Molanteile. Da der Boranteil sicher für Beryllium als Bremssubstanz viel zu groß ist, wurde auf eine genauere quantitative Untersuchung verzichtet. Bei den Versuchen von Haxel und Volz wurde das Hauptgewicht auf den Vorgang der Streuung und Verlangsamung schneller Neutronen gelegt. In diesem Fall ist der verhältnismäßig große Borgehalt des Berylliums unschädlich. Es sei noch bemerkt, daß von Merck bezogenes Berylliumoxyd kein Bor in nachweisbaren Mengen enthielt.

Gießen, den 17. III. 42. Hanle

Figure D.526: Wilhelm Hanle. *Spectroscopic Analysis of Carbon, Aluminum, and Beryllium.* 1942. [G-153]

E. Graphite

[High-quality graphite was widely used for high-temperature exhaust steering rudders on the A-4 (V-2) and other rockets, and was used for making electrodes, filters, and other components too. However, graphite could also have been quite useful as a neutron moderator to slow down neutrons and promote chain reactions in a fission reactor. The following documents illustrate that wartime production of graphite was widespread and sophisticated.]

Acheson Graphite Corporation to Frank Hodson. 29 July 1942. [NARA RG 77, Entry UD-22A, Box 169, Folder 32.32 Germ. Ind. TA]

Continental European Electrode Plants

Further to my letters of July 24th and 25th, I am glad to send along what information and estimates we have in regard to commercial electrode plants in Continental Europe.

Germany

Graphite

According to estimates made by our people in Europe at the end of 1939, the graphite electrode production in Germany during that year was approximately as follows:

Siemens-Planiawerke, Meitingen	8,500 tons
Conradty, Kolbermoor	2,000 ”
I. G. Farben, Bitterfeld	5,000 ”
	15,500 tons

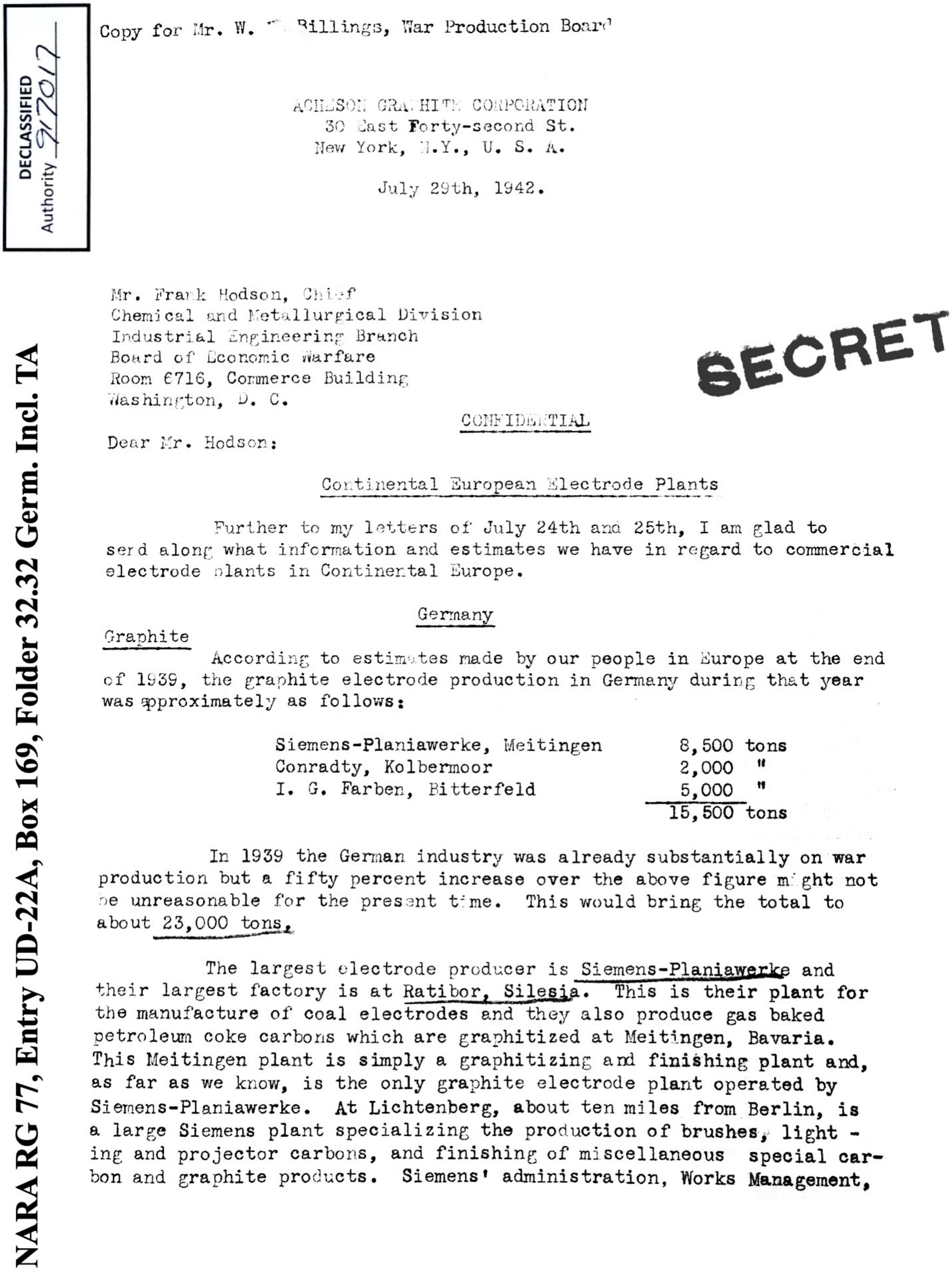
In 1939 the German industry was already substantially on war production but a fifty percent increase over the above figure might not be unreasonable for the present time. This would bring the total to about 23,000 tons. [...]

Coal Electrodes

Our estimate of the production capacity of the three German firms is as follows:

Siemens-Planiawerke, Ratibor	50,000 tons
Conradty, Nürnberg	6,000 ”
I. G. Farben, Bitterfeld	3,500 ”
	59,500 tons

[See document photos on pp. 4111–4113.]



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Authority 917017

NARA RG 77, Entry UD-22A, Box 169, Folder 32.32 Germ. Incl. TA

Copy for Mr. W. [illegible] Billings, War Production Board

ACHESON GRAPHITE CORPORATION
30 East Forty-second St.
New York, N.Y., U. S. A.

July 29th, 1942.

Mr. Frank Hodson, Chief
Chemical and Metallurgical Division
Industrial Engineering Branch
Board of Economic Warfare
Room 6716, Commerce Building
Washington, D. C.

SECRET

CONFIDENTIAL

Dear Mr. Hodson:

Continental European Electrode Plants

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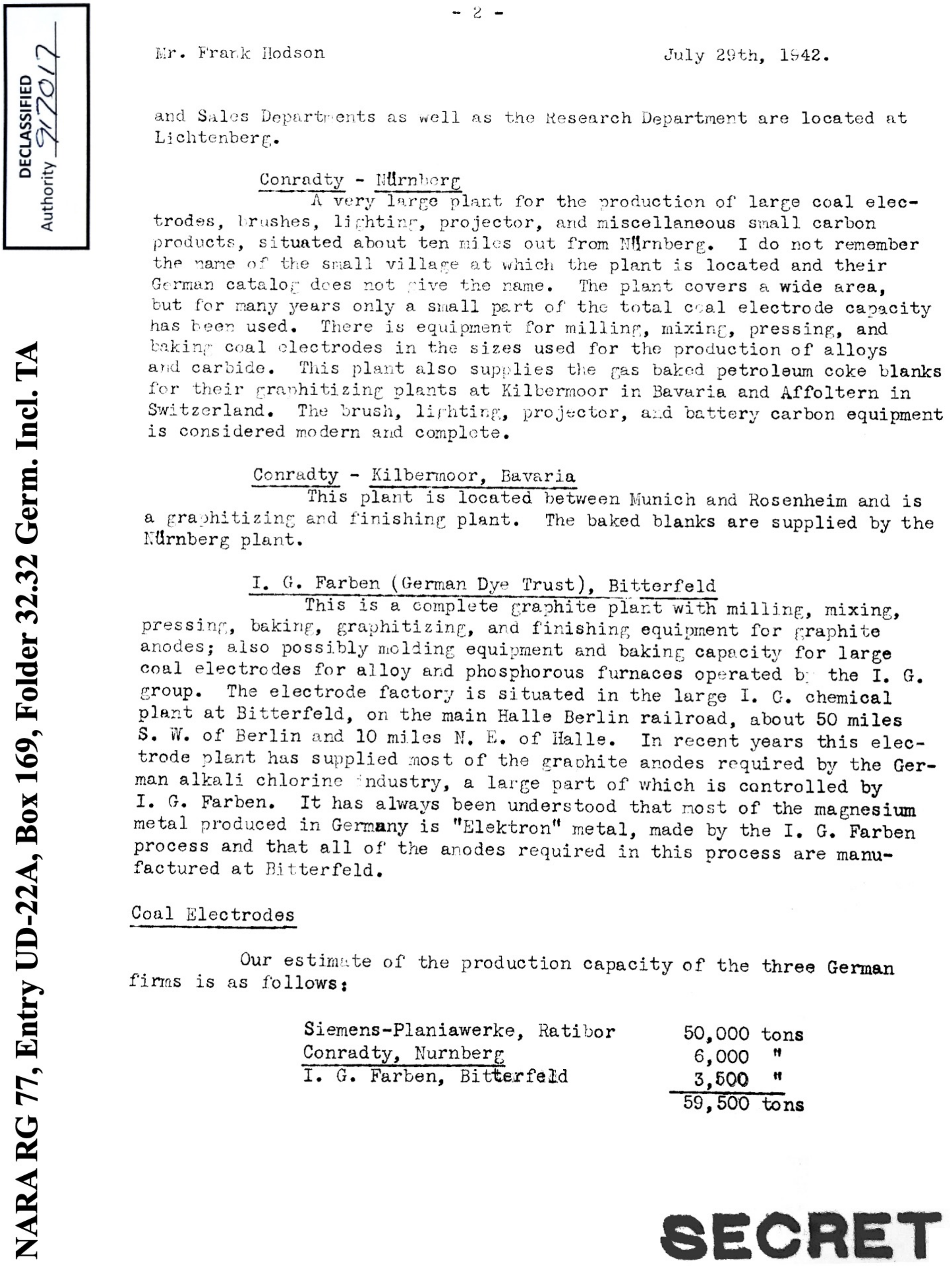
In 1939 the German industry was already substantially on war production but a fifty percent increase over the above figure might not be unreasonable for the present time. This would bring the total to about 23,000 tons.

The largest electrode producer is Siemens-Planiawerke and their largest factory is at Ratibor, Silesia. This is their plant for the manufacture of coal electrodes and they also produce gas baked petroleum coke carbons which are graphitized at Meitingen, Bavaria. This Meitingen plant is simply a graphitizing and finishing plant and, as far as we know, is the only graphite electrode plant operated by Siemens-Planiawerke. At Lichtenberg, about ten miles from Berlin, is a large Siemens plant specializing the production of brushes, lighting and projector carbons, and finishing of miscellaneous special carbon and graphite products. Siemens' administration, Works Management,

Figure D.527: Acheson Graphite Corporation to Frank Hodson. 29 July 1942. [NARA RG 77, Entry UD-22A, Box 169, Folder 32.32 Germ. Ind. TA]



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- 2 -

Mr. Frank Hodson July 29th, 1942.

and Sales Departments as well as the Research Department are located at Lichtenberg.

Conradty - Nürnberg

A very large plant for the production of large coal electrodes, brushes, lighting, projector, and miscellaneous small carbon products, situated about ten miles out from Nürnberg. I do not remember the name of the small village at which the plant is located and their German catalog does not give the name. The plant covers a wide area, but for many years only a small part of the total coal electrode capacity has been used. There is equipment for milling, mixing, pressing, and baking coal electrodes in the sizes used for the production of alloys and carbide. This plant also supplies the gas baked petroleum coke blanks for their graphitizing plants at Kilbermoor in Bavaria and Affoltern in Switzerland. The brush, lighting, projector, and battery carbon equipment is considered modern and complete.

Conradty - Kilbermoor, Bavaria

This plant is located between Munich and Rosenheim and is a graphitizing and finishing plant. The baked blanks are supplied by the Nürnberg plant.

I. G. Farben (German Dye Trust), Bitterfeld

This is a complete graphite plant with milling, mixing, pressing, baking, graphitizing, and finishing equipment for graphite anodes; also possibly molding equipment and baking capacity for large coal electrodes for alloy and phosphorous furnaces operated by the I. G. group. The electrode factory is situated in the large I. G. chemical plant at Bitterfeld, on the main Halle Berlin railroad, about 50 miles S. W. of Berlin and 10 miles N. E. of Halle. In recent years this electrode plant has supplied most of the graphite anodes required by the German alkali chlorine industry, a large part of which is controlled by I. G. Farben. It has always been understood that most of the magnesium metal produced in Germany is "Elektron" metal, made by the I. G. Farben process and that all of the anodes required in this process are manufactured at Bitterfeld.

Coal Electrodes

Our estimate of the production capacity of the three German firms is as follows:

Siemens-Planiawerke, Ratibor	50,000 tons
Conradty, Nurnberg	6,000 "
I. G. Farben, Bitterfeld	3,500 "
	59,500 tons

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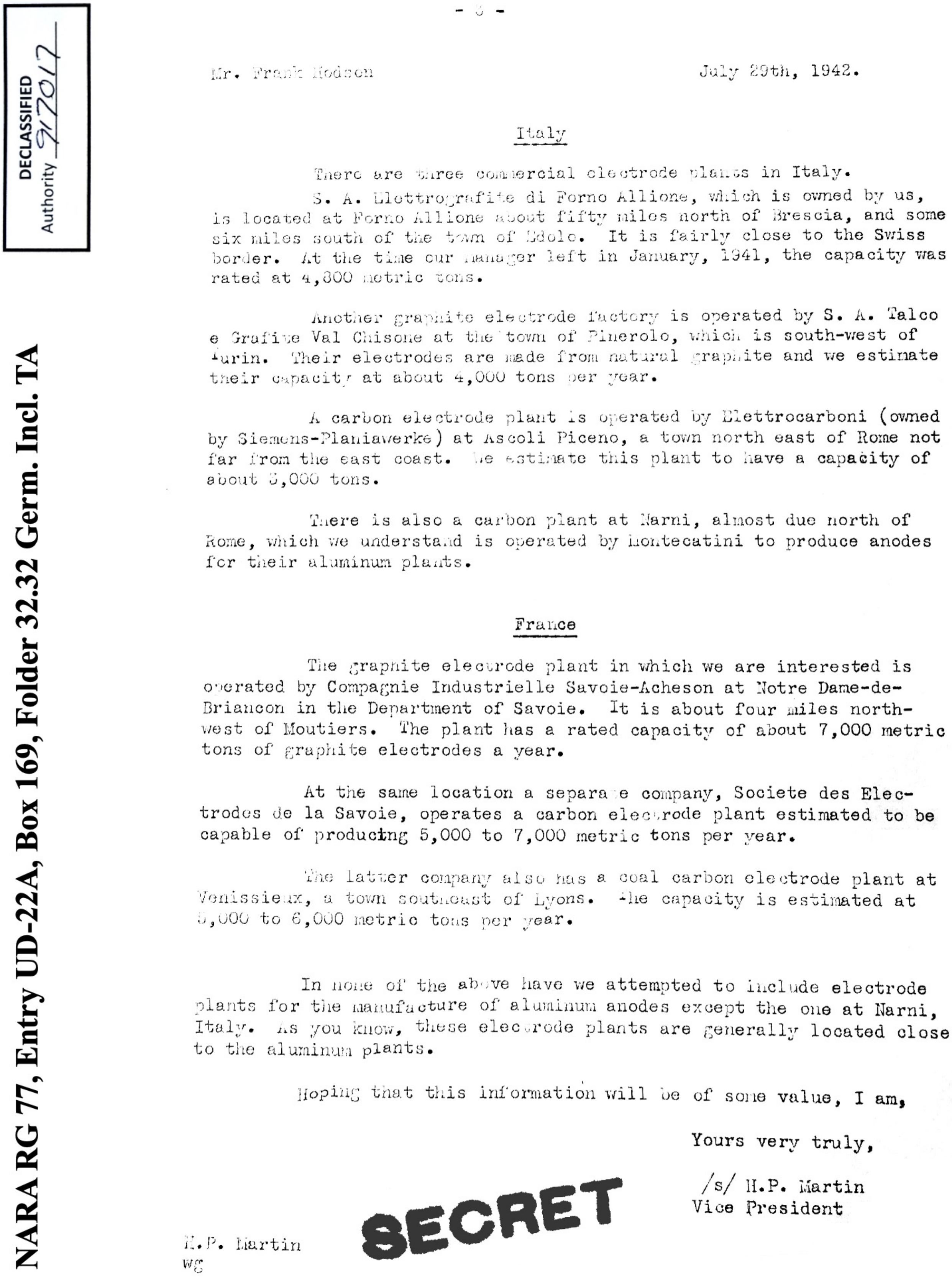
Figure D.528: Acheson Graphite Corporation to Frank Hodson. 29 July 1942. [NARA RG 77, Entry UD-22A, Box 169, Folder 32.32 Germ. Ind. TA]



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- 3 -

Mr. Frank Hodson July 29th, 1942.

Italy

There are three commercial electrode plants in Italy.

S. A. Elettrografite di Forno Allione, which is owned by us, is located at Forno Allione about fifty miles north of Brescia, and some six miles south of the town of Edolo. It is fairly close to the Swiss border. At the time our manager left in January, 1941, the capacity was rated at 4,800 metric tons.

Another graphite electrode factory is operated by S. A. Talco e Grafite Val Chisone at the town of Pinerolo, which is south-west of Turin. Their electrodes are made from natural graphite and we estimate their capacity at about 4,000 tons per year.

A carbon electrode plant is operated by Elettrocarboni (owned by Siemens-Planiawerke) at Ascoli Piceno, a town north east of Rome not far from the east coast. We estimate this plant to have a capacity of about 3,000 tons.

There is also a carbon plant at Narni, almost due north of Rome, which we understand is operated by Montecatini to produce anodes for their aluminum plants.

France

The graphite electrode plant in which we are interested is operated by Compagnie Industrielle Savoie-Acheson at Notre Dame-de-Briancon in the Department of Savoie. It is about four miles north-west of Moutiers. The plant has a rated capacity of about 7,000 metric tons of graphite electrodes a year.

At the same location a separate company, Societe des Electrodes de la Savoie, operates a carbon electrode plant estimated to be capable of producing 5,000 to 7,000 metric tons per year.

The latter company also has a coal carbon electrode plant at Venissieux, a town southeast of Lyons. The capacity is estimated at 5,000 to 6,000 metric tons per year.

In none of the above have we attempted to include electrode plants for the manufacture of aluminum anodes except the one at Narni, Italy. As you know, these electrode plants are generally located close to the aluminum plants.

Hoping that this information will be of some value, I am,

Yours very truly,

/s/ H.P. Martin
Vice President

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H.P. Martin
wg

Figure D.529: Acheson Graphite Corporation to Frank Hodson. 29 July 1942. [NARA RG 77, Entry UD-22A, Box 169, Folder 32.32 Germ. Ind. TA]

FIAT 397. *Survey of the Carbon and Graphite Electrode Industry of Germany.* With two supplements. pp. 6, 11.

[...] The discussions with the SIEMENS technical organization showed the possession of the extensive empirical know-how needed for successful operation in this industry, compounded as it must be of experience and science. Thus, as respects empirical know-how, the German industry could be rated as perhaps about equal to the U.S.

As far as scientific know-how and study of the fundamentals of carbon technology are concerned, the German industry has depended very largely upon collaboration with academic researchers, mainly with Prof. ULRICH HOFFMANN. The German industry has directed its technical work more along development lines. [...]

The following tabulation shows the total German production capacity for the baked basic stock for either carbon or graphite electrodes, comparing the installed capacity near the end of the war with that now available in the U.S. Zone [of Germany]. There is no other baked electrode capacity except at some of the aluminum plants which produce their own special electrodes.

The tabulation is in terms of baked weight. The indicated tons are of 1,000 kg. = 2,200 lb.

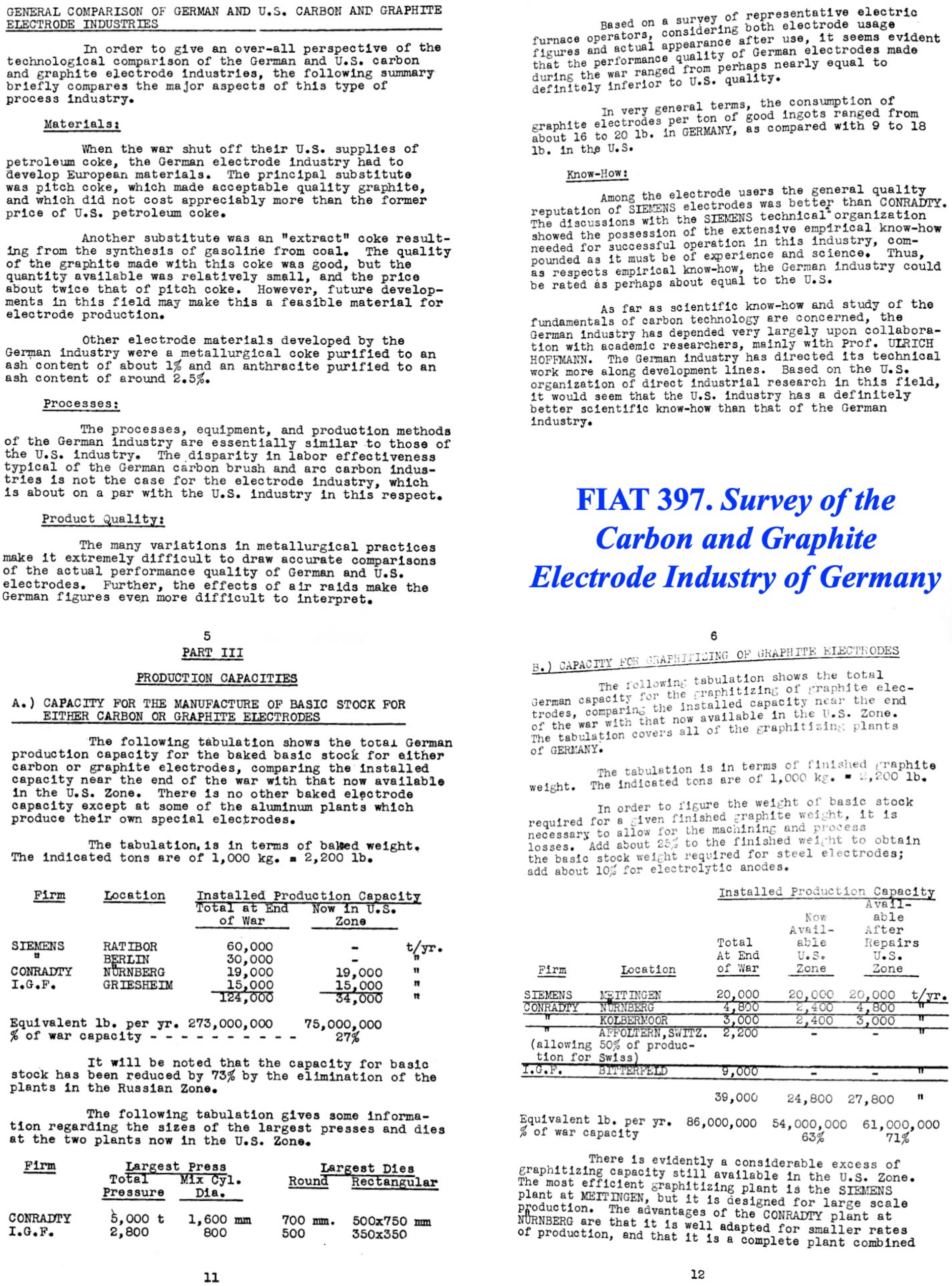
Firm	Location	Installed Total at End of War	Production Now in U.S. Zone	Capacity
SIEMENS	RATIBOR	60,000	–	t/yr.
”	BERLIN	30,000	–	”
CONRADTY	NÜRNBERG	19,000	19,000	”
I.G.F.	GRIESHEIM	15,000	15,000	”
		124,000	34,000	”

[See document photos on p. 4115.

Note that this postwar U.S. survey found that by the end of the war, the actual German annual production of graphite was even larger than what the United States had estimated during the war.

Conventional historians often claim that the German nuclear program foolishly rejected graphite as a reactor moderator, instead focusing only on heavy water. Heavy water has many advantages over graphite (p. 4029), yet there is evidence that the German nuclear program used graphite too. I.G. Farben's Bitterfeld facility was mass-producing both graphite (p. 4110) and heavy water (p. 4050) as well as other nuclear-related materials (pp. 4128, 4133, 4136). Similarly, Griesheim plants were producing both graphite (pp. 4114–4116) and heavy water (pp. 4066–4067), with other nuclear-related facilities such as Degussa in the same area [Hayes 2004; Nagel 2016]. Graphite was also mass-produced at the Siemens Plania Werke in Racibórz/Ratibor, Poland (pp. 4110–4114), near a reported heavy water plant at Auschwitz (pp. 4069, 4452) and reported uranium enrichment plants at Opava and Ostrava (p. 3749).]

FIAT 397. *Survey of the Carbon and Graphite Electrode Industry of Germany*



GENERAL COMPARISON OF GERMAN AND U.S. CARBON AND GRAPHITE ELECTRODE INDUSTRIES

In order to give an over-all perspective of the technological comparison of the German and U.S. carbon and graphite electrode industries, the following summary briefly compares the major aspects of this type of process industry.

Materials:

When the war shut off their U.S. supplies of petroleum coke, the German electrode industry had to develop European materials. The principal substitute was pitch coke, which made acceptable quality graphite, and which did not cost appreciably more than the former price of U.S. petroleum coke.

Another substitute was an "extract" coke resulting from the synthesis of gasoline from coal. The quality of the graphite made with this coke was good, but the quantity available was relatively small, and the price about twice that of pitch coke. However, future developments in this field may make this a feasible material for electrode production.

Other electrode materials developed by the German industry were a metallurgical coke purified to an ash content of about 1% and an anthracite purified to an ash content of around 2.5%.

Processes:

The processes, equipment, and production methods of the German industry are essentially similar to those of the U.S. industry. The disparity in labor effectiveness typical of the German carbon brush and arc carbon industries is not the case for the electrode industry, which is about on a par with the U.S. industry in this respect.

Product Quality:

The many variations in metallurgical practices make it extremely difficult to draw accurate comparisons of the actual performance quality of German and U.S. electrodes. Further, the effects of air raids make the German figures even more difficult to interpret.

Based on a survey of representative electric furnace operators, considering both electrode usage figures and actual appearance after use, it seems evident that the performance quality of German electrodes made during the war ranged from perhaps nearly equal to definitely inferior to U.S. quality.

In very general terms, the consumption of graphite electrodes per ton of good ingots ranged from about 16 to 20 lb. in GERMANY, as compared with 9 to 18 lb. in the U.S.

Know-How:

Among the electrode users the general quality reputation of SIEMENS electrodes was better than CONRADTY. The discussions with the SIEMENS technical organization showed the possession of the extensive empirical know-how needed for successful operation in this industry, compounded as it must be of experience and science. Thus, as respects empirical know-how, the German industry could be rated as perhaps about equal to the U.S.

As far as scientific know-how and study of the fundamentals of carbon technology are concerned, the German industry has depended very largely upon collaboration with academic researchers, mainly with Prof. ULRICH HOFFMANN. The German industry has directed its technical work more along development lines. Based on the U.S. organization of direct industrial research in this field, it would seem that the U.S. industry has a definitely better scientific know-how than that of the German industry.

PART III

PRODUCTION CAPACITIES

A.) CAPACITY FOR THE MANUFACTURE OF BASIC STOCK FOR EITHER CARBON OR GRAPHITE ELECTRODES

The following tabulation shows the total German production capacity for the baked basic stock for either carbon or graphite electrodes, comparing the installed capacity near the end of the war with that now available in the U.S. Zone. There is no other baked electrode capacity except at some of the aluminum plants which produce their own special electrodes.

The tabulation, is in terms of baked weight. The indicated tons are of 1,000 kg. = 2,200 lb.

Firm	Location	Installed Production Capacity Total at End of War	Now in U.S. Zone	
SIEMENS	RATIBOR	60,000	-	t/yr.
"	BERLIN	30,000	-	"
CONRADTY	NÜRNBERG	19,000	19,000	"
I.G.F.	GRIESHEIM	15,000	15,000	"
		124,000	34,000	"
Equivalent lb. per yr.		273,000,000	75,000,000	
% of war capacity		- - - - - - - - - -	27%	

It will be noted that the capacity for basic stock has been reduced by 73% by the elimination of the plants in the Russian Zone.

The following tabulation gives some information regarding the sizes of the largest presses and dies at the two plants now in the U.S. Zone.

Firm	Largest Press Total Pressure	Mix Cyl. Dia.	Largest Dies Round	Rectangular
CONRADTY	5,000 t	1,600 mm	700 mm.	500x750 mm
I.G.F.	2,800	800	500	350x350

B.) CAPACITY FOR GRAPHITIZING OF GRAPHITE ELECTRODES

The following tabulation shows the total German capacity for the graphitizing of graphite electrodes, comparing the installed capacity near the end of the war with that now available in the U.S. Zone. The tabulation covers all of the graphitizing plants of GERMANY.

The tabulation is in terms of finished graphite weight. The indicated tons are of 1,000 kg. = 2,200 lb.

In order to figure the weight of basic stock required for a given finished graphite weight, it is necessary to allow for the machining and process losses. Add about 25% to the finished weight to obtain the basic stock weight required for steel electrodes; add about 10% for electrolytic anodes.

Firm	Location	Installed Production Capacity Total At End of War	Now Available U.S. Zone	Available After Repairs U.S. Zone	
SIEMENS	MEITINGEN	20,000	20,000	20,000	t/yr.
CONRADTY	NÜRNBERG	4,800	2,400	4,800	"
"	KOLBERMOOR	3,000	2,400	3,000	"
" (allowing 50% of production for Swiss)	AFFOLTERN, SWITZ.	2,200	-	-	"
I.G.F.	BITTERFELD	9,000	-	-	"
		39,000	24,800	27,800	"
Equivalent lb. per yr.		86,000,000	54,000,000	61,000,000	
% of war capacity			63%	71%	

There is evidently a considerable excess of graphitizing capacity still available in the U.S. Zone. The most efficient graphitizing plant is the SIEMENS plant at MEITINGEN, but it is designed for large scale production. The advantages of the CONRADTY plant at NÜRNBERG are that it is well adapted for smaller rates of production, and that it is a complete plant combined

Figure D.530: FIAT 397. *Survey of the Carbon and Graphite Electrode Industry of Germany.*

For more information on wartime graphite production and applications, see:

BIOS 258. *Carbon Electrodes, I.G. Farben, Griesheim.*

BIOS 337. *German Graphitising Furnances at Meitingen (Siemens Plania).*

BIOS 338. *German Carbon Electrode Manufacture at Griesheim (I.G.F.).*

BIOS 533. *Electric Furnace Design. Manufacture and Application in Germany.*

BIOS 715. *The Microanalytical Methods Employed in the Analytical Laboratories of I.G. Farben, Elberfeld-Wuppertal, Germany.* [Micro-analytical measurement of carbon at I.G. Farben.]

BIOS 819. *Blast Furnaces. Notes on German Practice.* [Carbon hearths to blast furnaces; carbon paste and bricks.]

BIOS 845. *Constructional Details of Chlorine Plant at Hoechst and Gendorf.* [Carbon anodes for chlorine cells.]

BIOS 895. *Aluminium Production at Vereinigte Aluminiumwerke (V.A.W.), Lünen.* [Carbon paste for Soderberg electrodes manufacture.]

BIOS 1181. [Graphitising of carbon electrodes: graphite brushes.]

BIOS 1230. [Carbon rocket rudders]

BIOS 1338. *Developments in Magnesium Production and Fabrication.* [Beryllium, zirconium at Degussa; also fluorine and carbon at I.G. Farben.]

BIOS 1399. *The Production of Carbon Black from Carbon Monoxide.*

BIOS 1596. *Carbon Electrodes. Report on the Interrogations of Dr. Diederich Wilm.*

BIOS 1823. *German Carbon Industry and Hydraulic Press Manufacture.*

CIOS XVII-2. *Englebert Factories—Liege and Aachen Kabelundgummiwerke-Eupen.* [Carbon black.]

CIOS XVIII-1. *Chemical Installations in the Cologne Area.* [Carbon black.]

CIOS XXVI-51. *Plant of Chemische Werke, Huls.* [Carbon black.]

CIOS XXVII-84. *I.G. Farben AG, Ludwigshafen and Oppau Wehrmacht Items.* [Carbon black.]

CIOS XXIX-14. *I. G. Farbenindustrie A. G., Leverkusen, Germany.* [Carbon, activated, production.]

CIOS XXIX-19. *Aluminum Reduction and Scrap Recovery at the Erftwerk of the Vereinigte Aluminum-Werke AG, Grevenbroich.* [Carbon anode plant.]

CIOS XXXIII-31. *Investigation of Certain Chemical Factories in the Leipzig Area of Germany.* [Artificial gems, graphite at I.G. Farben]

FIAT 104. *Survey of the Arc Carbon Industry of Germany.*

FIAT 105. *Survey of Manufacture of Graphite Rudders for V-2 Rockets.*

FIAT 115. *Survey of the Carbon Brush Industry for Electrical Equipment in Germany.*

FIAT 408. *Metallurgical Coke.*

FIAT 524. *Production of Aluminum.* [Carbon paste for Soderberg electrodes.]

FIAT 617. *The Electrical and Technical Ceramic Industry of Germany.* [Graphite resistors.]

FIAT 732. *Electrochemical Operations at I.G. Farbenindustrie A.G., Bitterfeld.* With 30 supplements.

FIAT 816. *Horizontal Mercury Chlorine Cells, I.G. Farbenindustrie, A.G.* [Graphite anodes.]

FIAT 817. *Vertical Mercury Chlorine Cells, I.G. Farbenindustrie, A.G.* [Graphite anodes.]

FIAT 863. *Activated-Carbon Production at I.G. Farbenindustrie, Leverkusen.*

FIAT 986. *Carbon Electrodes in Germany for the Aluminum Reduction Industry.*

FIAT 993. *The Aluminum Reduction Industry in Germany.* [Carbon electrodes for aluminum production.]

FIAT 1052. *The High Current Carbon Arc.*

G-35. Wilhelm Hanle. *Investigation of Cadmium Content of Carbon.* 1940.

G-46. Georg Joos. *The Production of Extremely Pure Carbon.* 1940.

G-85. Wilhelm Hanle. *The Determination of Boron and Cadmium in Carbon.* 1941.

G-153. Wilhelm Hanle. *Spectroscopic Analysis of Carbon, Aluminum, and Beryllium.* 1942.

F. Fluorine

[Fluorine was used for various industrial chemical production processes, but it also would have been essential for producing uranium hexafluoride for the enrichment of uranium-235. The following documents demonstrate large-scale production of fluorine.

For information on wartime German production of uranium hexafluoride for uranium enrichment, see pp. 3478–3493.]

Philip Morrison to Samuel K. Allison. 20 December 1943. Report on Enemy Physics Literature: Survey Report P. [NARA RG 77, Entry UD-22A, Box 170, Folder 32.60-1 GERMANY: Summary Reports (1944)]

The nearly unique position of fluorine in most successful separation schemes leads to an interest in the state of fluorine chemistry. (The examination of this point is the work of Dr. J. Katz of Seaborg's division.)

The general interest of German chemical industry in inorganic preparations, and probably also early preparation for chemical warfare, has put German fluorine chemistry considerably ahead of our own. In 1939 it was possible to procure fluorine gas in bombs(18) from the inorganic section of the I.G. at Leverkusen, near Frankfurt a. M. It is still not easy to do this in the United States. The number of trained inorganic chemists and even of fluorine workers in Germany was greater then than the number now available to the three projects in this country. A few of the leading men and institutions are:

H. v. Wartenberg	Göttingen
Wilhelm Klemm (Klemm has been interested in the chemistry of 93.)	Danzig-Langfuhr
Wilhelm Biltz	Hanover u. Göttingen
Eduard Zintl	Darmstadt

There is little doubt that the I.G. would be the constructor of any large-scale separation plant. Such a plant would probably be at Leverkusen, near Frankfurt. Frankfurt a. M. is the center of the German chemical industry; the Deutsche Gold- und Silber-Scheide-Anstalt A.G. is there as well. One might speculate that Bothe's and Rajewsky's groups form the physics staff—with the K.W.I. f. Physik the Y [Los Alamos] equivalent—for a Leverkusen or Frankfurt plant.

(Can the information bearing on this region be especially searched for clues?) [...]

(18) Z. anorg. allg. Chem., 242, 406 (1939)

[See document photo on p. 4119.]

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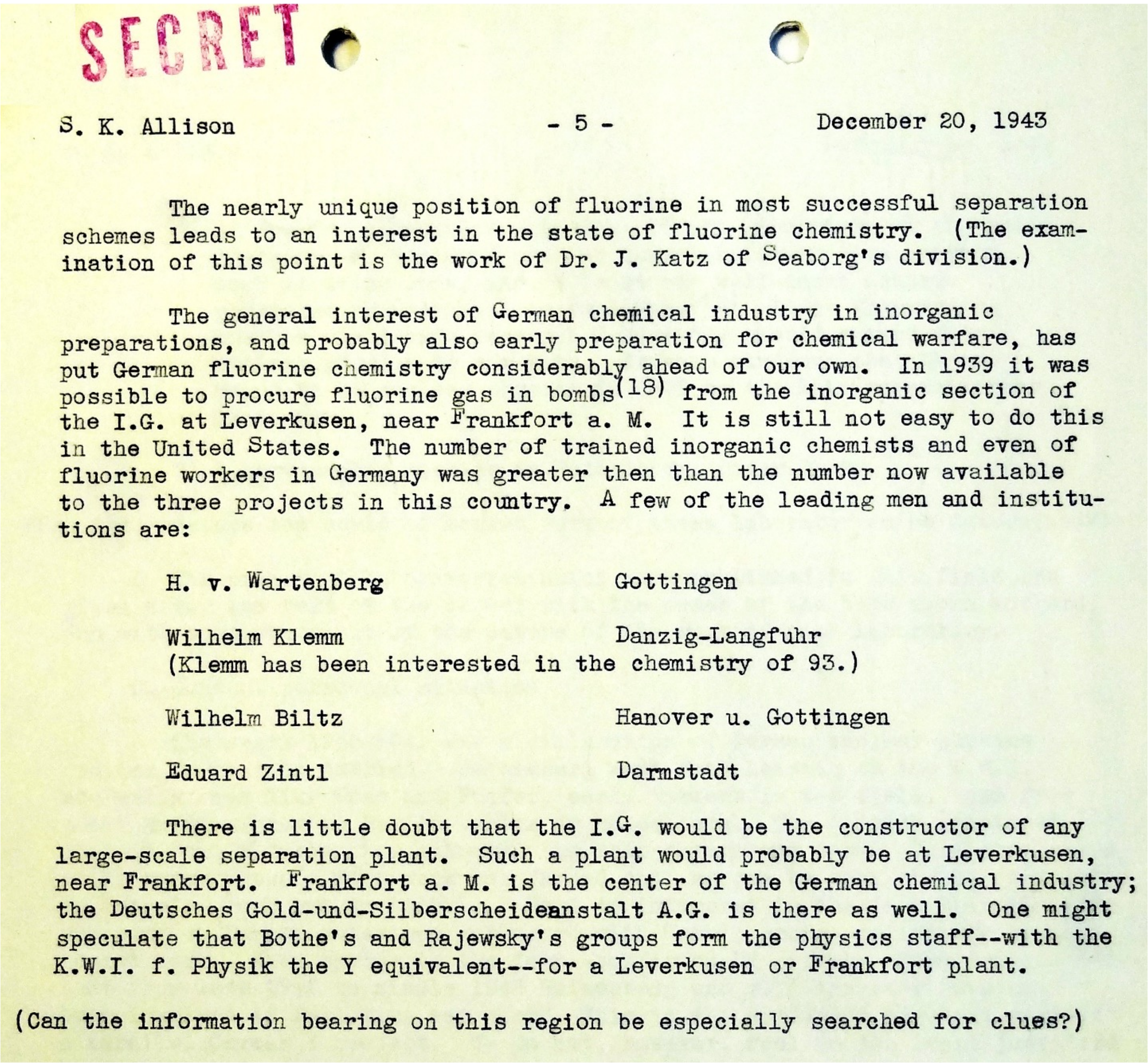
NARA RG 77, Entry UD-22A, Box 170, Folder 32.60-1 GERMANY: Summary Reports (1944), Philip Morrison to Samuel K. Allison, 20 December 1943, Report on Enemy Physics Literature: Survey Report P.



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S. K. Allison - 5 - December 20, 1943

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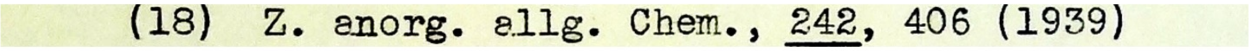
(Can the information bearing on this region be especially searched for clues?)



(18) Z. anorg. allg. Chem., 242, 406 (1939)

Figure D.531: Philip Morrison to Samuel K. Allison. 20 December 1943. Report on Enemy Physics Literature: Survey Report P. [NARA RG 77, Entry UD-22A, Box 170, Folder 32.60-1 GERMANY: Summary Reports (1944)]

J. A. Lane. 5 April 1945. SUBJECT: Interrogation of Doctor Halberland. [NARA RG 77, Entry UD-22A, Box 166, Folder 32.22-1—GERMANY—Research—TA—(1943–June 1946)]

1. Doctor Halberland, technical director of the lower Rhine division of the I. G. Farben Company, was located at I. G. Farben's plant at Uerdingen on the Rhine. [...]

3. [...] Large quantities of fluorine are produced at Leverkusen as well as Germany's major production of titanium. [...]

5. [...] In his opinion, eight days only would be required to bring the plant to 70 per cent production. [...]

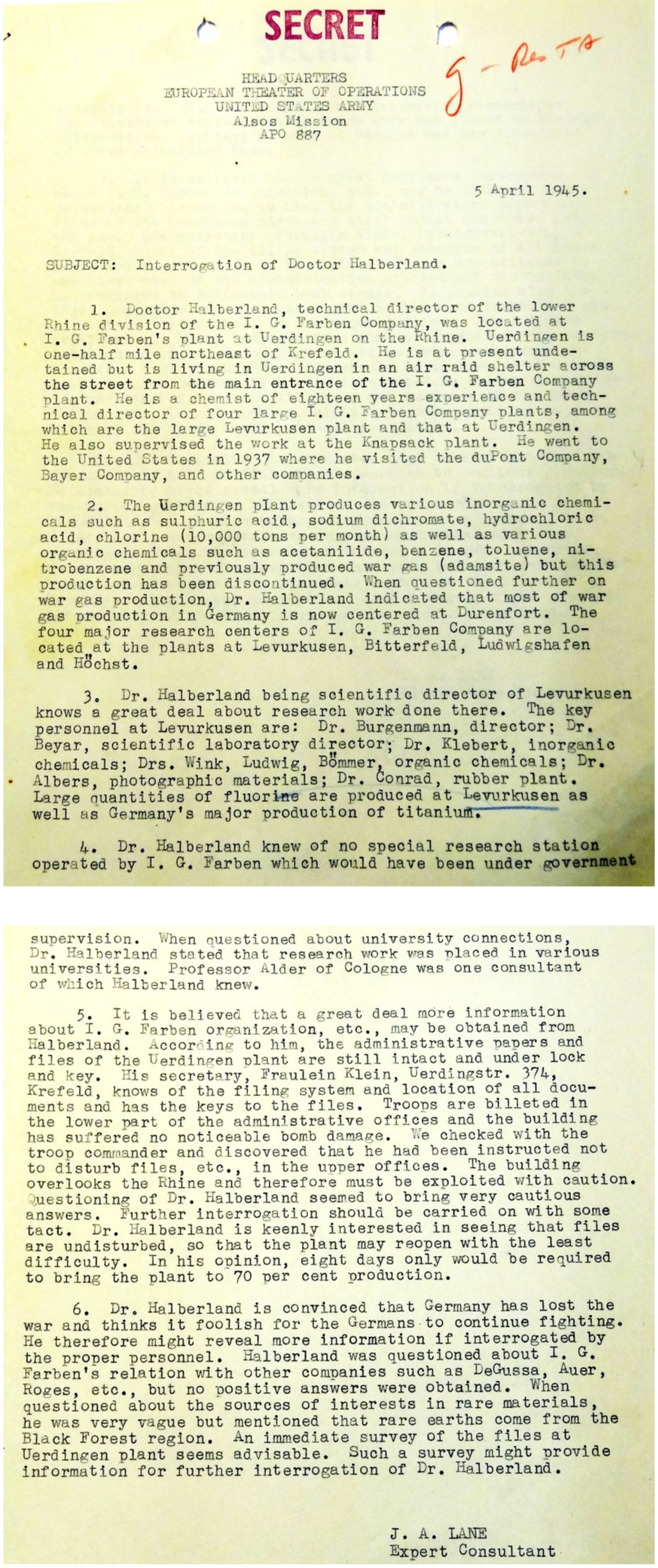
6. [...] Halberland was questioned about I. G. Farben's relation with other companies such as DeGussa, Auer, Roges, etc., but no positive answers were obtained. When questioned about the sources of interests in rare materials, he was very vague but mentioned that rare earths come from the Black Forest region. [...]

[See document photos on p. 4121.

I.G. Farben produced large quantities of fluorine. DeGussa, Auer, Roges, and other companies produced uranium. To produce uranium hexafluoride, it would have been necessary for I.G. Farben to collaborate with those companies. When the I.G. Farben director, Dr. Halberland, was interrogated about such collaborations, he refused to provide answers, but apparently indicated that they did exist.

Notes from this interrogation were considered so important regarding Germany's nuclear program that they were placed in the files of Leslie Groves's Foreign Intelligence Unit of the U.S. Manhattan Project.]

NARA RG 77, Entry UD-22A, Box 166, Folder 32.22-1—GERMANY—Research—TA—(1943–June 1946)



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HEADQUARTERS
EUROPEAN THEATER OF OPERATIONS
UNITED STATES ARMY
Alsos Mission
APO 887

5 April 1945.

SUBJECT: Interrogation of Doctor Halberland.

1. Doctor Halberland, technical director of the lower Rhine division of the I. G. Farben Company, was located at I. G. Farben's plant at Uerdingen on the Rhine. Uerdingen is one-half mile northeast of Krefeld. He is at present undetained but is living in Uerdingen in an air raid shelter across the street from the main entrance of the I. G. Farben Company plant. He is a chemist of eighteen years experience and technical director of four large I. G. Farben Company plants, among which are the large Levurkusen plant and that at Uerdingen. He also supervised the work at the Knapsack plant. He went to the United States in 1937 where he visited the duPont Company, Bayer Company, and other companies.

2. The Uerdingen plant produces various inorganic chemicals such as sulphuric acid, sodium dichromate, hydrochloric acid, chlorine (10,000 tons per month) as well as various organic chemicals such as acetanilide, benzene, toluene, nitrobenzene and previously produced war gas (adamsite) but this production has been discontinued. When questioned further on war gas production, Dr. Halberland indicated that most of war gas production in Germany is now centered at Durenfort. The four major research centers of I. G. Farben Company are located at the plants at Levurkusen, Bitterfeld, Ludwigshafen and Höchst.

3. Dr. Halberland being scientific director of Levurkusen knows a great deal about research work done there. The key personnel at Levurkusen are: Dr. Burgenmann, director; Dr. Beyar, scientific laboratory director; Dr. Klebert, inorganic chemicals; Drs. Wink, Ludwig, Bömmer, organic chemicals; Dr. Albers, photographic materials; Dr. Conrad, rubber plant. Large quantities of fluorine are produced at Levurkusen as well as Germany's major production of titanium.

4. Dr. Halberland knew of no special research station operated by I. G. Farben which would have been under government supervision. When questioned about university connections, Dr. Halberland stated that research work was placed in various universities. Professor Alder of Cologne was one consultant of which Halberland knew.

5. It is believed that a great deal more information about I. G. Farben organization, etc., may be obtained from Halberland. According to him, the administrative papers and files of the Uerdingen plant are still intact and under lock and key. His secretary, Fraulein Klein, Uerdingstr. 374, Krefeld, knows of the filing system and location of all documents and has the keys to the files. Troops are billeted in the lower part of the administrative offices and the building has suffered no noticeable bomb damage. We checked with the troop commander and discovered that he had been instructed not to disturb files, etc., in the upper offices. The building overlooks the Rhine and therefore must be exploited with caution. Questioning of Dr. Halberland seemed to bring very cautious answers. Further interrogation should be carried on with some tact. Dr. Halberland is keenly interested in seeing that files are undisturbed, so that the plant may reopen with the least difficulty. In his opinion, eight days only would be required to bring the plant to 70 per cent production.

6. Dr. Halberland is convinced that Germany has lost the war and thinks it foolish for the Germans to continue fighting. He therefore might reveal more information if interrogated by the proper personnel. Halberland was questioned about I. G. Farben's relation with other companies such as DeGussa, Auer, Roges, etc., but no positive answers were obtained. When questioned about the sources of interests in rare materials, he was very vague but mentioned that rare earths come from the Black Forest region. An immediate survey of the files at Uerdingen plant seems advisable. Such a survey might provide information for further interrogation of Dr. Halberland.

J. A. LANE
Expert Consultant

Figure D.532: James A. Lane. 5 April 1945. SUBJECT: Interrogation of Doctor Halberland [NARA RG 77, Entry UD-22A, Box 166, Folder 32.22-1—GERMANY—Research—TA—(1943–June 1946)].

BIOS 1595. *German Fluorine and Fluoride Industry.* pp. 5–7.

The first system has been developed by Dr. Siemans of Riedel de Haen. This has been installed at Vereinigte Flusspatgruben where six sets of retorts were erected complete with absorption systems and redistillation equipment and a further six in process of erection. The completed factory would have been capable of producing at least 6000 tons of pure anhydrous hydrofluoric acid per year. [...]

The completed plant at Leverkusen Works is capable of producing hydrofluoric acid at 80% strength equivalent to 9,600 tons per year, of which 960 tons per year would be 98–100% without redistillation. [...]

An unique system has been installed at the I.G. Oppau Works for the production of cryolite from low grade feldspar. The process is cyclic and appears very efficient. [...]

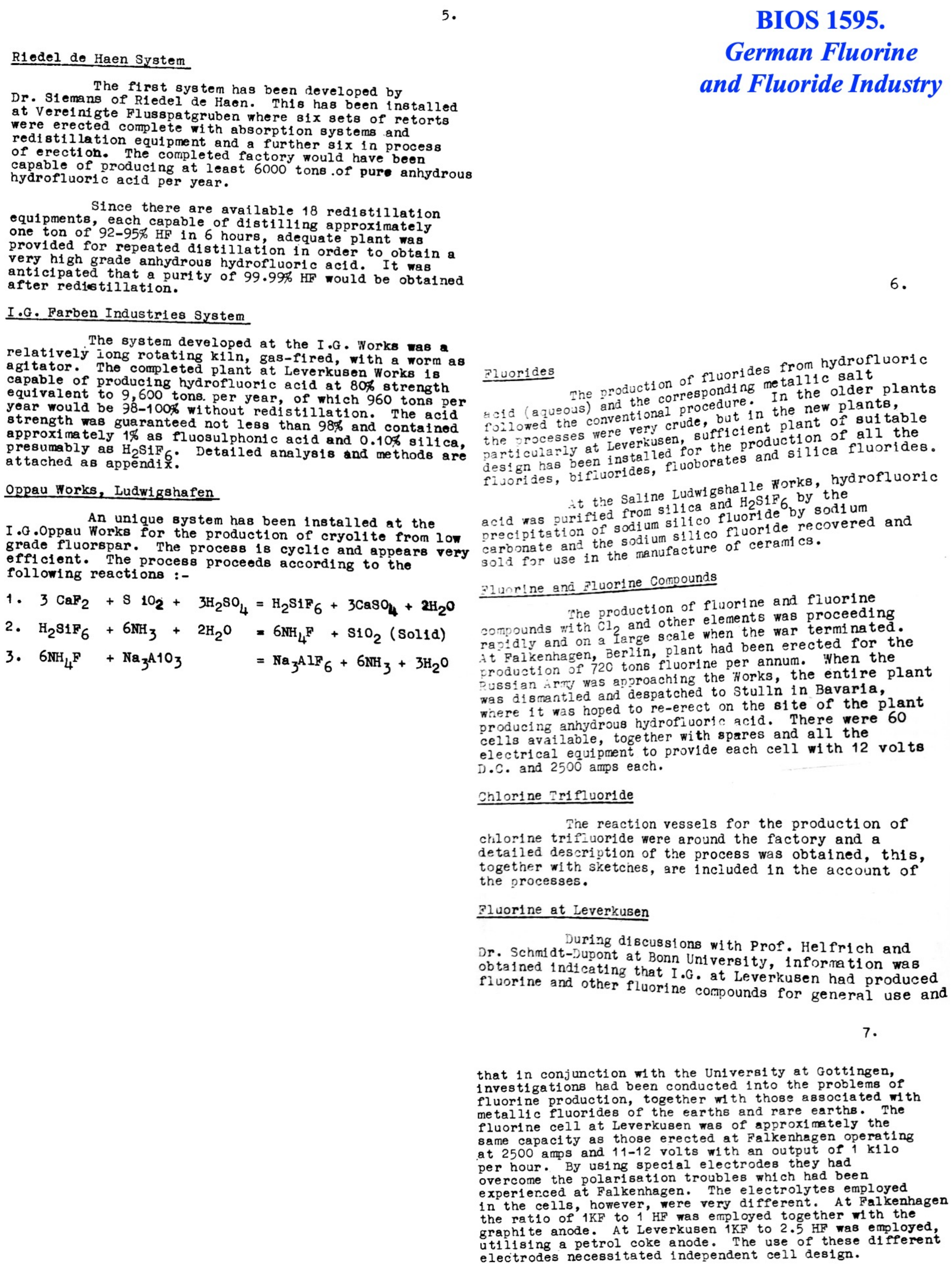
The production of fluorides from hydrofluoric acid (aqueous) and the corresponding metallic salt followed the conventional procedure. In the older plants the processes were very crude, but in the new plants, particularly at Leverkusen, sufficient plant of suitable design has been installed for the production of all the fluorides, bifluorides, fluoborates and silica fluorides. [...]

At Falkenhagen, Berlin, plant had been erected for the production of 720 tons fluorine per annum. When the Russian Army was approaching the Works, the entire plant was dismantled and despatched to Stulln in Bavaria, where it was hoped to re-erect on the site of the plant producing anhydrous hydrofluoric acid. [...]

During discussions with Prof. Helfrich and Dr. Schmidt-Dupont at Bonn University, information was obtained indicating that I.G. at Leverkusen had produced fluorine and other fluorine compounds for general use and that in conjunction with the University of Göttingen, investigations had been conducted into the problems of fluorine production, together with those associated with metallic fluorides of the earths and rare earths. [...]

[See document photos on p. 4123.

Metallic fluorides could have included uranium hexafluoride.]



BIOS 1595.
German Fluorine and Fluoride Industry

Riedel de Haen System

The first system has been developed by Dr. Siemans of Riedel de Haen. This has been installed at Vereinigte Flusspatgruben where six sets of retorts were erected complete with absorption systems and redistillation equipment and a further six in process of erection. The completed factory would have been capable of producing at least 6000 tons of pure anhydrous hydrofluoric acid per year.

Since there are available 18 redistillation equipments, each capable of distilling approximately one ton of 92-95% HF in 6 hours, adequate plant was provided for repeated distillation in order to obtain a very high grade anhydrous hydrofluoric acid. It was anticipated that a purity of 99.99% HF would be obtained after redistillation.

I.G. Farben Industries System

The system developed at the I.G. Works was a relatively long rotating kiln, gas-fired, with a worm as agitator. The completed plant at Leverkusen Works is capable of producing hydrofluoric acid at 80% strength equivalent to 9,600 tons per year, of which 960 tons per year would be 98-100% without redistillation. The acid strength was guaranteed not less than 98% and contained approximately 1% as fluosulphonic acid and 0.10% silica, presumably as H_2SiF_6. Detailed analysis and methods are attached as appendix.

Oppau Works, Ludwigshafen

An unique system has been installed at the I.G. Oppau Works for the production of cryolite from low grade fluorspar. The process is cyclic and appears very efficient. The process proceeds according to the following reactions :-

1. $3\,CaF_2 + SiO_2 + 3H_2SO_4 = H_2SiF_6 + 3CaSO_4 + 2H_2O$
2. $H_2SiF_6 + 6NH_3 + 2H_2O = 6NH_4F + SiO_2$ (Solid)
3. $6NH_4F + Na_3AlO_3 = Na_3AlF_6 + 6NH_3 + 3H_2O$

Fluorides

The production of fluorides from hydrofluoric acid (aqueous) and the corresponding metallic salt followed the conventional procedure. In the older plants the processes were very crude, but in the new plants, particularly at Leverkusen, sufficient plant of suitable design has been installed for the production of all the fluorides, bifluorides, fluoborates and silica fluorides.

At the Saline Ludwigshalle Works, hydrofluoric acid was purified from silica and H_2SiF_6 by the precipitation of sodium silico fluoride by sodium carbonate and the sodium silico fluoride recovered and sold for use in the manufacture of ceramics.

Fluorine and Fluorine Compounds

The production of fluorine and fluorine compounds with Cl_2 and other elements was proceeding rapidly and on a large scale when the war terminated. At Falkenhagen, Berlin, plant had been erected for the production of 720 tons fluorine per annum. When the Russian Army was approaching the Works, the entire plant was dismantled and despatched to Stulln in Bavaria, where it was hoped to re-erect on the site of the plant producing anhydrous hydrofluoric acid. There were 60 cells available, together with spares and all the electrical equipment to provide each cell with 12 volts D.C. and 2500 amps each.

Chlorine Trifluoride

The reaction vessels for the production of chlorine trifluoride were around the factory and a detailed description of the process was obtained, this, together with sketches, are included in the account of the processes.

Fluorine at Leverkusen

During discussions with Prof. Helfrich and Dr. Schmidt-Dupont at Bonn University, information was obtained indicating that I.G. at Leverkusen had produced fluorine and other fluorine compounds for general use and

that in conjunction with the University at Gottingen, investigations had been conducted into the problems of fluorine production, together with those associated with metallic fluorides of the earths and rare earths. The fluorine cell at Leverkusen was of approximately the same capacity as those erected at Falkenhagen operating at 2500 amps and 11-12 volts with an output of 1 kilo per hour. By using special electrodes they had overcome the polarisation troubles which had been experienced at Falkenhagen. The electrolytes employed in the cells, however, were very different. At Falkenhagen the ratio of 1KF to 1 HF was employed together with the graphite anode. At Leverkusen 1KF to 2.5 HF was employed, utilising a petrol coke anode. The use of these different electrodes necessitated independent cell design.

Figure D.533: BIOS 1595. *German Fluorine and Fluoride Industry.*

For more information on wartime fluorine production and applications, see:

BIOS 261. *Hydrofluoric Acid Vereinigte Flusspathgruben G.m.b.H. Stulln.*

BIOS 714. *The Development of New Insecticides and Chemical Warfare Agents.* [Fluorine compounds.]

BIOS 764. *Production of Aluminium Compounds in Germany.* [Fluoride of aluminum manufacture.]

BIOS 785. *The German Mica Industry.* [Fluorine-phlogopite (synthetic mica) manufacture and properties.]

BIOS 896. *The Manufacture of Zirconium-Potassium Fluoride, Zirconium Oxide and Zirconium Oxychloride.*

BIOS 1095. *Developments in Methods and Materials for the Control of Plant Pests and Diseases in Germany.* [Fluorine compounds.]

BIOS 1335. *The Fluorspar Industry in Germany. Mines and Treatment Plants in the Nabburg and Regensburg Districts, Upper Palatinate (Bavaria).*

BIOS 1338. *Developments in Magnesium Production and Fabrication.* [Beryllium and zirconium at Degussa; also fluorine and carbon at I.G. Farben.]

BIOS 1433. *I.G. Farbenindustrie, A.G. The Manufacture of Triphenylmethane Dyestuffs at Hoechst, Ludwigshafen and Leverkusen.* [Fluorol 5G manufacture at Ludwigshafen.]

BIOS 1480. *The Manufacture, Formulation and Application of the Major Pest Control Products in the British, U.S. & French Zones of Germany.* [Fluorides.]

BIOS Misc. 14. [Fluorine organic compounds.]

CIOS XXIX-14. *I. G. Farbenindustrie A. G., Leverkusen, Germany.* [Fluoride production.]

FIAT 524. *Production of Aluminum.* [Fluoride recovery from aluminum furnace gases.]

FIAT 747. *The Synthesis of Fluorine-Mica of the Phlogopite Group.*

FIAT 838. *Elemental Fluorine, I.G. Farbenindustrie—Leverkusen.* [potentially nuclear-related]

FIAT 1114. *Recent German Research Work on Fluorine and Fluorine Compounds.* [W. Kwasnik and P. Scherer—nuclear-related!]

[For information on wartime German production of uranium hexafluoride for uranium enrichment, see pp. 3478–3493.]

G. Aluminum

[Aluminum was used for fabricating a wide variety of metal structures and packaging. On the other hand, aluminum could have been quite useful as cladding around fission fuel in a reactor, or as spherical pusher and casing shells in an atomic bomb as described on p. 4486. The following documents illustrate that wartime production of aluminum was widespread and sophisticated.]

For information on wartime aluminum production and applications, see for example:

BIOS 127. *The Aluminum Fabricating Plant of Aluminium Wals-on Persbedrljvon N. V., Utrecht, Holland.*

BIOS 144. *Wrought Light Alloy Plants in North-West Germany.*

BIOS 151. *German Aluminum and Magnesium Melting and Rolling Practices.*

BIOS 179. *German Cable Industry.*

BIOS 214. *Non-destructive Testing of Materials, Siemens-Werner Werk "M", Berlin/Siemenstadt.*

BIOS 229. *Wrought Light Alloy Plants in Southern Germany.*

BIOS 264. *German Brass and Copper Wire Industry.*

BIOS 279. *German Technique in the Production of Light Alloys.*

BIOS 288. *Aluminium Hydrate and Alumina Production in German Factories.*

BIOS 316. *German Light Alloy Foundry Industry.*

BIOS 374. *German Aluminum Foil Industry.*

BIOS 376. *Recovery of Aluminium Alloys from Aircraft Scraps.*

BIOS 392. *Welding of Aluminium and Aluminium Alloys with Particular Reference to the Manufacture of Pressure Vessels.*

BIOS 462. *Impact Extrusion.*

BIOS 465. *High Temperature Refractories and Ceramics.*

BIOS 470. *Specialized Ceramic Materials with Particular Reference to Ceramic Gas Turbine Blades.*

BIOS 504. *Visit to Metallgesellschaft A.G., Frankfurt a.M.*

BIOS 527. *Iron, Steel and Non-Ferrous Metal Works Plant and Machinery.*

BIOS 533. *Electric Furnace Design. Manufacture and Application in Germany.*

BIOS 605. *Some Marine Applications of Light Alloys in Germany.*

BIOS 643. *German Anodising Practice.*

BIOS 681. *German Cold Rolled Strip Industry.*

BIOS 693. *Investigation of the Light Alloy Forging Industry in Germany.*

BIOS 720. *Metallurgical Research and Testing Laboratories in the Stuttgart Area.*

BIOS 724. *Electronic Principles as Applied in Germany to the Testing of Materials.*

BIOS 764. *Production of Aluminium Compounds in Germany.*

BIOS 766. *The Manufacture of Pharmaceuticals and Fine Chemicals in the U.S. and French Zones of Germany.*

BIOS 895. *Aluminium Production at Vereinigte Aluminiumwerke (V.A.W.), Lünen.*

BIOS 974. *Alumina and Aluminium Production at the Lippewerk of the Vereinigte Aluminium-Werke A.G. Lünen.*

BIOS 975. *Alumina Production at Martinswerk Bergheim/Rhineland.*

BIOS 976. *Electro-Thermic Production of Aluminium-Silicon Alloys at Lurgi-Thermie G.m.b.H., Horrem.*

BIOS 981. *Light Alloys. Notes on German Technique on Continuous Casting and Extrusion of Aluminium Alloys with Particular Reference to Tube Extrusion, Tube Reducing Machines and Vertical Extrusion Presses.*

BIOS 982. *Light Alloy Rolling, Osnabrück Kupfer and Drahtwerke Osnabrück.*

BIOS 995. *Hot-Dipping and Electro-Deposition of Tin and Tin Alloys in Germany.*

BIOS 1084. *German Aluminium Fabricating Equipment.*

BIOS 1089. *Aluminium Refining and Scrap Recovery at V.A.W. Erftwerk Grevenbroich.*

BIOS 1099. *Survey of Secondary Aluminium Industry in Germany.*

BIOS 1100. *German Aluminium Foil Industry.*

BIOS 1165. *Aluminium Holloware Industry in the British Occupied Zone of Germany.*

BIOS 1190. *German Cable Industry.*

BIOS 1205. *Chemische Fabriken, Oker and Bramschweig. Aktiengesellschaft, Oker and Harz. Manufacture of Aluminium Hydroxide Pigment (Tonerde-Gel) and Aluminium Sulphate.*

BIOS 1215. *German Methods of Rhodiumizing, Aluminizing, Anti-Reflection Surface Coating and Allied Subjects.*

BIOS 1231. *The German Container and Canning Industries.* [Aluminum cans]

BIOS 1271. *Food Preparing Machinery.* [Aluminum cans]

BIOS 1295. *The Production of Certain Types of Phosphor Bronze, Brass and Light Alloy Castings in Germany. Composite Report of Interrogations of Dr. Heinrich Bauer, Dürener Metallwerke, Düren.*

BIOS 1342. *German Optical Mirrors and Reflectors.*

BIOS 1366. *The Production in Germany of Extruded Sections and Tubes in Aluminium and Magnesium Alloys.*

BIOS 1405. *Impact Extrusion. German Practice. 1946.*

BIOS 1409. *Cold Impact Extrusion of Aluminium, Etc.*

BIOS 1423. *The Application of Aluminium and Its Alloys in Germany.*

BIOS 1454. *Aluminium Pressings.*

BIOS 1467. *German Methods of Production of Aluminium Coated and Continuous Electroplated Steel Strip.*

BIOS 1535. *Report on Investigation of Methods of Gaseous Metal Treatment.*

BIOS 1550. *Sheathing of Cables with Aluminium.*

BIOS 1567. *Manufacture of Aluminium Clad Steel Strip by Wickede Eisen und Stahlwerke.*

BIOS 1595. *German Fluorine and Fluoride Industry.* [Aluminum fluoride manufacture and analysis.]

BIOS 1656. *Extrusion of Light Alloys at I.G. Farbenindustrie, Bitterfeld. Interrogation of Herr K. F. Brauninger.*

BIOS 1660. *A General Survey of the German Non-Ferrous Industry.*

BIOS 1667. *Some Notes on Open Hearth Furnace Design and Operation.*

BIOS 1703. *Manufacture of Aluminium at I.G. Farben Factory, Bitterfeld.*

BIOS 1757. *Manufacture of Super-Purity Aluminium at the Vereinigte Aluminium Werke, Erftwerk, Grevenbroich.*

BIOS 1770. *High Strength Aluminium-Zinc-Magnesium Alloy Development in Germany.*

BIOS 1861. *Light Alloy Foundries in Germany.*

CIOS XXII-4. *Aluminum Woerwerke, Erftwerke, Gravenbroich.*

CIOS XXIV-22. *The Electrochemical Industry, Bitterfeld Area.*

CIOS XXV-17. *The Electrochemical Industry, Burghausen Area.*

CIOS XXV-30. *Felten and Guilleaume Carlswerke, Cologne.*

CIOS XXV-31. *Suddeutsche Kabelwerke, Mannheim.*

CIOS XXV-32. *Hackethal Draht Und Kabelwerke AG, Hanover.*

CIOS XXVI-47. *Gelr. Guifine G.m.b.H., Ludwigshafen Am Rhein.*

CIOS XXVI-60. *Light Metal Production and Development for Aircraft, I.G. Farben.*

CIOS XXVII-9. *Kupfer U Drahtwerke, Osnabruck.*

CIOS XXVII-94. *Vereinigte Deutsche Metallwerke AG.*

CIOS XXIX-14. *I. G. Farbenindustrie A. G., Leverkusen, Germany.* [Aluminum fluoride production.]

CIOS XXIX-18. *Metal Fabrication at Mansfeld AG Kupfer Und Messing Werke, Hettstedt.*

CIOS XXIX-19. *Aluminum Reduction and Scrap Recovery at the Erftwerk of the Vereinigte Aluminum-Werke AG, Grevenbroich.*

CIOS XXX-72. *Aluminum and Magnesium Fabrication, Leipziger Leichtmetall, Werk-Rackwitz, Rackwitz.*

CIOS XXX-73. *Aluminum Fabrication, Osnabrucker Kupfer and Drahtwerk, Osnabruck.*

CIOS XXX-85. *A Survey of the German Can Industry During the Second World War.*

CIOS XXXI-57. *Hugo Schneider AG, Messingwerke Aluminum Werke, Leipzig.*

CIOS XXXI-73. *Vereingte Leichtmetall Werke G.m.b.H., Hannover Linden.*

CIOS XXXII-21. *Aluminum from Clay.*

CIOS XXXII-55. *Recovery of Metals from Scrapped Airplanes.*

CIOS XXXII-59. *Aluminum and Magnesium Production and Fabrication.*

CIOS XXXIII-31. *Investigation of Certain Chemical Factories in the Leipzig Area of Germany.*

CIOS XXXIII-32. *The Vereinigte Leightmetall-Werke, Hanover.*

CIOS XXXIII-59. *The Vereinigte Leightmetall-Werke, Hanover.*

FIAT 395. *Metallurgical Practices in Germany. The Fields of Non-Ferrous Melting and Casting.*

FIAT 406. *Non-ferrous Metal Rolling Mill Practice in Germany.*

FIAT 417. *"Press-Welding" Aluminum for Aircraft Radiators.*

FIAT 501. *The German Aluminum and Magnesium Industries.*

FIAT 516. *Report on Recent Cable Development in Germany.*

FIAT 522. *The Beryllium Industries of Germany and Italy (1939 to 1945).* [Alloys of beryllium with Al, Cu, Ni, Mg, etc.]

FIAT 524. *Production of Aluminum.*

FIAT 569. *Manufacturing Bronze, Aluminum or Other Flake Metal Powders.*

FIAT 602. *Aluminum Pistons for Automobile and Aircraft Engines.*

FIAT 686. *Casting Methods for Aluminum and Aluminum Alloys Billets.*

FIAT 699. *Magnesium Determinations in Aluminum.*

FIAT 731. *Technology of Aluminum and Aluminum Alloy Production in Germany Including Early Fabrication and Recoveries from Scrap.*

FIAT 754. *Vibrating Ball Mill for Pulverizing Fine Materials.*

FIAT 787. *Precious Metal Refining and Fabrication by W. C. Heraeus and G. Siebert Platinschmelze of Hanau.* [Aluminum and rhodium mirrors]

FIAT 805. *German Research on Experimental Aluminum-Base Bearings.*

FIAT 829. *Non-ferrous Metal Production Processes in the Hamburg District.*

FIAT 876. *Continuous Casting of Metals in Germany.*

FIAT 907. *Review of Recent Developments in Aluminum Refining.*

FIAT 927. *Production of High Alumina Slags in Blast Furnaces and Allied Processes for Recovering Alumina.*

FIAT 980. *German Aluminum Industry.*

FIAT 986. *Carbon Electrodes in Germany for the Aluminum Reduction Industry.*

FIAT 989. *Alumina Production in Germany.*

FIAT 992. *The Electrothermal Production of Aluminum Silicon Alloy.*

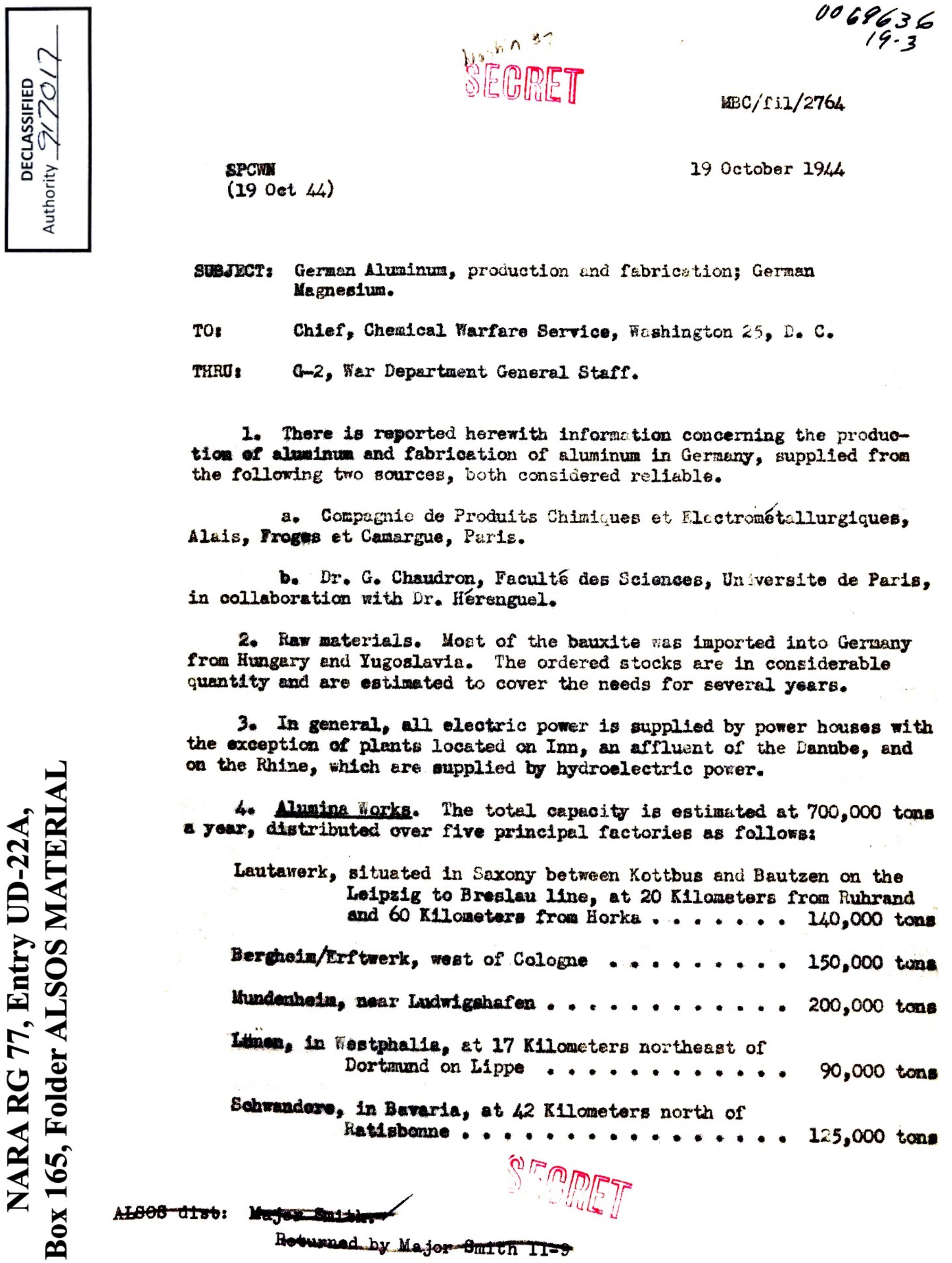
FIAT 993. *The Aluminum Reduction Industry in Germany.*

FIAT 997. *German Research in the Light Metals Industry.*

FIAT 1011. *Fabrication of Aluminum in Germany. A Study of Some Specialized Practices and Techniques Employed in the Industry.*

G-80. Rudolf Fleischmann. *The Capture Cross Sections of Aluminum for Thermal Neutrons.* 1941.

G-153. Wilhelm Hanle. *Spectroscopic Analysis of Carbon, Aluminum, and Beryllium.* 1942.



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NARA RG 77, Entry UD-22A,
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SPCWN
(19 Oct 44)

19 October 1944

SUBJECT: German Aluminum, production and fabrication; German Magnesium.

TO: Chief, Chemical Warfare Service, Washington 25, D. C.

THRU: G-2, War Department General Staff.

1\. There is reported herewith information concerning the production of aluminum and fabrication of aluminum in Germany, supplied from the following two sources, both considered reliable.

a\. Compagnie de Produits Chimiques et Electrométallurgiques, Alais, Froges et Camargue, Paris.

b\. Dr. G. Chaudron, Faculté des Sciences, Universite de Paris, in collaboration with Dr. Hérenguel.

2\. Raw materials. Most of the bauxite was imported into Germany from Hungary and Yugoslavia. The ordered stocks are in considerable quantity and are estimated to cover the needs for several years.

3\. In general, all electric power is supplied by power houses with the exception of plants located on Inn, an affluent of the Danube, and on the Rhine, which are supplied by hydroelectric power.

4\. <u>Alumina Works</u>. The total capacity is estimated at 700,000 tons a year, distributed over five principal factories as follows:

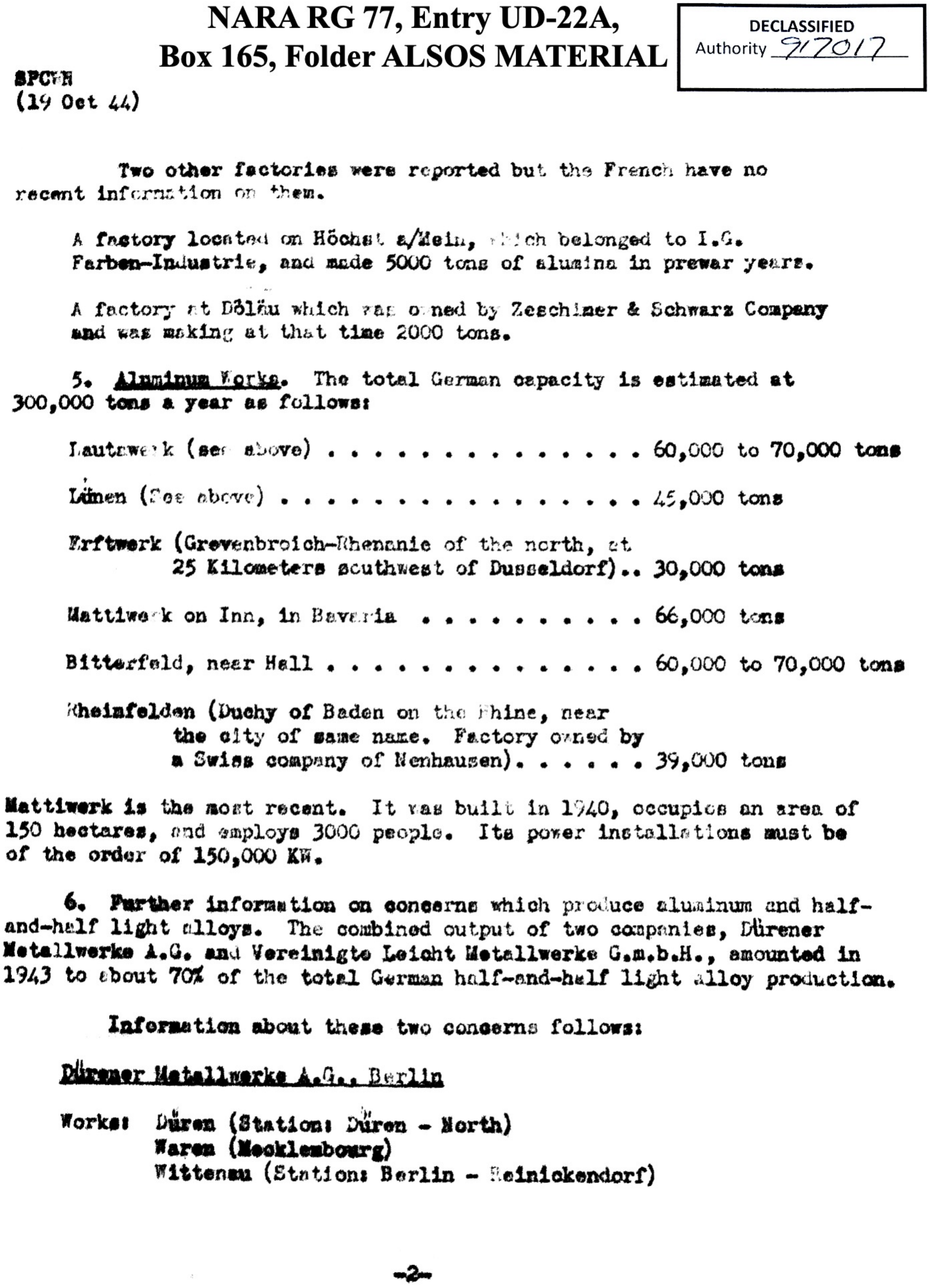
Lautawerk, situated in Saxony between Kottbus and Bautzen on the Leipzig to Breslau line, at 20 Kilometers from Ruhrand and 60 Kilometers from Horka	140,000 tons
Bergheim/Erftwerk, west of Cologne	150,000 tons
Mundenheim, near Ludwigshafen	200,000 tons
Lünen, in Westphalia, at 17 Kilometers northeast of Dortmund on Lippe	90,000 tons
Schwandorf, in Bavaria, at 42 Kilometers north of Ratisbonne	125,000 tons

SECRET

~~ALSOS dist: Major Smith.~~

~~Returned by Major Smith 11-9~~

Figure D.534: M. B. Chittick. 19 October 1944. Subject: German Aluminum, production and fabrication; German Magnesium [NARA RG 77, Entry UD-22A, Box 165, Folder ALSOS MATERIAL].



**NARA RG 77, Entry UD-22A,
Box 165, Folder ALSOS MATERIAL**

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Authority 917017

SPCWH
(19 Oct 44)

Two other factories were reported but the French have no recent information on them.

A factory located on Höchst a/Main, which belonged to I.G. Farben-Industrie, and made 5000 tons of alumina in prewar years.

A factory at Dölau which was owned by Zeschimer & Schwarz Company and was making at that time 2000 tons.

5. Aluminum Works. The total German capacity is estimated at 300,000 tons a year as follows:

Lautawerk (see above)	60,000 to 70,000 tons
Lünen (See above)	45,000 tons
Erftwerk (Grevenbroich-Rhenanie of the north, at 25 Kilometers southwest of Dusseldorf)	30,000 tons
Mattiwerk on Inn, in Bavaria	66,000 tons
Bitterfeld, near Hall	60,000 to 70,000 tons
Rheinfelden (Duchy of Baden on the Rhine, near the city of same name. Factory owned by a Swiss company of Nenhausen)	39,000 tons

Mattiwerk is the most recent. It was built in 1940, occupies an area of 150 hectares, and employs 3000 people. Its power installations must be of the order of 150,000 KW.

6. Further information on concerns which produce aluminum and half-and-half light alloys. The combined output of two companies, Dürener Metallwerke A.G. and Vereinigte Leicht Metallwerke G.m.b.H., amounted in 1943 to about 70% of the total German half-and-half light alloy production.

Information about these two concerns follows:

Dürener Metallwerke A.G., Berlin

Works: Düren (Station: Düren - North)
Waren (Mecklembourg)
Wittenau (Station: Berlin - Reinickendorf)

-2-

Figure D.535: M. B. Chittick. 19 October 1944. Subject: German Aluminum, production and fabrication; German Magnesium [NARA RG 77, Entry UD-22A, Box 165, Folder ALSOS MATERIAL].

H. Calcium

[Calcium was used in making certain metal alloys, but it also would have been extremely useful in key steps of the purification of thorium, uranium, and/or plutonium. The following documents demonstrate large-scale production and use of calcium, and even methods of utilizing calcium to purify thorium and uranium.]

BIOS 236. *Developments in Pure and Applied Microbiology (American, British and French Zones) During World War II.* [Calcium gluconate from hydrolysis of starch.]

BIOS 489. *Chemische Fabrik Joh. A. Benckiser, G.m.b.H. Ladenburg Works. Manufacture of Calcium Citrate.*

BIOS 636. *Mineralölwerke F. Harmsen, Kiel—Germany: Lubricants.* [Calcium soap greases.]

BIOS 675. *The Production of Thorium and Uranium in Germany.* [Using calcium to process thorium and uranium—see pp. 4134–4135.]

BIOS 798. *The German Ferro-Alloy Industry.* [Calcium silicide manufacture.]

BIOS 883. *Notes on Casting and Fabrication of Lead and Production of Bahnmetall.* [Calcium-lead alloy manufacture.]

BIOS 1044. *German Carbide and Cyanamide Industry. Carbide Production.* [Calcium carbide manufacture.]

BIOS 1045. *German Carbide and Cyanamide Industry. Handling of Carbide in Bulk.* [Calcium carbide, bulk transport of.]

BIOS 1046. *German Carbide and Cyanamide Industry. Manufacture of Calcium Cyanamide.* [Calcium cyanamide manufacture from carbide.]

BIOS 1385. *The German Hard Metal Industry.* [Electron microscope, zirconium, uranium, thorium, calcium tungstate manufacture, etc.]

BIOS 1443. *The German Nitrogenous Fertiliser Industry (Excluding Cyanamide) in the Western Zones.* [Calcium nitrate manufacture for fertilizers.]

BIOS 1480. *The Manufacture, Formulation and Application of the Major Pest Control Products in the British, U.S. & French Zones of Germany.* [Calcium compounds.]

BIOS 1490. *German Gypsum Industry (British, American and French Zones).* [calcium sulfate mining]

BIOS 1539. *German Chlorate Industry.* [Calcium chlorate manufacture.]

BIOS 1700. *The Manufacture of Glycerophosphates and Hypophosphites in Germany.* [Calcium glycerophosphate and calcium hypophosphite manufacture.]

CIOS X-1. *Caves at Bad Mor Mories, Near Vaas Used for Storage of Peroxide.* [Calcium permanganate underground tank storage.]

CIOS XVIII-1. *Chemical Installation in the Cologne Area.* [Calcium carbide.]

CIOS XXV-17. *The Electrochemical Industry, Burghausen Area.* [Calcium cyanamide production.]

CIOS XXVII-83. *AG für Stickstoffdünger, Knapsack.* [Calcium carbide production.]

CIOS XXVII-85. *Miscellaneous Chemicals, I.G. Farben AG, Ludwigshafen and Oppau.* [Calcium carbide.]

CIOS XXVII-92. *German Carbide, Cyanamide and Cyanide Industry.* [Calcium carbide.]

CIOS XXXIII-31. *Investigation of Certain Chemical Factories in the Leipzig Area of Germany.* [Calcium manufacture at I.G. Farben, Bitterfeld.]

CIOS XXXIII-47. *Manufacture of Sodium and Calcium Permanganate.*

FIAT 229. *Copper, Lead, Zinc, Tin, and Antimony Smelting and Refining in Northwestern Germany.* [Calcium-lead alloys.]

FIAT 431. *A Survey of the Chlorine and Caustic Plants in Western and Southern Germany.* [Calcium chlorate production.]

FIAT 665. *German Fertilizers and Soil Fertility.* [Calcium magnesium phosphate fertilizer.]

FIAT 728. *AG für Stickstoffdünger, Knapsack.* [Calcium cyanamide.]

FIAT 732. *Electrochemical Operations at I.G. Farbenindustrie AG, Bitterfeld.* [Calcium manufacture.]

FIAT 750. *Rare and Minor Metals.* [Calcium production.]

FIAT 756. *Calcium Metal and Calcium Hydride.*

FIAT 859. *Continuous Chilling and Cooling of Calcium Carbide.*

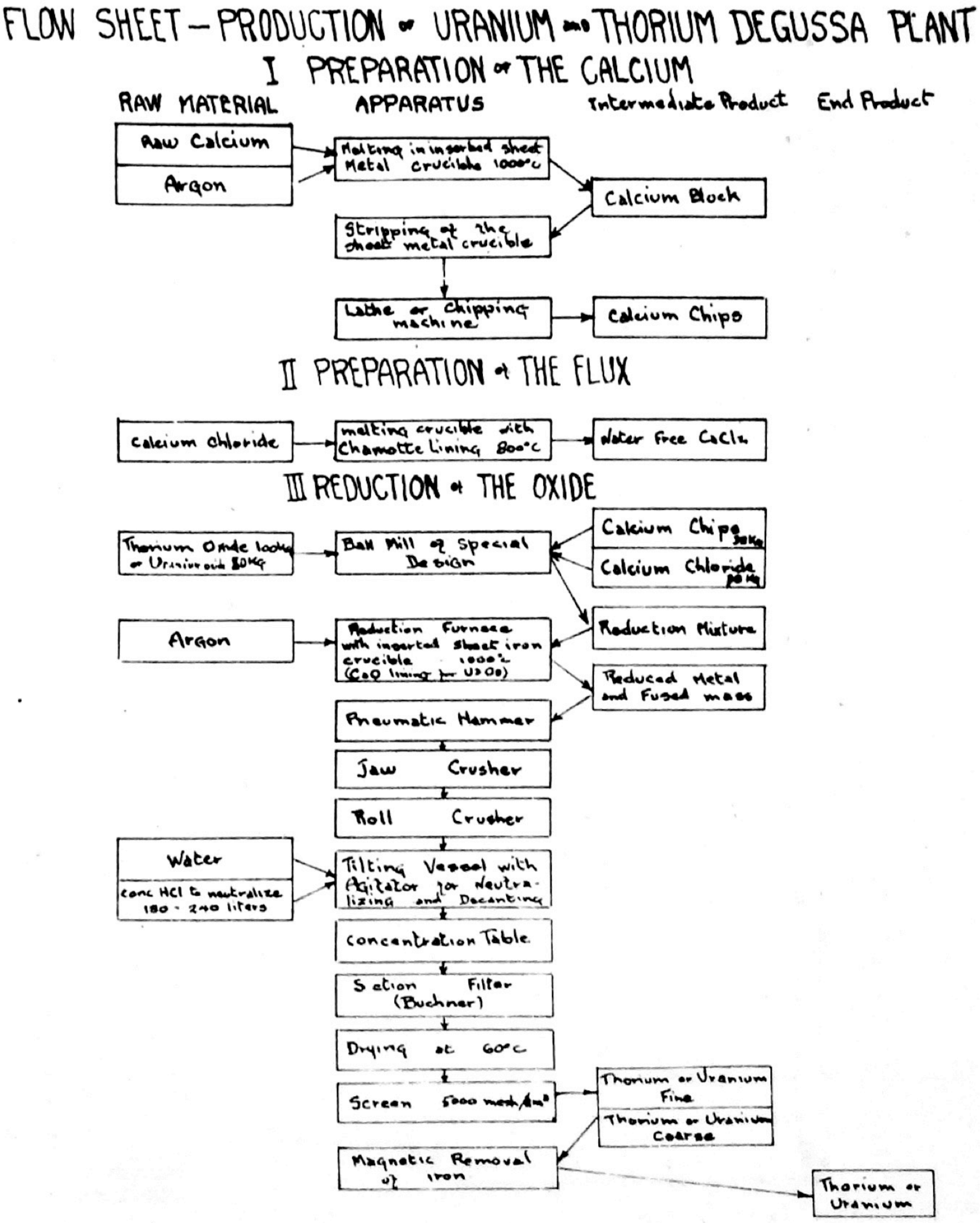


Figure D.536: Flowchart of German methods of using calcium to process uranium and thorium [BIOS 675].

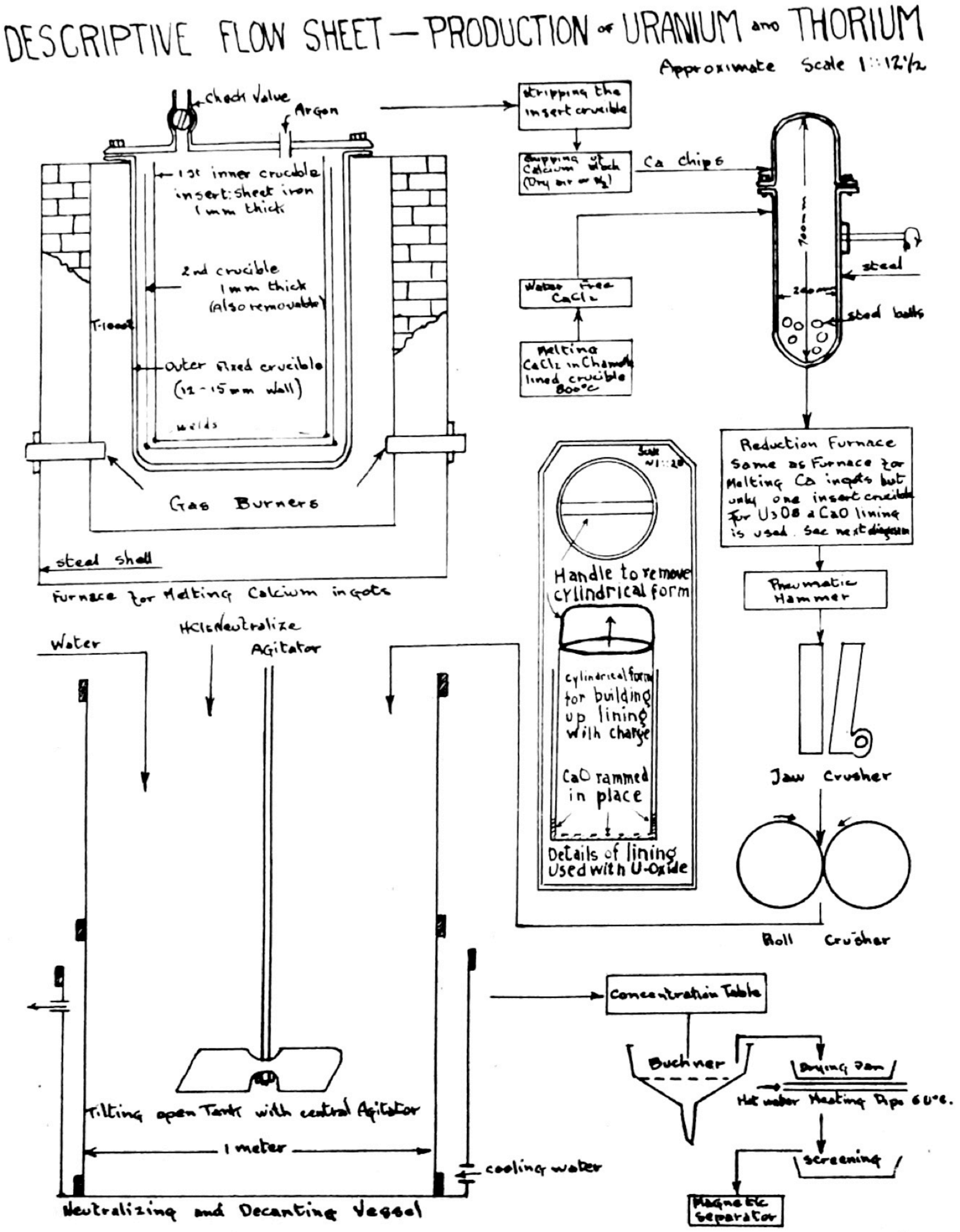


Figure D.537: Flowchart of German methods of using calcium to process uranium and thorium [BIOS 675].

Henry S. Lowenhaupt. 1996. Chasing Bitterfeld Calcium. CIA Historical Review Program. https://www.cia.gov/static/Chasing-Bitterfeld-Calcium.pdf

In December 1946 a chemical engineer from the former I. G. Farben plant at Bitterfeld in East Germany volunteered in Berlin that this plant "had started in the past few weeks producing 500 kilograms per day of metallic calcium. Boxes of the chemical are sent by truck every afternoon to Berlin, labeled to Zaporozhe on the Dnieper. Calcium is believed to be used as a slowing agent in processes connected with the production of atomic explosive."

This was the lead we in the Foreign Intelligence Section of the Manhattan District Headquarters had been waiting for. We had read the technical investigation reports from FIAT (Field Information Agency /Technical) on the production of uranium at the Auergesellschaft Plant in Berlin/Oranienburg. We also knew that Dr. Nikolaus Riehl—with his whole research team from Auergesellschaft—had met the Russians, volunteering to help them make uranium for their atomic bomb project. We knew from intercepted letters that the group was still together, writing from the cover address PO Box 1037P, Moscow. We knew Auergesellschaft during World War II had made the uranium metal for the German Uranverein—the unsuccessful German atomic bomb project—by using metallic calcium to reduce uranium oxide to uranium metal (not as "slowing agent"). We had analyzed the two-inch cubes of uranium metal from the incomplete German nuclear reactor which the Alsos Mission had found in the minuscule village of Stadtilm in Thuringia. We knew German uranium was terrible—full of oxides and voids, though it was fairly pure otherwise by non-atomic standards. The files also disgorged that in 1945 the Russians had started to dismantle and take to Russia the small calcium plant at the enormous Bitterfeld Combine, in addition to the big magnesium facility.

Cables went out immediately to the European Command in Germany via G-2 and directly to Col. Edgar P. Dean, Manhattan District representative in London, to locate and interrogate all engineers who had fled Bitterfeld to the West or were currently willing to sell information on their unloved masters. We wanted to know how much calcium was to be produced, what its specifications were, and where it was to be shipped. We wanted to know what non-atomic normal German industries used calcium, and in what quantities. We wished Col. Dean to keep our British colleagues in the Division of Atomic Energy, Ministry of Supply, informed.

At home, the Scientific Division of the Office of Special Operations in the newly-formed Central Intelligence Group was also apprised of our needs. Col. Frank A. Valente of our section was asked to take time out from his task of organizing an atomic detection system to talk to the U.S. Atomic Energy Commission in depth about the use in the U.S. program of calcium to reduce uranium salts to uranium metal. Major Randolph Archer, also of our office, was asked to talk to U.S, firms making calcium metal, and find out what it was used for and in what quantities.

As so often happens, the people involved and their experience were crucial ingredients. On the American side was the Foreign Intelligence Section of the Washington Liaison Office of the Manhattan District, then in the process of transferring as a unit to the newly formed Central Intelligence Group. It was headed by Col. L. E. Seeman, a career Corps of Engineers officer who had run the American engineering forces of the CBI theater during World War II and would go on to become major general. The section was staffed with a few career Corps of Engineers personnel, several officers and civilians trained in science, and the remainder trained in investigative procedures in the Counter Intelligence Corps.

The orientation toward engineering on the part of our management led directly to a pragmatic approach—do what works, and get on with the job. The engineering orientation also led materially toward the estimative method of technical evaluation. Engineering officers are accustomed to laying out engineering tasks to find out how long they will take at a minimum—and then to evaluate likely slippage. They think in quantitative terms—man days, truckloads, cubic yards. The scientific side of the section, Col. Valente, Mr. Charles Campbell, Mr. Donald Quigley, and I learned gradually to ferret out the crucial technical facts, the bottlenecks as it were, that could be used in these engineering-type evaluations.

A remnant of the wartime cooperation in the atomic field was the direct liaison at that time with the Intelligence Section of the British Division of Atomic Energy of the Ministry of Supply. Col. Dean, Assistant Military Attaché, was our representative in London. This cooperation was normalized gradually into more regular country-to-country liaison channels after our section was deployed to the newly formed CIG early in 1947. The Atomic Energy Act of 1946, which restricted much atomic data to "cleared" U.S. personnel, also tended to perpetuate differences between the U.S. and UK intelligence efforts already in being in 1946 because of the "nationalistic" policies on the parts of both General Leslie R. Groves, Manhattan District Commander, and Sir John Anderson, head of the UK atomic effort.

The British office was staffed with technical personnel, much as our own was. Mr. David Gattiker, their liaison to our section, had been a chemical engineer with Imperial Chemicals Incorporated before World War II. Mr. Kenneth Townley, one of the London members, was a geologist by profession with some experience in uranium prospecting. Its leader, Commander Eric Welsh, however, was also a career member of MI-6. Commander Welsh had masterminded the sabotage of Norsk Hydro in Norway in 1943 to prevent the Germans from getting heavy water and completing an operating reactor at Stadtilm. In 1940 he had been instrumental in smuggling the great nuclear physicist Niels Bohr out of occupied Denmark. And in the thirties he had been a chemist at Bitterfeld.

Returning to the calcium problem, by mid-January 1947 the Bitterfeld activity was definitely confirmed, and indeed amplified: Russian requirements were for 30 tons of metallic calcium per month, and distillation was needed to achieve adequate purity. A number of former Bitterfeld engineers were soon interviewed, especially by Major Paul O. Langguth working for Col. Dean in London. As we learned more, some were even re-interviewed. I remember, for instance, flying to Wright Patterson Airbase in late 1947 to talk once again to a Bitterfeld metallurgist whom Langguth had previously interrogated, and who had in the interim come to the U.S. as a member of the Air Force's Operation PAPERCLIP. [...]

[During the war, German industry produced calcium and used it to purify uranium and thorium (pp. 4134–4135). After the war, German industry continued to produce calcium for nuclear purposes—for the Soviet Union, as shown by the above document.]

I. Nickel

[Nickel was used for nickel-cadmium batteries and certain alloys. Yet because nickel is much more resistant than other metals to corrosion by uranium hexafluoride (used in uranium enrichment), it would have been invaluable in a nuclear program. The following documents demonstrate large-scale production of nickel.]

For information on wartime nickel production and applications, see for example:

BIOS 26. *Copper Smelting and Refining, Together with Related Metallurgical Activities at Nord Deutsche Affinerie, Hamburg.* [Nickel ores (Petsamo) treatment.]

BIOS 263. *Part I. I.G. Farben Industrie-Oppau Works, Ludwigshafen (Report on Nickel and Iron Powder Plants. Part II. Nord Deutsche Affinerie, Hamburg (Report on the Treatment of Nickel-Copper Ores and Residues).*

BIOS 358. *Acrylic Esters, Synthesis from Acetylene and Nickel Carbonyl.* [Nickel carbonyl regeneration from nickel salts.]

BIOS 371. *Regeneration of Nickel Carbonyl (from Aqueous Solutions).* [Nickel carbonyl regeneration from nickel salt solutions.]

BIOS 511. *Ruhr-Chemie A.G. Sterkrade Holten. Interrogation of Dr. O. Roelin.* [Nickel catalysts in Fischer-Tropsch process.]

BIOS 681. *German Cold Rolled Strip Industry.* [Nickel plated steel strip manufacture.]

BIOS 708. *German Alkaline Accumulator Industry.* [Nickel for alkaline accumulators: nickel carbonyl]

BIOS 755. *Manufacture of Butanol, Methoxybutanol, Butyraldehyde, Glycerogen at I.G. Hoechst.* [Nickel catalyst preparation for glycerogen manufacture.]

BIOS 778. *German Manufacture of Wires and Strips for Electrical Heating.* [Nickel-chromium and Ni-Cr-Iron alloys for heating.]

BIOS 779. [Nickel-chrome alloys for pyrometers.]

BIOS 1003. *Some Aspects of Copper, Nickel and Cobalt Production in Germany.* [Nickel, nickel sulfate, and nickel carbonate.]

BIOS 1009. *A Survey of German Electro-Plating Methods.* [Nickel plating methods.]

BIOS 1241. *The Manufacture of p:p' Diaminodicyclohexyl Methane (Dicykan).* [Nickel oxide catalyst manufacture.]

BIOS 1323. *The Production of Powdered Iron and Sintered Iron Driving Bands in Germany.* [Nickel-iron sheets from sintered metal.]

BIOS 1372. *German Silver & E.P.N.S. Holloware Industry.* [Nickel-silver holloware manufacture.]

CIOS XXXI-20. *Refining of Cobalt, Nickel, Zinc and Cadmium.*

CIOS XXII-15. *I.G. Farbenindustrie Plant, Frose, Germany.* [Nickel production.]

CIOS XXIV-12. *I.G. Farben—Oppau Works, Ludwigshafen.* [Nickel production.]

CIOS XXXIII-59. *German War List for Ferrous Materials (Kreigsliste).*

FIAT 422. *Manufacture and Regeneration of Catalysts at I.G. Farbenindustrie, Ludwigshafen Oppau.* [Nickel sulfate.]

FIAT 522. *The Beryllium Industries of Germany and Italy (1939 to 1945).* [Alloys of beryllium with Al, Cu, Ni, Mg, etc.]

FIAT 879. *Notes on the Peeling of Nickel Deposits.*

FIAT 800. *Nickel Cadmium Storage Batteries in Germany.*

FIAT 881. *Contribution to the Production of Cast Nickel Anodes.*

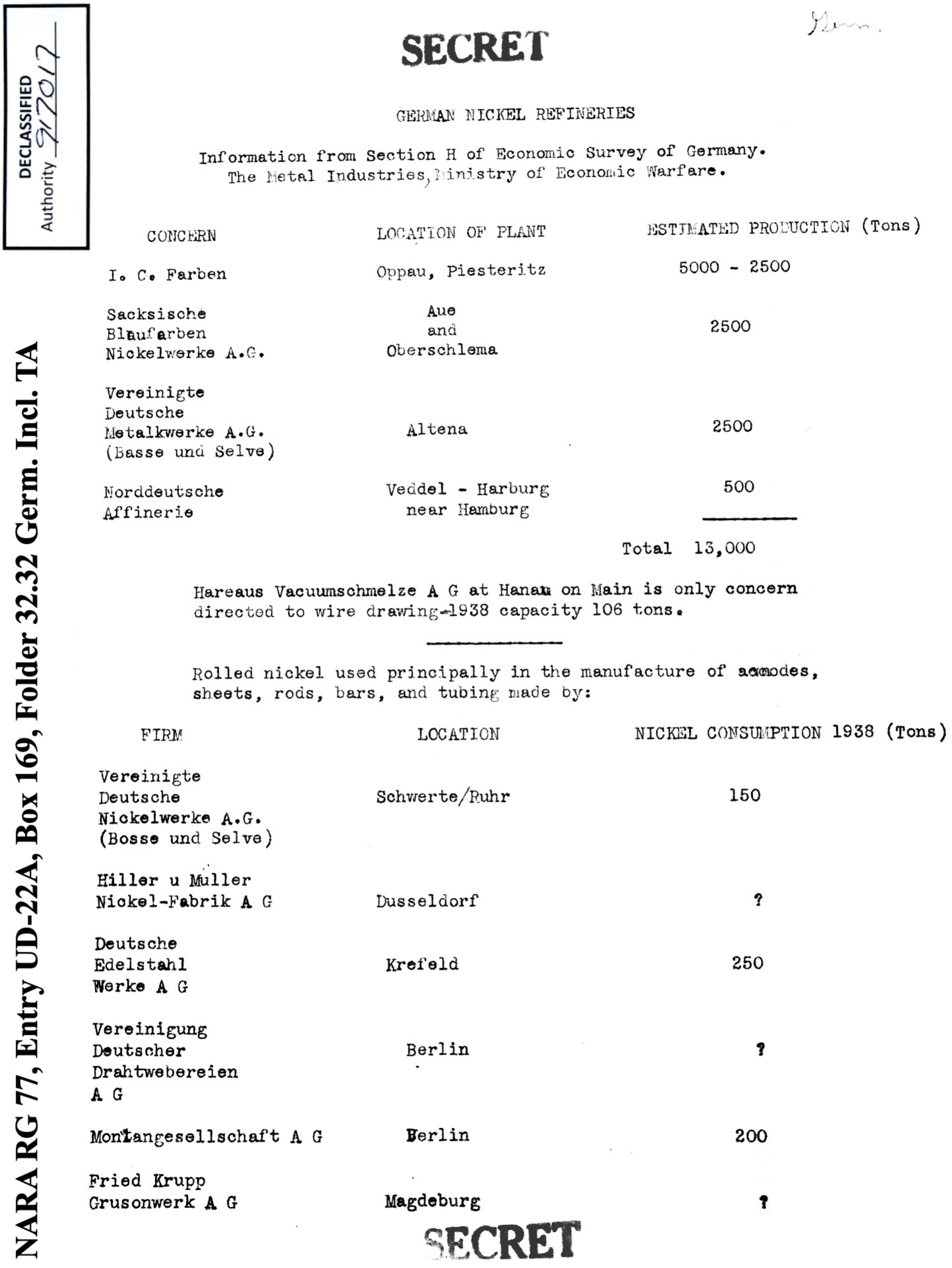
FIAT 882. *Anodes.* [Nickel anodes in electrolytic processes.]

German Nickel Refineries. Undated but probably 1944. [NARA RG 77, Entry UD-22A, Box 169, Folder 32.32 Germ. Ind. TA]

Information from Section H of Economic Survey of Germany.
The Metal Industries, Ministry of Economic Warfare.

CONCERN	LOCATION OF PLANT	ESTIMATED PRODUCTION (Tons)
I. G. Farben	Oppau, Piesteritz	5000–2500
Sacksische Blaufarben Nickelwerke AG	Aue and Oberschlema	2500
Vereinigte Deutsche Metallwerke AG (Basse und Selva)	Altena	2500
Norddeutsche Affinerie	Veddel—Harburg near Hamburg	500
		Total 13,000

[See document photos on pp. 4140–4141. This U.S. intelligence document was considered so important with regard to Germany's nuclear program that it was placed in the files of Leslie Groves's Foreign Intelligence Unit of the Manhattan Project.]



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NARA RG 77, Entry UD-22A, Box 169, Folder 32.32 Germ. Incl. TA

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GERMAN NICKEL REFINERIES

Information from Section H of Economic Survey of Germany.
The Metal Industries, Ministry of Economic Warfare.

CONCERN	LOCATION OF PLANT	ESTIMATED PRODUCTION (Tons)
I. C. Farben	Oppau, Piesteritz	5000 - 2500
Sacksische Blaufarben Nickelwerke A.G.	Aue and Oberschlema	2500
Vereinigte Deutsche Metalkwerke A.G. (Basse und Selve)	Altena	2500
Norddeutsche Affinerie	Veddel - Harburg near Hamburg	500
	Total	13,000

Hareaus Vacuumschmelze A G at Hanau on Main is only concern directed to wire drawing-1938 capacity 106 tons.

Rolled nickel used principally in the manufacture of anodes, sheets, rods, bars, and tubing made by:

FIRM	LOCATION	NICKEL CONSUMPTION 1938 (Tons)
Vereinigte Deutsche Nickelwerke A.G. (Bosse und Selve)	Schwerte/Ruhr	150
Hiller u Muller Nickel-Fabrik A G	Dusseldorf	?
Deutsche Edelstahl Werke A G	Krefeld	250
Vereinigung Deutscher Drahtwebereien A G	Berlin	?
Montangesellschaft A G	Berlin	200
Fried Krupp Grusonwerk A G	Magdeburg	?

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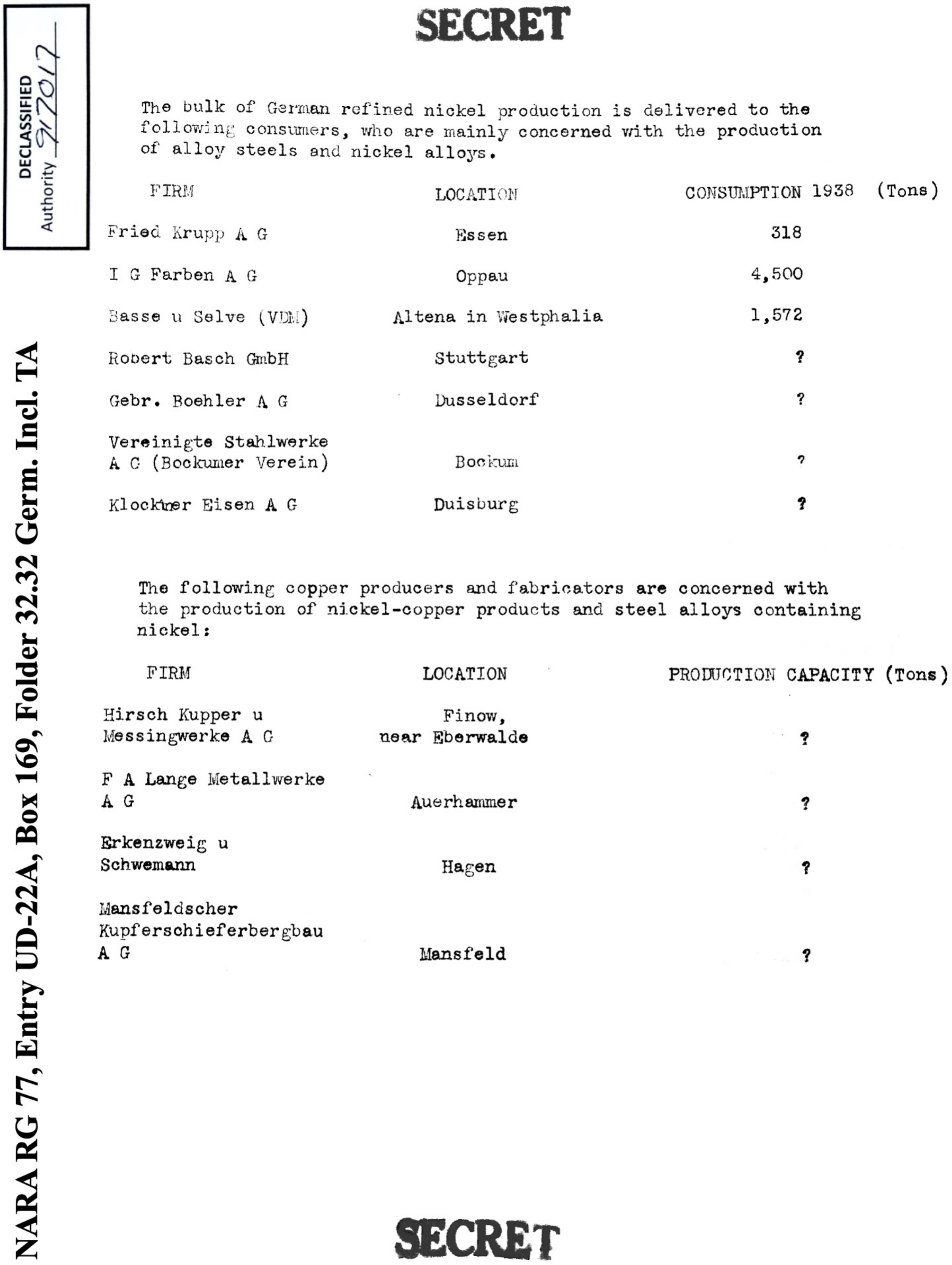
Figure D.538: German Nickel Refineries. Undated but probably 1944. [NARA RG 77, Entry UD-22A, Box 169, Folder 32.32 Germ. Ind. TA]



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The bulk of German refined nickel production is delivered to the following consumers, who are mainly concerned with the production of alloy steels and nickel alloys.

FIRM	LOCATION	CONSUMPTION 1938 (Tons)
Fried Krupp A G	Essen	318
I G Farben A G	Oppau	4,500
Basse u Selve (VDM)	Altena in Westphalia	1,572
Robert Basch GmbH	Stuttgart	?
Gebr. Boehler A G	Dusseldorf	?
Vereinigte Stahlwerke A G (Bockumer Verein)	Bockum	?
Klockner Eisen A G	Duisburg	?

The following copper producers and fabricators are concerned with the production of nickel-copper products and steel alloys containing nickel:

FIRM	LOCATION	PRODUCTION CAPACITY (Tons)
Hirsch Kupper u Messingwerke A G	Finow, near Eberwalde	?
F A Lange Metallwerke A G	Auerhammer	?
Erkenzweig u Schwemann	Hagen	?
Mansfeldscher Kupferschieferbergbau A G	Mansfeld	?

SECRET

Figure D.539: German Nickel Refineries. Undated but probably 1944. [NARA RG 77, Entry UD-22A, Box 169, Folder 32.32 Germ. Ind. TA]

J. Zirconium

[Zirconium was used for high-temperature metals and ceramics in non-nuclear applications, but its high temperature resistance and other properties also would have made it ideal as a fuel cladding material in fission reactors.]

FIAT 750. *Rare and Minor Metals.* p. 16. [See document photos on p. 4143.]

[...] The element is imported principally in the form of zircon mixed with monazite. In 1936 the production of metallic zirconium was 2,000 kg. and the pre-war price (1938) was RM 35 per kg. There are three producers of the metal:

Deutsche Gold- und Silver-Scheideanstalt[...]

I.G. Farbenindustrie A.G.[...]

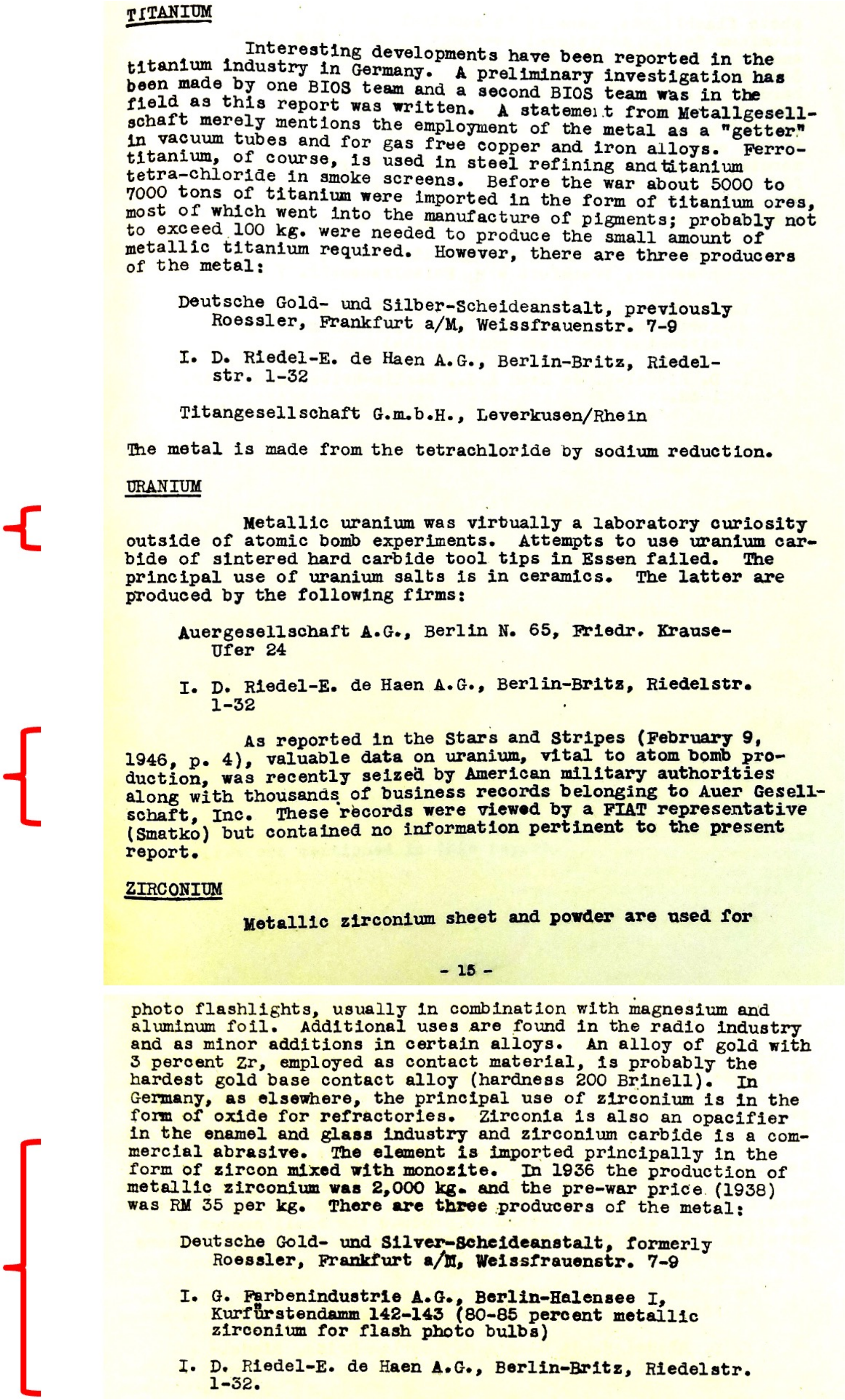
I. D. Riedel—E. de Haen A.G.[...]

These documents also demonstrate commercial production and use of zirconium:

> BIOS 276. *Telefunken Gesellschaft für Drahtlose Telegraphie m.b.h., Berlin; Special Materials for Radio Valves.* [Zirconium for radio valves, treatment of.]
>
> BIOS 896. *The Manufacture of Zirconium-Potassium Fluoride, Zirconium Oxide and Zirconium Oxychloride.*
>
> BIOS 1338. *Developments in Magnesium Production and Fabrication.* [Beryllium, zirconium at Degussa; also fluorine and carbon at I.G. Farben.]
>
> BIOS 1385. *The German Hard Metal Industry.* With Addenda. [Electron microscope, zirconium, uranium, thorium, etc.]
>
> CIOS XXIX-14. *I. G. Farbenindustrie A. G., Leverkusen, Germany.* [Zirconium compounds, production.]
>
> FIAT 89. *Metallurgical and Industrial Developments in Magnesium.* [Zirconium alloys]
>
> FIAT 617. *The Electrical and Technical Ceramic Industry of Germany.* [High temp zirconium ceramics]
>
> FIAT 774. *Anhydrous Chlorides Manufacture.* [Zirconium chlorides.]
>
> FIAT 785. *Electrical Contacts.* [Zirconium alloys for electrical contacts.]
>
> FIAT 1048. *The Production of Zirconium Oxide.*

[For documentation of the shipment of zirconium to Japan, along with other apparently nuclear-related materials, see p. 4094. This evidence suggests that at least some of the zirconium produced in Germany during the war was intended for nuclear applications.]

FIAT 750. *Rare and Minor Metals*



TITANIUM

Interesting developments have been reported in the titanium industry in Germany. A preliminary investigation has been made by one BIOS team and a second BIOS team was in the field as this report was written. A statement from Metallgesellschaft merely mentions the employment of the metal as a "getter" in vacuum tubes and for gas free copper and iron alloys. Ferro-titanium, of course, is used in steel refining and titanium tetra-chloride in smoke screens. Before the war about 5000 to 7000 tons of titanium were imported in the form of titanium ores, most of which went into the manufacture of pigments; probably not to exceed 100 kg. were needed to produce the small amount of metallic titanium required. However, there are three producers of the metal:

Deutsche Gold- und Silber-Scheideanstalt, previously Roessler, Frankfurt a/M, Weissfrauenstr. 7-9

I. D. Riedel-E. de Haen A.G., Berlin-Britz, Riedelstr. 1-32

Titangesellschaft G.m.b.H., Leverkusen/Rhein

The metal is made from the tetrachloride by sodium reduction.

URANIUM

Metallic uranium was virtually a laboratory curiosity outside of atomic bomb experiments. Attempts to use uranium carbide of sintered hard carbide tool tips in Essen failed. The principal use of uranium salts is in ceramics. The latter are produced by the following firms:

Auergesellschaft A.G., Berlin N. 65, Friedr. Krause-Ufer 24

I. D. Riedel-E. de Haen A.G., Berlin-Britz, Riedelstr. 1-32

As reported in the Stars and Stripes (February 9, 1946, p. 4), valuable data on uranium, vital to atom bomb production, was recently seized by American military authorities along with thousands of business records belonging to Auer Gesellschaft, Inc. These records were viewed by a FIAT representative (Smatko) but contained no information pertinent to the present report.

ZIRCONIUM

Metallic zirconium sheet and powder are used for

- 15 -

photo flashlights, usually in combination with magnesium and aluminum foil. Additional uses are found in the radio industry and as minor additions in certain alloys. An alloy of gold with 3 percent Zr, employed as contact material, is probably the hardest gold base contact alloy (hardness 200 Brinell). In Germany, as elsewhere, the principal use of zirconium is in the form of oxide for refractories. Zirconia is also an opacifier in the enamel and glass industry and zirconium carbide is a commercial abrasive. The element is imported principally in the form of zircon mixed with monozite. In 1936 the production of metallic zirconium was 2,000 kg. and the pre-war price (1938) was RM 35 per kg. There are three producers of the metal:

Deutsche Gold- und Silver-Scheideanstalt, formerly Roessler, Frankfurt a/M, Weissfrauenstr. 7-9

I. G. Farbenindustrie A.G., Berlin-Halensee I, Kurfürstendamm 142-143 (80-85 percent metallic zirconium for flash photo bulbs)

I. D. Riedel-E. de Haen A.G., Berlin-Britz, Riedelstr. 1-32.

Figure D.540: FIAT 750. *Rare and Minor Metals.*

Frederic A. C. Wardenburg and Samuel A. Goudsmit. 18 November 1944 [NARA RG 77, Entry UD-22A, Box 167, Folder 32.12-1 GERMANY: Personnel (Mar 43–Dec 44)].

In our investigations of the Soc. de. Terres Rares (STR) in Paris we uncovered the following information, as reported in part before: [...]

Dr. Jansen worked with Ford in Cologne until the end of 1942. He was then hired by Auer and sent to Paris in January 1943. He returned to Germany only for occasional visits. [...]

After reporting to Dr. Ihwe, he was sent back to Saarbrucken to start a search for a lost railroad car loaded with zirconium and other products of the STR. [...]

According to Jansen, Dr. Ihwe is about 50 years old. He studied at Darmstadt and has been with Auer probably five or six years. He is very ambitious, a "Streber." Dr. Ihwe is in complete charge of the department of Rare Earths of the Auer Company. This department has all its facilities at Oranienburg. He is in charge of research as well as applications and some commercial matters. [...]

Jansen had only a very superficial knowledge of the materials produced by STR. He asked Ihwe what it was used for, but received the answer that it was secret. [...]

Jansen said that the Germans removed the electro-magnetic separator and classifier from the STR plant at Serquigny.

[See photos of the first two pages of this document on p. 4145.

The same Auer Oranienburg plant that spent the war acquiring and processing uranium for secret programs was also acquiring railroad cars worth of zirconium for secret programs, and its officials were eager to make sure that no zirconium went to waste. This evidence suggests that some if not all of the zirconium was intended for nuclear applications.]

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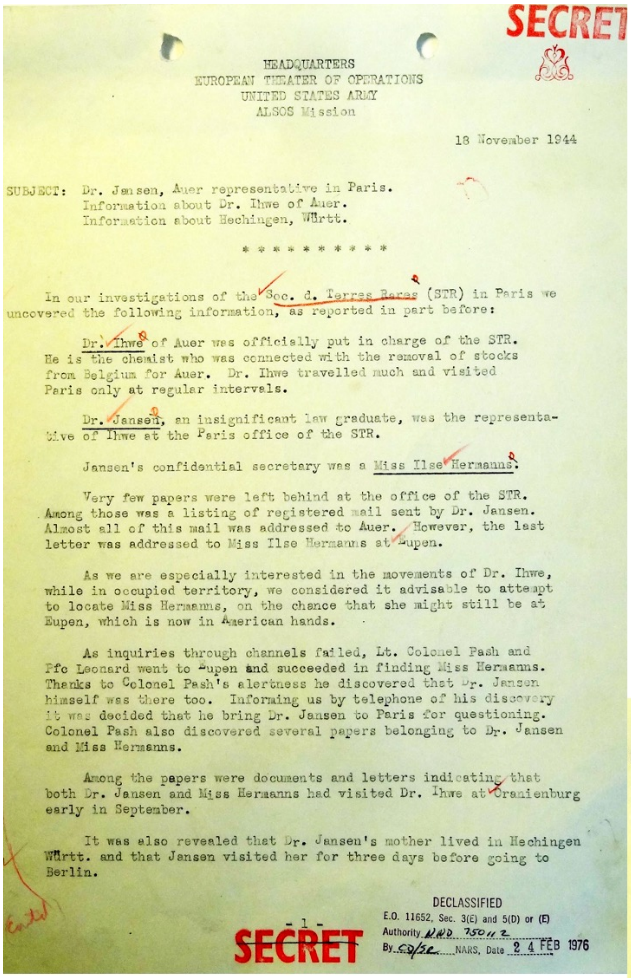

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HEADQUARTERS
EUROPEAN THEATER OF OPERATIONS
UNITED STATES ARMY
ALSOS Mission

18 November 1944

SUBJECT: Dr. Jansen, Auer representative in Paris.
Information about Dr. Ihwe of Auer.
Information about Hechingen, Württ.

* * * * * * * * * *

In our investigations of the Soc. d. Terres Rares (STR) in Paris we uncovered the following information, as reported in part before:

Dr. Ihwe of Auer was officially put in charge of the STR. He is the chemist who was connected with the removal of stocks from Belgium for Auer. Dr. Ihwe travelled much and visited Paris only at regular intervals.

Dr. Jansen, an insignificant law graduate, was the representative of Ihwe at the Paris office of the STR.

Jansen's confidential secretary was a Miss Ilse Hermanns.

Very few papers were left behind at the office of the STR. Among those was a listing of registered mail sent by Dr. Jansen. Almost all of this mail was addressed to Auer. However, the last letter was addressed to Miss Ilse Hermanns at Eupen.

As we are especially interested in the movements of Dr. Ihwe, while in occupied territory, we considered it advisable to attempt to locate Miss Hermanns, on the chance that she might still be at Eupen, which is now in American hands.

As inquiries through channels failed, Lt. Colonel Pash and Pfc Leonard went to Eupen and succeeded in finding Miss Hermanns. Thanks to Colonel Pash's alertness he discovered that Dr. Jansen himself was there too. Informing us by telephone of his discovery it was decided that he bring Dr. Jansen to Paris for questioning. Colonel Pash also discovered several papers belonging to Dr. Jansen and Miss Hermanns.

Among the papers were documents and letters indicating that both Dr. Jansen and Miss Hermanns had visited Dr. Ihwe at Oranienburg early in September.

It was also revealed that Dr. Jansen's mother lived in Hechingen Württ. and that Jansen visited her for three days before going to Berlin.

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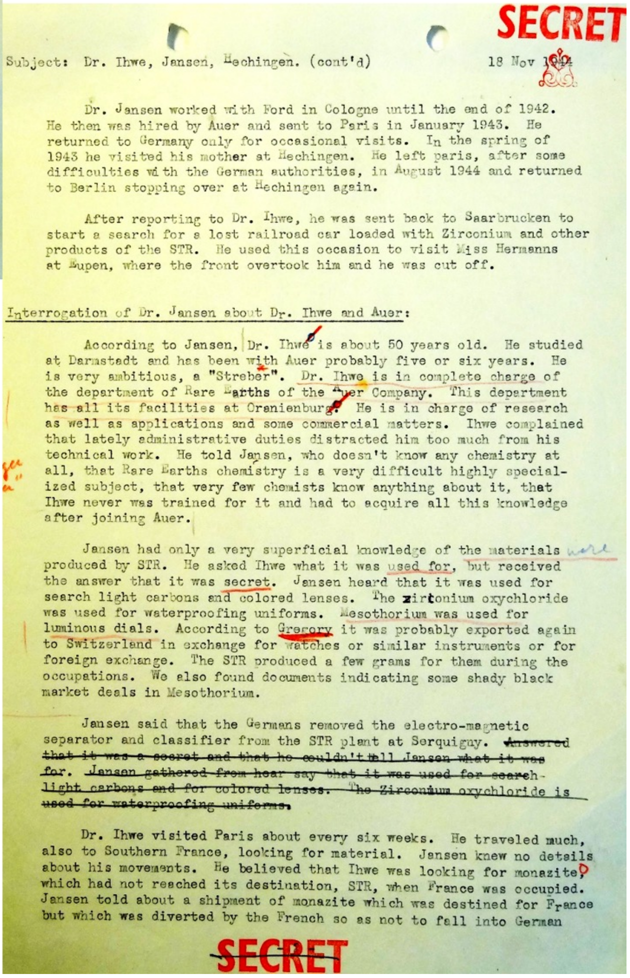

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Subject: Dr. Ihwe, Jansen, Hechingen. (cont'd) 18 Nov 1944

Dr. Jansen worked with Ford in Cologne until the end of 1942. He then was hired by Auer and sent to Paris in January 1943. He returned to Germany only for occasional visits. In the spring of 1943 he visited his mother at Hechingen. He left paris, after some difficulties with the German authorities, in August 1944 and returned to Berlin stopping over at Hechingen again.

After reporting to Dr. Ihwe, he was sent back to Saarbrucken to start a search for a lost railroad car loaded with Zirconium and other products of the STR. He used this occasion to visit Miss Hermanns at Eupen, where the front overtook him and he was cut off.

Interrogation of Dr. Jansen about Dr. Ihwe and Auer:

According to Jansen, Dr. Ihwe is about 50 years old. He studied at Darmstadt and has been with Auer probably five or six years. He is very ambitious, a "Streber". Dr. Ihwe is in complete charge of the department of Rare Earths of the Auer Company. This department has all its facilities at Oranienburg. He is in charge of research as well as applications and some commercial matters. Ihwe complained that lately administrative duties distracted him too much from his technical work. He told Jansen, who doesn't know any chemistry at all, that Rare Earths chemistry is a very difficult highly specialized subject, that very few chemists know anything about it, that Ihwe never was trained for it and had to acquire all this knowledge after joining Auer.

Jansen had only a very superficial knowledge of the materials were produced by STR. He asked Ihwe what it was used for, but received the answer that it was secret. Jansen heard that it was used for search light carbons and colored lenses. The zirtonium oxychloride was used for waterproofing uniforms. Mesothorium was used for luminous dials. According to Gregory it was probably exported again to Switzerland in exchange for watches or similar instruments or for foreign exchange. The STR produced a few grams for them during the occupations. We also found documents indicating some shady black market deals in Mesothorium.

Jansen said that the Germans removed the electro-magnetic separator and classifier from the STR plant at Serquigny. ~~Answered that it was a secret and that he couldn't tell Jansen what it was for. Jansen gathered from hear say that it was used for search light carbons and for colored lenses. The Zirconium oxychloride is used for waterproofing uniforms.~~

Dr. Ihwe visited Paris about every six weeks. He traveled much, also to Southern France, looking for material. Jansen knew no details about his movements. He believed that Ihwe was looking for monazite, which had not reached its destination, STR, when France was occupied. Jansen told about a shipment of monazite which was destined for France but which was diverted by the French so as not to fall into German

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NARA RG 77, Entry UD-22A, Box 167, Folder 32.12-1 GERMANY: Personnel (Mar 43-Dec 44)

Figure D.541: Frederic A. C. Wardenburg and Samuel A. Goudsmit. 18 November 1944 [NARA RG 77, Entry UD-22A, Box 167, Folder 32.12-1 GERMANY: Personnel (Mar 43–Dec 44)]. "After reporting to Dr. Ihwe, he was sent back to Saarbrucken to start a search for a lost railroad car loaded with zirconium and other products of the STR."

[Further evidence of German zirconium production for nuclear purposes comes from a postwar shipwreck, as shown on p. 4147.

The SS *Flying Enterprise*, a commercial U.S. cargo ship, left Hamburg on 21 December 1951 with a variety of cargo headed for the United States. While passing near the southern coast of England, the ship was badly damaged in a storm on 25 December 1951. Despite extensive efforts by other ships to prevent the *Flying Enterprise* from sinking, it finally went down on 10 January 1952. (Everyone onboard was saved except for one person.)

In later interviews, the captain of the *Flying Enterprise*, Kurt Carlsen, stated that among the cargo was five tons of German-produced zirconium, left over from the wartime German nuclear program and destined to be used as cladding for the uranium fuel rods in the first U.S. nuclear submarine, USS *Nautilus*. Carlsen also stated that Navy divers salvaged the zirconium from the underwater wreck of his ship and took the zirconium back to the United States, causing a six-month delay in the launch of the Nautilus (finally launched in 1954).

This information confirms that some of the German zirconium that was being produced during the war was specifically intended for nuclear applications. It is not clear if those applications included submarine reactors, breeder reactors for producing plutonium, or other purposes. It is also not clear how far such nuclear work progressed in Germany during the war.

Any U.S. government documents on this shipment of zirconium or its origins in the wartime German nuclear program appear to remain classified and unavailable. This incident seems to confirm that the U.S. government has a much deeper knowledge of the wartime German nuclear program than it has admitted publicly, and that that knowledge shows the German nuclear program to have been more advanced than has been publicly stated.]

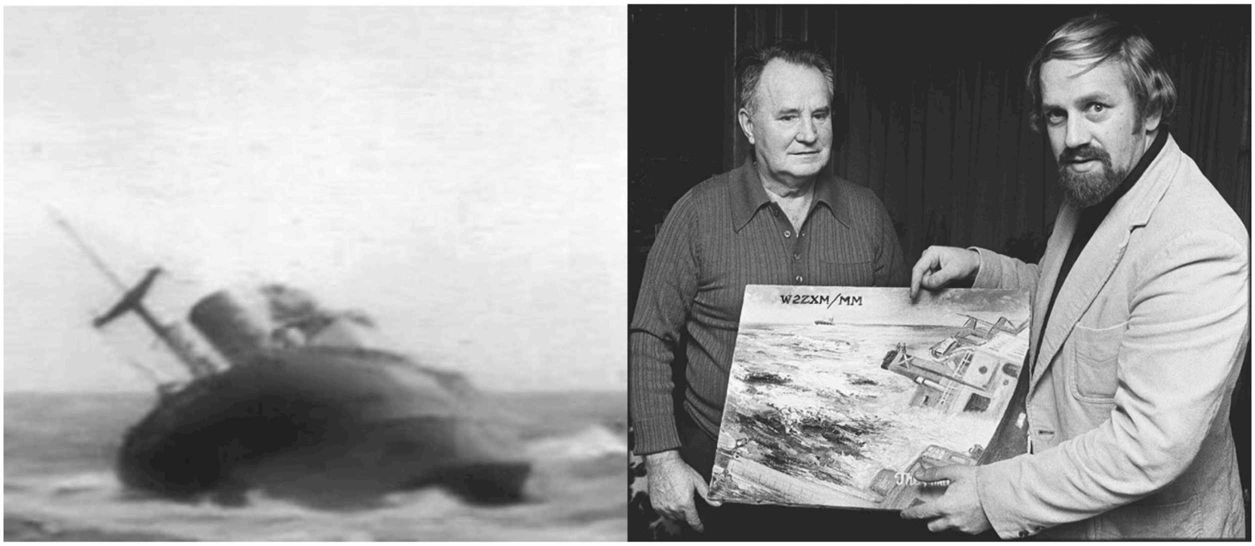
Bjarne Bekker. 2013. *Flying Enterprise & Kurt Carlsen.* Svendborg, Denmark: Bekker. p. 141. http://flying-enterprise.øavisen.dk

The reactor on "Nautilus" needed zirconium from "Flying Enterprise"

Kurt Carlsen spoke of it as if it were a story about onshore shooting in the Faroe Islands, water skiing on the lakes at Silkeborg or landing a sports plane on the beach on the west coast on a visit to his in-laws in Tane near Blavand. Quietly and matter-of-factly he sat in his retirement in Woodbridge and explained the cargo of zirconium. That the American military and secret service had found the material in West Germany. That Hitler was to use it in his nuclear program and that it was now to be used in the reactor of the first nuclear submarine "Nautilus".

"The launch was delayed six months, because divers had to enter the "Flying Enterprise" and retrieve the five tons of zirconium. Several idiotic reporters at the time wrote that my cargo was nuclear bombs. That was so wrong. My cargo was a material which encapsulates radioactivity".

[See also:
Deutsches Zirkonium war für erstes Atom-U-Boot der Welt bestimmt: Taucher bargen geheime Fracht des See-Helden Kapitän Carlsen. *Ruhr-Nachtrichten* (Dortmund). 24 January 1987.
https://www.youtube.com/watch?v=d99zNLh5E0U
https://www.youtube.com/watch?v=DzCOYlMcOiA
Lasse Spang Olsen and Emil Oigaard. 2002. The Mystery of Flying Enterprise. Copenhagen: Offshore Film Production.]



Sinking of the SS *Flying Enterprise* (10 January 1952)

Kurt Carlsen, captain of the *Flying Enterprise*

Journalist Bjarne Bekker interviewed Carlsen in 1976

First U.S. nuclear submarine, USS *Nautilus* (launched 1954)

Figure D.542: The SS *Flying Enterprise* sank on 10 January 1952 while carrying cargo from Hamburg to the United States. Its captain, Kurt Carlsen, later told interviewers such as Bjarne Bekker that the cargo included five tons of zirconium, left over from the wartime German nuclear program, which was salvaged from his sunken ship and used in the first U.S. nuclear submarine, USS *Nautilus*.

K. Cadmium

[Cadmium was used for nickel-cadmium batteries and soldering, but it also could have been extremely useful as a neutron absorber.

The following documents illustrate the production and applications of cadmium, as well as methods for electroplating thin layers of materials such as cadmium onto aluminum (which could be useful for nuclear applications).

German capabilities to electroplate cadmium on aluminum are potentially quite relevant for creating a neutron-absorbing cadmium layer on a spherical aluminum pusher as in the German fission implosion bomb described in March 1945—see p. 4486.

For a description of how cadmium was mined on a large scale with specific knowledge of its utility in atomic bombs, see p. 4255.]

English translation of Rudolf Fleishmann to Georg Stetter [both nuclear scientists]. 12 June 1942. [Deutsches Museum Archive, Munich, FA 002/0401]

[...] I am having thin cadmium sheets (foil) 0.5 mm and 1 mm thickness rolled out at the G. A. Scheid Co. refinery, Gumpendorferstrasse 85, Vienna VI. To be sure I must obtain the cadmium. I used to get it from the organization in Berlin you know about. [...]

English translation of Rudolf Fleishmann to Dr. Th. Schuchardt Firm, Goerlitz. 14 December 1943. [Deutsches Museum Archive, Munich, FA 002/0401]

[...] We require cadmium sheets for work with slow neutrons: 4 sheets 50 x 40 cm x 0.6 mm. [...]

For some examples of cadmium production and uses, see:

BIOS 264. *German Brass and Copper Wire Industry.* [Cadmium copper wire substitute production.]

BIOS 379. *The German Zinc Smelting Industry.* [Cadmium production.]

BIOS 708. *German Alkaline Accumulator Industry.* [Cadmium—iron “masse” for alkaline accumulators]

BIOS 813. *Zinc Works at Porto Marghera, Italy (Montecatini-Montevecchio, Soc. Italiana del Piombo e dello Zinco).* [Cadmium recovery in zinc refining.]

CIOS XIII-5. *Photo Lenses and Optical Instruments.* [Cadmium glass preparation.]

CIOS XXIX-14. *I. G. Farbenindustrie A. G., Leverkusen, Germany.* [Production of cadmium compounds.]

CIOS XXXI-20. *Refining of Cobalt, Nickel, Zinc and Cadmium.*

CIOS XXXI-56. *George Von Giesche’s Erben, Magdeburg.* [Cadmium production.]

FIAT 733. *Vertical Retort Zinc and By-Products: Oker, Harz Mts.*

FIAT 800. *Nickel Cadmium Storage Batteries in Germany.*

FIAT 814. *German Production of Some of the More Important Inorganic Pigments.* [Cadmium pigments manufacture.]

FIAT 882. *Anodes.* [Cadmium anodes]

BIOS 1159. *The Uses of Zinc in Germany.*

[p. 27:] 3 CADMIUM—Supply and Consumption

SOURCES OF INFORMATION

The information on supply was obtained from the same sources as that on the supply of zinc, viz; the Reichsstelle Eisen und Metalle and the Metallgesellschaft. The production figures obtained from the former were said to be actual figures and not estimates; but it is thought that the export and import figures from the latter are estimates only.

TOTAL SUPPLY

The following table, in metric tons, shows German and Austrian production and includes that from Upper Silesia from September, 1939, from the following Smelters—Giesche (Kattowitz), Hohenlohe and Schlesag:

	1938	1939	1940	1941	1942	1943	1944
PRODUCTION	437	477	531	608	484	496	404
Imports	100	253	86	1	72	10	7
TOTAL SUPPLY	537	730	617	609	556	506	411
less exports	50	47	62	37	128	108	29
NET SUPPLY	487	683	555	572	428	398	382

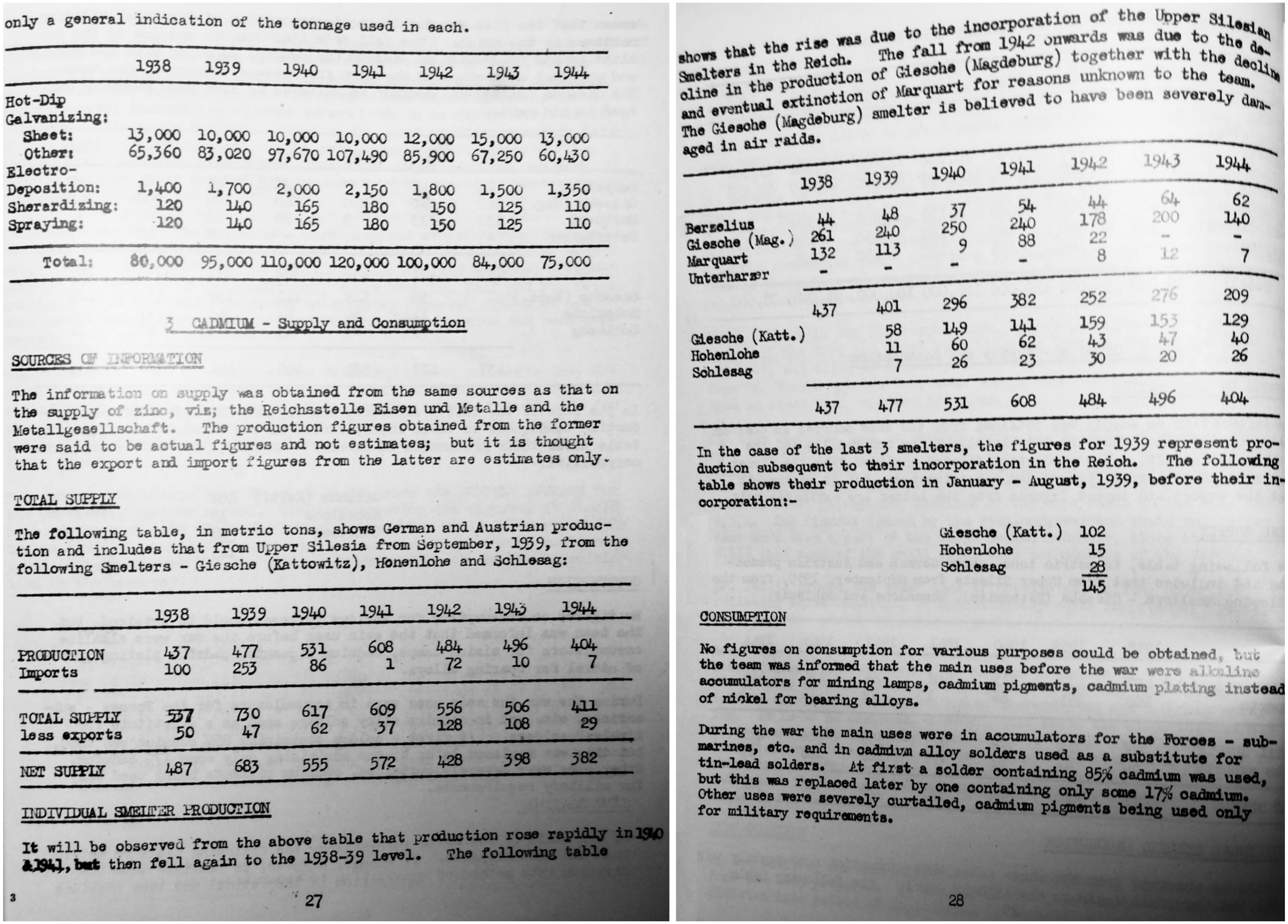
[p. 28:] CONSUMPTION

No figures on consumption for various purposes could be obtained, but the team was informed that the main uses before the war were alkaline accumulators for mining lamps, cadmium pigments, cadmium plating instead of nickel for bearing alloys.

During the war the main uses were in accumulators [nickel-cadmium batteries] for the Forces—submarines, etc. and in cadmium alloy solders used as a substitute for tin-lead solders. [...] Other uses were severely curtailed, cadmium pigments being used only for military requirements.

[See document photos on p. 4151.]

BIOS 1159. ***The Uses of Zinc in Germany***



only a general indication of the tonnage used in each.

	1938	1939	1940	1941	1942	1943	1944
Hot-Dip Galvanizing:							
Sheet:	13,000	10,000	10,000	10,000	12,000	15,000	13,000
Other:	65,360	83,020	97,670	107,490	85,900	67,250	60,430
Electro-Deposition:	1,400	1,700	2,000	2,150	1,800	1,500	1,350
Sherardizing:	120	140	165	180	150	125	110
Spraying:	120	140	165	180	150	125	110
Total:	80,000	95,000	110,000	120,000	100,000	84,000	75,000

3 CADMIUM - Supply and Consumption

SOURCES OF INFORMATION

The information on supply was obtained from the same sources as that on the supply of zinc, viz; the Reichsstelle Eisen und Metalle and the Metallgesellschaft. The production figures obtained from the former were said to be actual figures and not estimates; but it is thought that the export and import figures from the latter are estimates only.

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less exports	50	47	62	37	128	108	29
NET SUPPLY	487	683	555	572	428	398	382

INDIVIDUAL SMELTER PRODUCTION

It will be observed from the above table that production rose rapidly in 1940 & 1941, but then fell again to the 1938-39 level. The following table

3

27

shows that the rise was due to the incorporation of the Upper Silesian Smelters in the Reich. The fall from 1942 onwards was due to the decline in the production of Giesche (Magdeburg) together with the decline and eventual extinction of Marquart for reasons unknown to the team. The Giesche (Magdeburg) smelter is believed to have been severely damaged in air raids.

	1938	1939	1940	1941	1942	1943	1944
Berzelius	44	48	37	54	44	64	62
Giesche (Mag.)	261	240	250	240	178	200	140
Marquart	132	113	9	88	22	-	-
Unterharzer	-	-	-	-	8	12	7
	437	401	296	382	252	276	209
Giesche (Katt.)		58	149	141	159	153	129
Hohenlohe		11	60	62	43	47	40
Schlesag		7	26	23	30	20	26
	437	477	531	608	484	496	404

In the case of the last 3 smelters, the figures for 1939 represent production subsequent to their incorporation in the Reich. The following table shows their production in January - August, 1939, before their incorporation:-

Giesche (Katt.)	102
Hohenlohe	15
Schlesag	28
	145

CONSUMPTION

No figures on consumption for various purposes could be obtained, but the team was informed that the main uses before the war were alkaline accumulators for mining lamps, cadmium pigments, cadmium plating instead of nickel for bearing alloys.

During the war the main uses were in accumulators for the Forces - submarines, etc. and in cadmium alloy solders used as a substitute for tin-lead solders. At first a solder containing 85% cadmium was used, but this was replaced later by one containing only some 17% cadmium. Other uses were severely curtailed, cadmium pigments being used only for military requirements.

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Figure D.543: BIOS 1159. *The Uses of Zinc in Germany.* 3 CADMIUM—Supply and Consumption.

BIOS 1009. *A Survey of German Electro-Plating Methods.*

[p. 24:] CADMIUM.

A process of cadmium deposition by immersion was mentioned MR. MEYER but this was not seen.

[p. 67:] CADMIUM PLATING.

This was produced in small quantities but it appeared that zinc was used in practically all cases. This may have been due to shortage.

[p. 68:] CHROMIUM PLATING OF ALUMINIUM.

This had been done on a commercial scale but seemed to have faded out, due possibly to general disuse of decorative chromium plating during the war and the imperative saving of man power. One or two firms catalogued the finish. Interrogation brought little information.

[See document photos on p. 4153.]

BIOS 1615. *The German Metal Finishing Industry.*

[p. 5:] Cadmium Plating

This is employed to a limited extent and the solutions are analogous to the higher current density type used in this country. [...]

[p. 8:] Plating on Aluminium and its Alloys

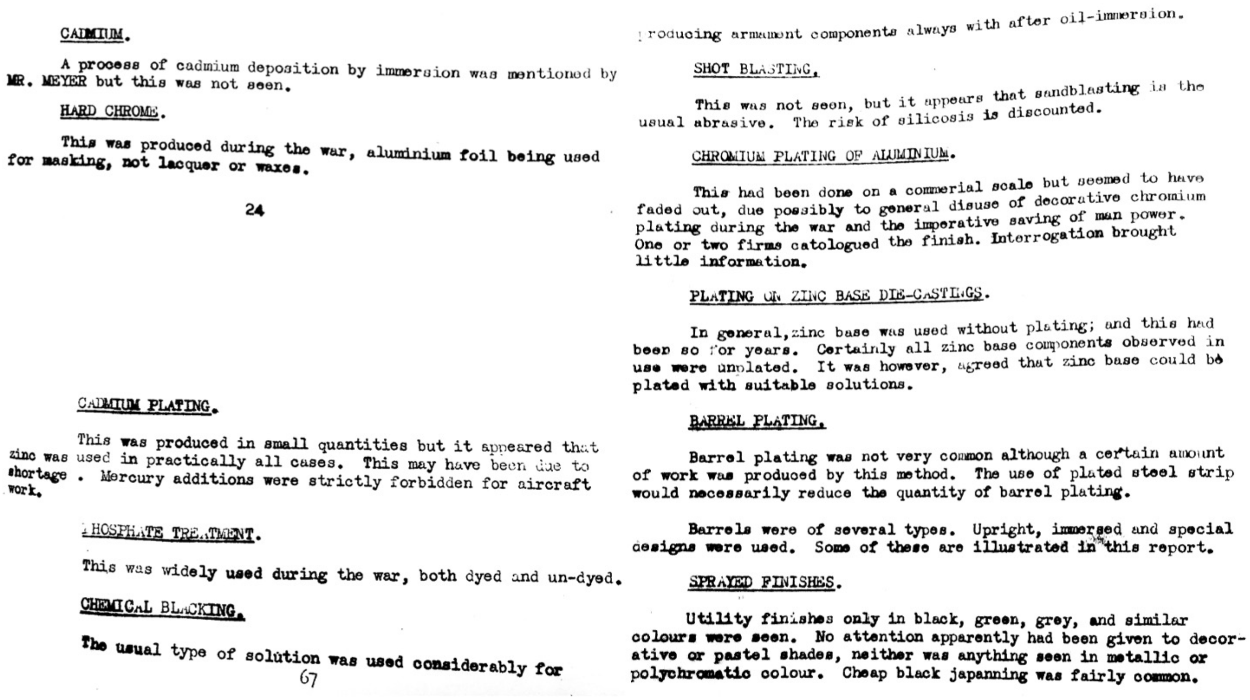
Although aluminium is widely used in Germany, no actual samples of nickel plus chromium plated aluminium were seen. Samples of lead plated battery lugs were encountered at Robert Bosch, Stuttgart and direct chromium plated aluminium at Blasberg's, Sollingen. Numerous references are made to the plating of aluminium and its alloys, however, and the most popular treatment for plating on this metal appears to be a primary application of a zincate dip followed by either a copper or brass deposit and then final plating.

[See document photos on p. 4153.]

For more technology for electroplating on aluminum, see:

BIOS 429. *German Electroplating Industry.*

BIOS 1009. *A Survey of German Electro-Plating Methods*



CADMIUM.

A process of cadmium deposition by immersion was mentioned by MR. MEYER but this was not seen.

HARD CHROME.

This was produced during the war, aluminium foil being used for masking, not lacquer or waxes.

CADMIUM PLATING.

This was produced in small quantities but it appeared that zinc was used in practically all cases. This may have been due to shortage . Mercury additions were strictly forbidden for aircraft work.

PHOSPHATE TREATMENT.

This was widely used during the war, both dyed and un-dyed.

CHEMICAL BLACKING.

The usual type of solution was used considerably for producing armament components always with after oil-immersion.

SHOT BLASTING.

This was not seen, but it appears that sandblasting is the usual abrasive. The risk of silicosis is discounted.

CHROMIUM PLATING OF ALUMINIUM.

This had been done on a commerial scale but seemed to have faded out, due possibly to general disuse of decorative chromium plating during the war and the imperative saving of man power. One or two firms catologued the finish. Interrogation brought little information.

PLATING ON ZINC BASE DIE-CASTINGS.

In general,zinc base was used without plating; and this had been so for years. Certainly all zinc base components observed in use were unplated. It was however, agreed that zinc base could be plated with suitable solutions.

BARREL PLATING.

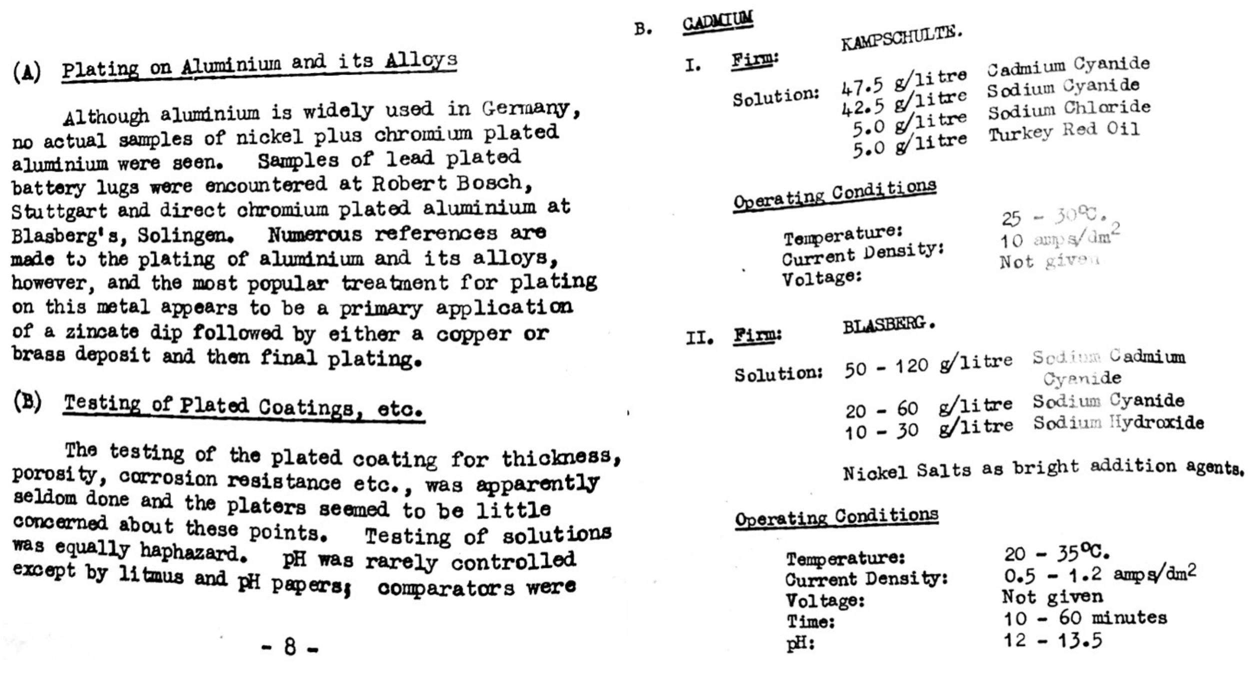
Barrel plating was not very common although a certain amount of work was produced by this method. The use of plated steel strip would necessarily reduce the quantity of barrel plating.

Barrels were of several types. Upright, immersed and special designs were used. Some of these are illustrated in this report.

SPRAYED FINISHES.

Utility finishes only in black, green, grey, and similar colours were seen. No attention apparently had been given to decorative or pastel shades, neither was anything seen in metallic or polychromatic colour. Cheap black japanning was fairly common.

BIOS 1615. *The German Metal Finishing Industry*



(A) Plating on Aluminium and its Alloys

Although aluminium is widely used in Germany, no actual samples of nickel plus chromium plated aluminium were seen. Samples of lead plated battery lugs were encountered at Robert Bosch, Stuttgart and direct chromium plated aluminium at Blasberg's, Solingen. Numerous references are made to the plating of aluminium and its alloys, however, and the most popular treatment for plating on this metal appears to be a primary application of a zincate dip followed by either a copper or brass deposit and then final plating.

(B) Testing of Plated Coatings, etc.

The testing of the plated coating for thickness, porosity, corrosion resistance etc., was apparently seldom done and the platers seemed to be little concerned about these points. Testing of solutions was equally haphazard. pH was rarely controlled except by litmus and pH papers; comparators were

B. CADMIUM

I. Firm: KAMPSCHULTE.

Solution:
47.5 g/litre Cadmium Cyanide
42.5 g/litre Sodium Cyanide
5.0 g/litre Sodium Chloride
5.0 g/litre Turkey Red Oil

Operating Conditions

Temperature: 25 - 30°C.
Current Density: 10 amps/dm^2
Voltage: Not given

II. Firm: BLASBERG.

Solution:
50 - 120 g/litre Sodium Cadmium Cyanide
20 - 60 g/litre Sodium Cyanide
10 - 30 g/litre Sodium Hydroxide

Nickel Salts as bright addition agents.

Operating Conditions

Temperature: 20 - 35°C.
Current Density: 0.5 - 1.2 amps/dm^2
Voltage: Not given
Time: 10 - 60 minutes
pH: 12 - 13.5

Figure D.544: Top: BIOS 1009. *A Survey of German Electro-Plating Methods.* Bottom: BIOS 1615. *The German Metal Finishing Industry.*

D.8 Fission Bomb Design

[The following documents demonstrate that the German nuclear program had sophisticated implosion bomb designs that would be highly suitable for either a fission implosion bomb or a fusion-boosted fission implosion bomb, and moreover that the German program carried out serious experimental work on implosion bombs from an early date. The most important design details are summarized in Table D.2.

Adolf Busemann (German, 1901–1986), Rolf Engel (German, 1912–1993), Gottfried Guderley (German, 1910–1997), Walter Hantzsche (German, 19??–19??), Rudi Schall (German, 1913–2002), Hubert Schardin (German, 1902–1965), Erich Schumann (German, 1898–1985), Walter Trinks (German, 1910–1995), Hilmar Wendt (German, 1913–19??), and many others worked in teams that developed and demonstrated implosion bomb designs:

- H. Rausch von Traubenberg and other scientists in the German-speaking world began using neutron reflectors around their nuclear reaction experiments no later than 1936 (pp. 4158–4159).

- Herbert Wagner and other scientists at the Henschel aircraft company proposed nuclear weapons at the beginning of the war and apparently worked to develop them during the war (pp. 4160–4166).

- No later than 1940, the German mathematicians Walter Hantzsche and Hilmar Wendt predicted the pressure, density, and temperature in spherical and cylindrical implosion bomb configurations, mathematical solutions that are still used today (pp. 4166–4169).

- No later than 1942, Gottfried Guderley, a hydrodynamics expert working for the German military, performed very similar calculations for spherical and cylindrical implosions (pp. 4170–4171).

- 1943 U.S. intelligence reports stated that "several factories and hundreds of workers" just south of Hamburg were producing an unusual material that was a new type of explosive, that was so energetic that one kilogram of the new material would have a blast radius of several kilometers, and that would be placed into bombs of a highly unusual spherical design (pp. 4172–4182, 4406).

- Manfred von Ardenne worked throughout the war to produce fission bombs each containing a few kilograms of uranium-235 (pp. 3561–3617, 4180, 4183–4184). After the war he played a key role in the Soviet nuclear weapons program.

- Based on several inside sources, on 22 October 1944 the *New York Times* reported that Germany was developing an atomic bomb that simultaneously used high-voltage electricity (i.e., a high-voltage fusion neutron initiator) and the detonation of surrounding conventional explosives (i.e., implosion) to release large amounts of energy from fission fuel ("the force of the disintegrating atoms"). See p. 4185.

- In November 1944, *Time* magazine published an intelligence report that Germany was developing an atomic bomb with a spherical implosion design to cause uranium fuel to fission in an explosive reaction (p. 4185).

- A 23 March 1945 letter from General Ivan Ilyichev to Joseph Stalin reported that Germany had built and successfully tested an atomic bomb, and described it in considerable detail as a 2-ton, 1.3-meter-diameter spherical implosion bomb with multiple concentric layers and a uranium-235 core (p. 4485).

- Erich Schumann, the German Army Ordnance Office's head physicist, along with others on his staff, worked throughout the war designing and testing ever more sophisticated bombs that used an outer shell of conventional explosives to implode an inner core of various materials, including nuclear fuels (pp. 4187–4255). (Schumann was also Wernher von Braun's Ph.D. thesis advisor for the development of rockets, as well as a key figure in Germany's biological warfare program and several other advanced research programs. Yet Goudsmit testified to the U.S. Senate that Schumann was mainly interested in "the physics of piano strings.")

- In November 1945, the German economist Erwin Respondek wrote that Erich Schumann had been involved in the development of an atomic bomb that used uranium fuel and a neutron initiator (and apparently Schumann's expertise, conventional explosives for spherical implosion) (p. 4194).

- The implosion expert Walter Trinks worked closely with Schumann during the war. Trinks was imprisoned by the U.S. Army from June 1945 to June 1946, and he informed them that "At the end of the war I was occupied with experiments for... the initiation of atomic bombs" (pp. 4257–4259).

- A Top Secret U.S. cable from March 1946 stated that a "capable young engineer" in Poland knew that atomic bomb casings included a layer of cadmium, which was true for the implosion bomb designs described by both Ilyichev and Schumann (p. 4255).

- A 1946 U.S intelligence report (which was not declassified until 2006) stated that at the end of the war, General Hans Kammler's deputy Erich "Purucker was driving a large civilian car which contained many of the plans on the atom bomb. This car plus material fell into the hands of the Russians" (p. 4914).

- A U.S. intelligence card catalog shows that there were postwar reports giving details of the German atomic bomb plans, but those reports are still classified and unavailable to the public (pp. 5074–5074).

- After the war, Kurt Diebner discussed spherical implosion bomb designs, specifically showing a spherical core of fission fuel with a center of fusion fuel (pp. 4260–4267).

- German witnesses described secretive and mysterious work that had been conducted during the war to produce and test nesting aluminum spheres that apparently matched the description of those in the implosion bomb designs (p. 4270).

- Hubert Schardin led a Luftwaffe research group that also appears to have been developing fission implosion bombs during the war, and he aided the French nuclear weapons program after the war (pp. 4190, 4268–4269). [See also Krehl 2009, pp. 1160–1162; Nagel 2012, p. 149 ff.]

- In 2000–2002 interviews, Heinrich Himmler's chief adjutant, Werner Grothmann, mentioned the development of an atomic bomb that "would have possessed a spherical shape with a diameter of over one meter. It was very heavy, even though the bomb body itself was supposed to be out of aluminum. It was said, if one reduces the weight, the yield is not as high" (pp. 4271–4273).

- Werner Grothmann (pp. 4271–4273) and Erich Schumann and Walter Trinks (pp. 4187–4255) stated that there were actually several different versions of the implosion bomb design for different geometries (spherical vs. cylindrical), sizes, and fuels.

- German scientists also appear to have been aware of the gun-type fission bomb design [Karlsch and Walker 2005; Thirring 1946]. However, any development seems to have been focused on the implosion design, since it requires much less fission fuel and has a much higher efficiency than the gun design.

For sources describing weapon designs with a significant amount of fusion fuel as well as fission fuel, see Section D.9.]

	Primary sources for fission bomb design										
Component	**Guderley 10/1942**	**Loofbourow 10/1943**	***Time* 11/1944**	**Ilyichev 3/1945**	**Kurchatov 3/1945**	**Respondek 11/1945**	**Schumann 1945-1952**	**Polish eng. 3/1946**	**Diebner 1956-1962**	**Grothmann 2000-2002**	**König 2004**
Neutron initiator				1. Internal high-voltage fusion neutrons 2. External gamma rays (via betatron)	1. Internal high-voltage fusion neutrons 2. External gamma rays (via betatron)	Neutron source	Fusion fuel	Neutron source (implied)	Fusion fuel	Ignition system	
Pit		High-density, high-energy new material, laborious to produce	Uranium	U-235	U-235	U-235	Uranium	Fission fuel	Uranium	U-235	
Reflector /tamper				``Delay mechanism” that was apparently also uranium			Uranium				
Neutron absorber				Cadmium	Cadmium		Cadmium	Cadmium			
Pusher				Aluminum			Aluminum				Aluminum
Explosive	Explosive designed for spherical implosion	Explosive designed for spherical implosion (implied)	Explosive designed for spherical implosion	Shaped segments of TNT with liquid oxygen, made lighter for rocket	Shaped segments of TNT with liquid oxygen, made lighter for rocket	Explosive designed for spherical implosion (implied)	Many shaped segments of TNT, RDX (explosive lenses) with simultaneous ignition		TNT and RDX	Complex explosive system with simultaneous ignition, made lighter for rocket	
Explosive case	Spherical case	Spherical case	Spherical case	Spherical aluminum	Spherical case	Case	Spherical aluminum	Case	Spherical case	Spherical aluminum	Spherical aluminum
Ballistic case				Steel case for rocket			Iron/ steel			Part of rocket	
Position for test				Positioned in a test area	Positioned in a test area		Suspended a few meters above the ground			On metal scaffold	

Table D.2: Details about fission implosion bomb design from primary sources.

H. Rausch von Traubenberg and H. Adam. 1937. Über die Rückstreuung von Neutronen und die Herstellung von Räumen mit erhöhter Neutronenkonzentration. *Zeitschrift für Physik* 104:442–447.

Wir beabsichtigen, unsere Versuche mit schwerem Wasser als bremsender Substanz fortzusetzen, da bei diesem eine geringere Absorption von Neutronen (Tritonenbildung) zu erwarten ist.

Zum Schluß haben wir noch Versuche über die Richtungsverteilung der an Eisen gestreuten Neutronen angestellt. Zu diesem Zwecke wurde ein Eisenstab von 3x3 cm als “Reflektor” benutzt und die Aktivierung des Rhodiumzylinders in verschiedenen Orientierungen zum Eisenstab ermittelt. Jedoch konnte die Frage bei der Schwäche unserer Neutronenquelle trotz langer Meßreihen noch nicht eindeutig beantwortet werden und wir beabsichtigen daher, das Problem der Richtungsverteilung mit stärkeren Neutronenquellen erneut in Angriff zu nehmen.

Zusammenfassung. In der vorliegenden Untersuchung wurden die Resultate von Mitchell und Mitarbeitern über die starke Rückstreuung langsamer Neutronen an Eisen und Blei bestätigt. Es gelang in geschlossenen Hohlräumen (bis zu 9 Liter) durch Verwendung von reflektierenden Eisen- bzw. Bleiwänden Neutronenkonzentrationen herzustellen, die die Werte ohne reflektierende Wände um ein Vielfaches übertrafen. Auf diese Weise wurde erstmalig eine gewisse Anreicherung von Neutronen (Kernbestandteilen) in leeren Räumen erreicht und so die Möglichkeit gegeben, mit einem reinen “Neutronengas” ohne Anwesenheit von störender Materie zu arbeiten.

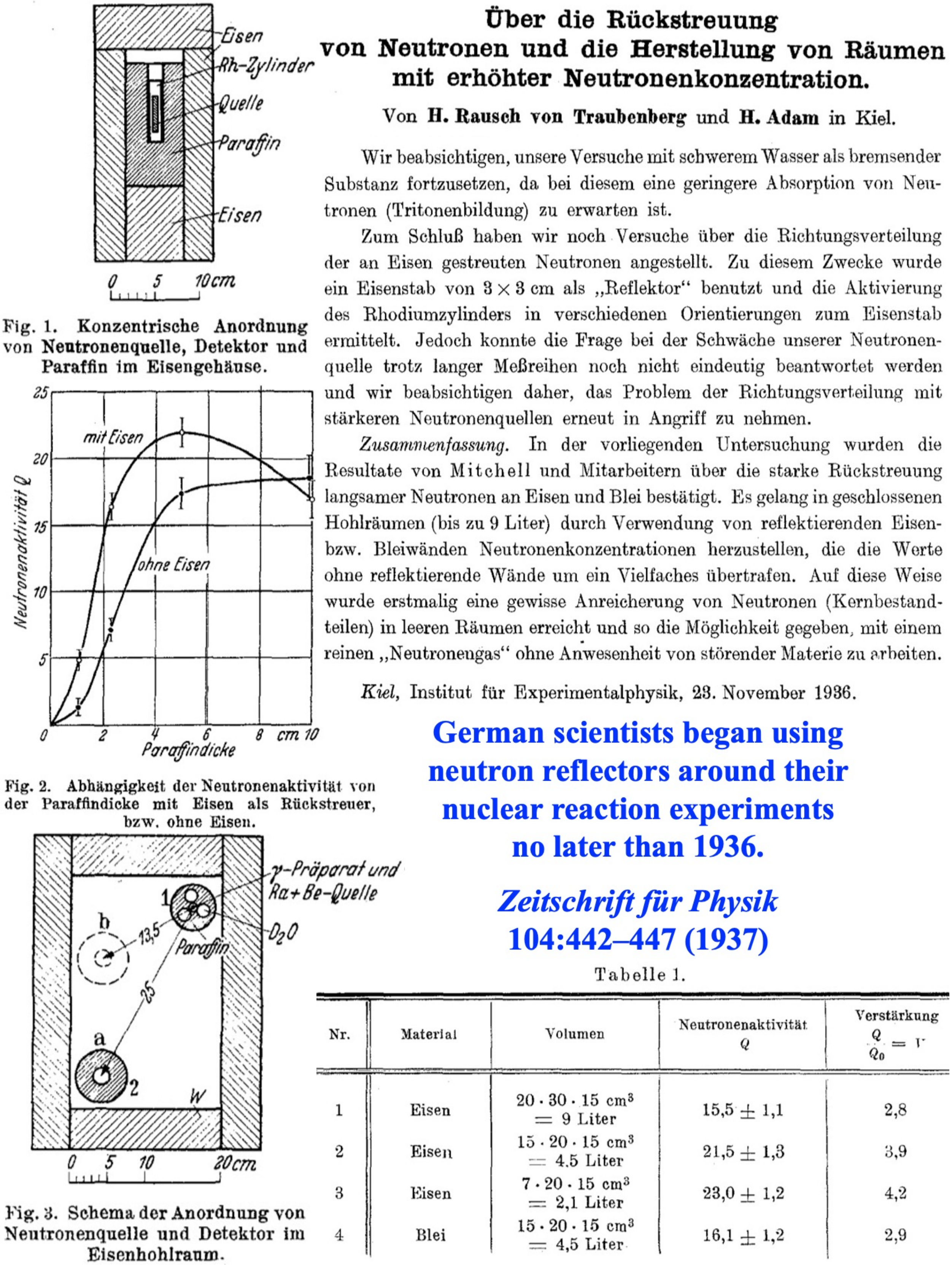
We intend to continue our experiments with heavy water as a moderating substance, since a lower absorption of neutrons (triton formation) is to be expected with this.

Finally, we performed experiments on the directional distribution of neutrons scattered by iron. For this purpose an iron rod of 3x3 cm was used as a “reflector” and the activation of the rhodium cylinder in different orientations to the iron rod was determined. However, given the weakness of our neutron source, the question could not yet be answered unambiguously, despite long series of measurements, and we therefore intend to tackle the problem of directional distribution again with stronger neutron sources.

Summary. In the present investigation, the results of Mitchell and coworkers on the strong backscattering of slow neutrons by iron and lead were confirmed. It was possible to produce neutron concentrations in closed cavities (up to 9 liters) by the use of reflecting iron or lead walls which exceeded many times the values without reflecting walls. In this way, for the first time, a certain enrichment of neutrons (nuclear constituents) was achieved in empty spaces, thus making it possible to work with a pure “neutron gas” without the presence of interfering matter.

[German scientists began using neutron reflectors around their nuclear reaction experiments no later than 1936. See Fig. D.545. Neutron reflectors are important for both fission reactors and fission bombs.

H. Rausch von Traubenberg also did important very early work on tritium production and fusion reactions. See p. 4281.]



Über die Rückstreuung von Neutronen und die Herstellung von Räumen mit erhöhter Neutronenkonzentration.

Von **H. Rausch von Traubenberg** und **H. Adam** in Kiel.

Wir beabsichtigen, unsere Versuche mit schwerem Wasser als bremsender Substanz fortzusetzen, da bei diesem eine geringere Absorption von Neutronen (Tritonenbildung) zu erwarten ist.

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Kiel, Institut für Experimentalphysik, 23. November 1936.

Fig. 1. Konzentrische Anordnung von Neutronenquelle, Detektor und Paraffin im Eisengehäuse.

Fig. 2. Abhängigkeit der Neutronenaktivität von der Paraffindicke mit Eisen als Rückstreuer, bzw. ohne Eisen.

Fig. 3. Schema der Anordnung von Neutronenquelle und Detektor im Eisenhohlraum.

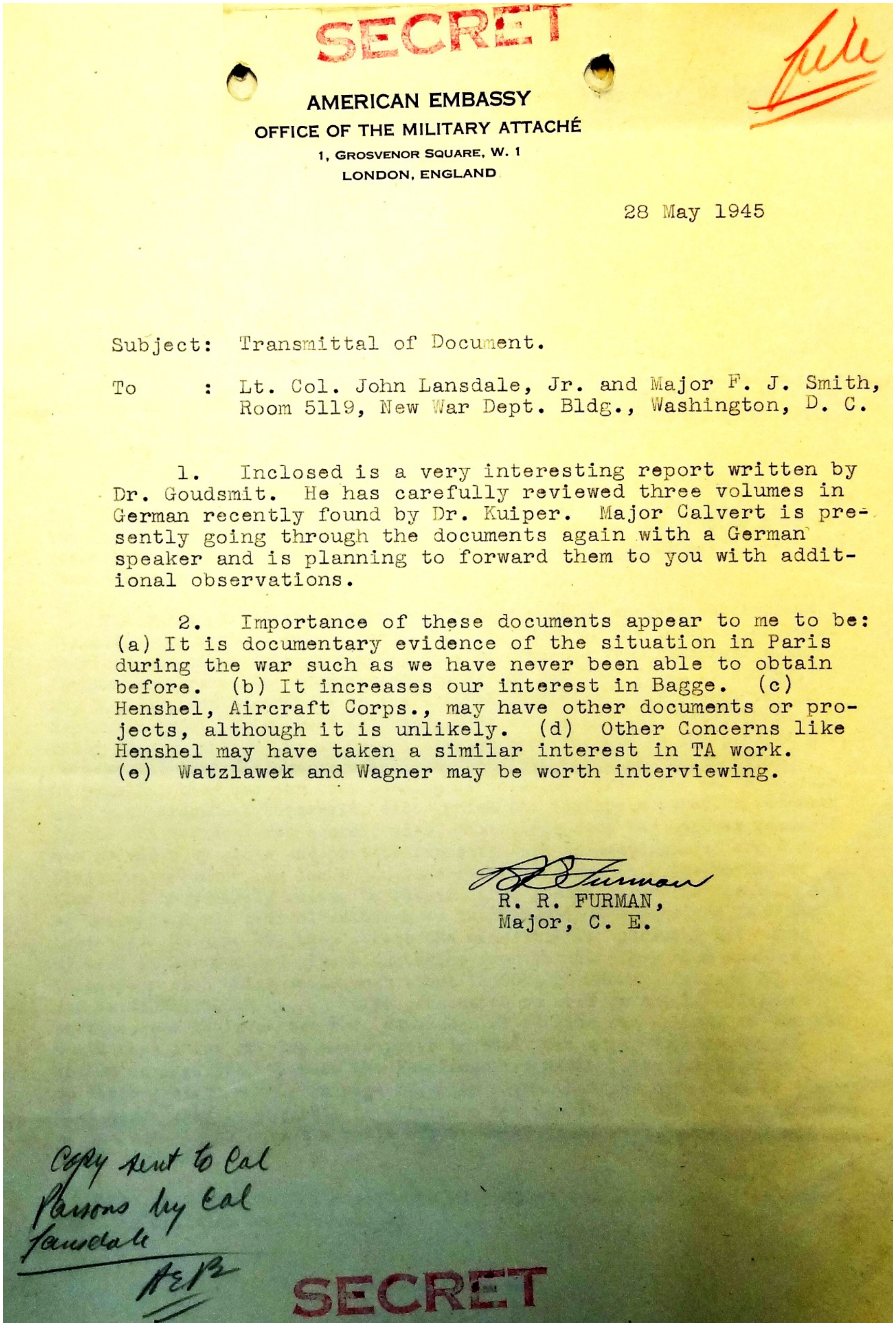
German scientists began using neutron reflectors around their nuclear reaction experiments no later than 1936.

***Zeitschrift für Physik* 104:442–447 (1937)**

Tabelle 1.

Nr.	Material	Volumen	Neutronenaktivität Q	Verstärkung $\frac{Q}{Q_0} = V$
1	Eisen	$20 \cdot 30 \cdot 15$ cm^3 = 9 Liter	15,5 ± 1,1	2,8
2	Eisen	$15 \cdot 20 \cdot 15$ cm^3 = 4.5 Liter	21,5 ± 1,3	3,9
3	Eisen	$7 \cdot 20 \cdot 15$ cm^3 = 2,1 Liter	23,0 ± 1,2	4,2
4	Blei	$15 \cdot 20 \cdot 15$ cm^3 = 4,5 Liter	16,1 ± 1,2	2,9

Figure D.545: German scientists began using neutron reflectors around their nuclear reaction experiments no later than 1936 [*Zeitschrift für Physik* 104:442–447 (1937)].



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file

AMERICAN EMBASSY
OFFICE OF THE MILITARY ATTACHÉ
1, GROSVENOR SQUARE, W. 1
LONDON, ENGLAND

28 May 1945

Subject: Transmittal of Document.

To : Lt. Col. John Lansdale, Jr. and Major F. J. Smith,
Room 5119, New War Dept. Bldg., Washington, D. C.

1. Inclosed is a very interesting report written by Dr. Goudsmit. He has carefully reviewed three volumes in German recently found by Dr. Kuiper. Major Calvert is presently going through the documents again with a German speaker and is planning to forward them to you with additional observations.

2. Importance of these documents appear to me to be: (a) It is documentary evidence of the situation in Paris during the war such as we have never been able to obtain before. (b) It increases our interest in Bagge. (c) Henshel, Aircraft Corps., may have other documents or projects, although it is unlikely. (d) Other Concerns like Henshel may have taken a similar interest in TA work. (e) Watzlawek and Wagner may be worth interviewing.

R R Furman
R. R. FURMAN,
Major, C. E.

Copy sent to Col
Parsons by Col
Lansdale

AEB

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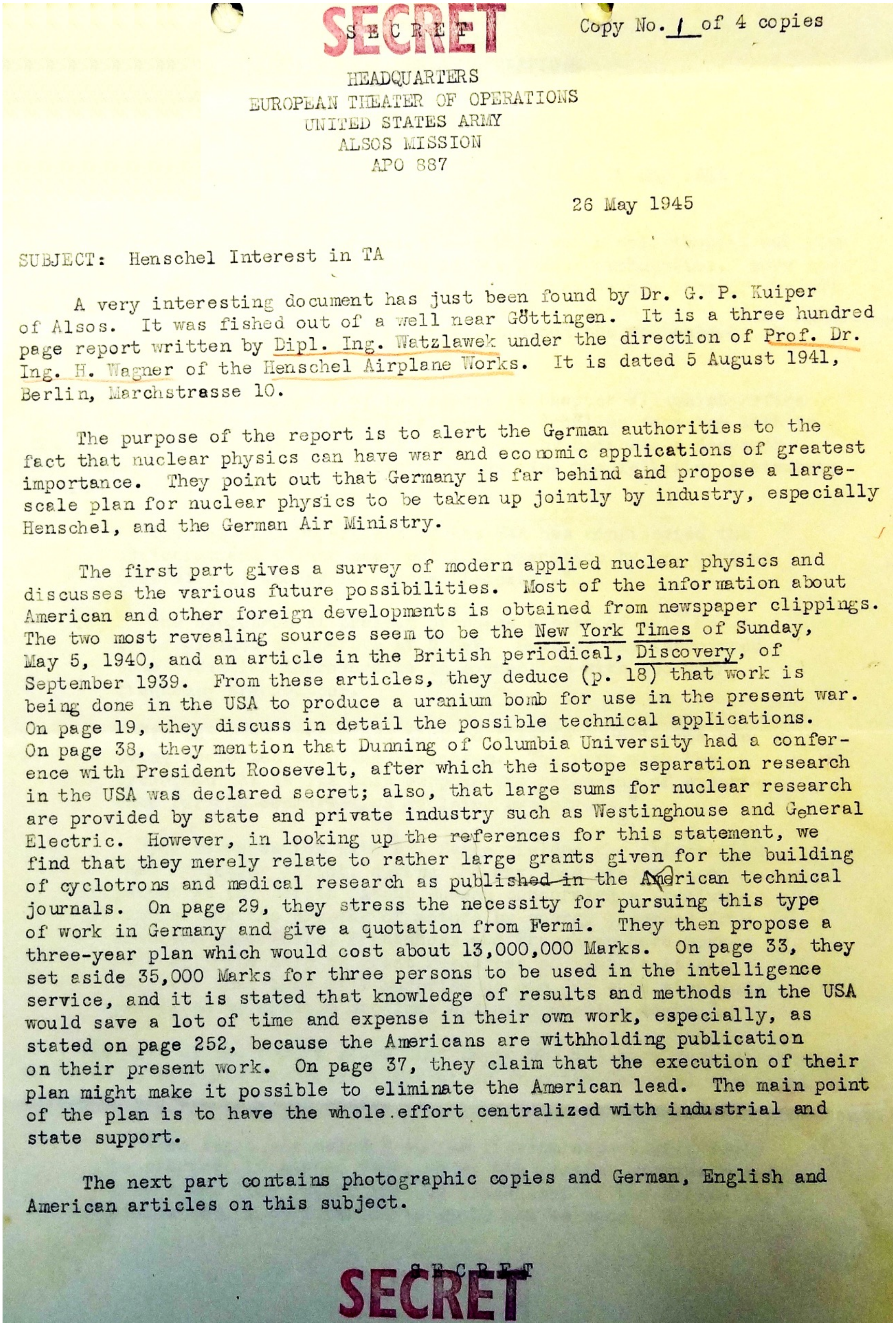
NARA RG 77, Entry UD-22A, Box 169,
Folder 32.32. Germ. Ind. TA

Figure D.546: Robert R. Furman to John Lansdale, Jr. and Francis J. Smith. 28 May 1945. Subject: Transmittal of Document [NARA RG 77, Entry UD-22A, Box 169, Folder 32.32. Germ. Ind. TA].



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SECRET Copy No. 1 of 4 copies

HEADQUARTERS
EUROPEAN THEATER OF OPERATIONS
UNITED STATES ARMY
ALSOS MISSION
APO 887

26 May 1945

SUBJECT: Henschel Interest in TA

A very interesting document has just been found by Dr. G. P. Kuiper of Alsos. It was fished out of a well near Göttingen. It is a three hundred page report written by Dipl. Ing. Watzlawek under the direction of Prof. Dr. Ing. H. Wagner of the Henschel Airplane Works. It is dated 5 August 1941, Berlin, Marchstrasse 10.

The purpose of the report is to alert the German authorities to the fact that nuclear physics can have war and economic applications of greatest importance. They point out that Germany is far behind and propose a large-scale plan for nuclear physics to be taken up jointly by industry, especially Henschel, and the German Air Ministry.

The first part gives a survey of modern applied nuclear physics and discusses the various future possibilities. Most of the information about American and other foreign developments is obtained from newspaper clippings. The two most revealing sources seem to be the New York Times of Sunday, May 5, 1940, and an article in the British periodical, Discovery, of September 1939. From these articles, they deduce (p. 18) that work is being done in the USA to produce a uranium bomb for use in the present war. On page 19, they discuss in detail the possible technical applications. On page 38, they mention that Dunning of Columbia University had a conference with President Roosevelt, after which the isotope separation research in the USA was declared secret; also, that large sums for nuclear research are provided by state and private industry such as Westinghouse and General Electric. However, in looking up the references for this statement, we find that they merely relate to rather large grants given for the building of cyclotrons and medical research as published in the American technical journals. On page 29, they stress the necessity for pursuing this type of work in Germany and give a quotation from Fermi. They then propose a three-year plan which would cost about 13,000,000 Marks. On page 33, they set aside 35,000 Marks for three persons to be used in the intelligence service, and it is stated that knowledge of results and methods in the USA would save a lot of time and expense in their own work, especially, as stated on page 252, because the Americans are withholding publication on their present work. On page 37, they claim that the execution of their plan might make it possible to eliminate the American lead. The main point of the plan is to have the whole effort centralized with industrial and state support.

The next part contains photographic copies and German, English and American articles on this subject.

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NARA RG 77, Entry UD-22A, Box 169, Folder 32.32. Germ. Ind. TA

Figure D.547: Gerard P. Kuiper and Samuel A. Goudsmit. 26 May 1945. SUBJECT: Henschel Interest in TA [NARA RG 77, Entry UD-22A, Box 169, Folder 32.32. Germ. Ind. TA].

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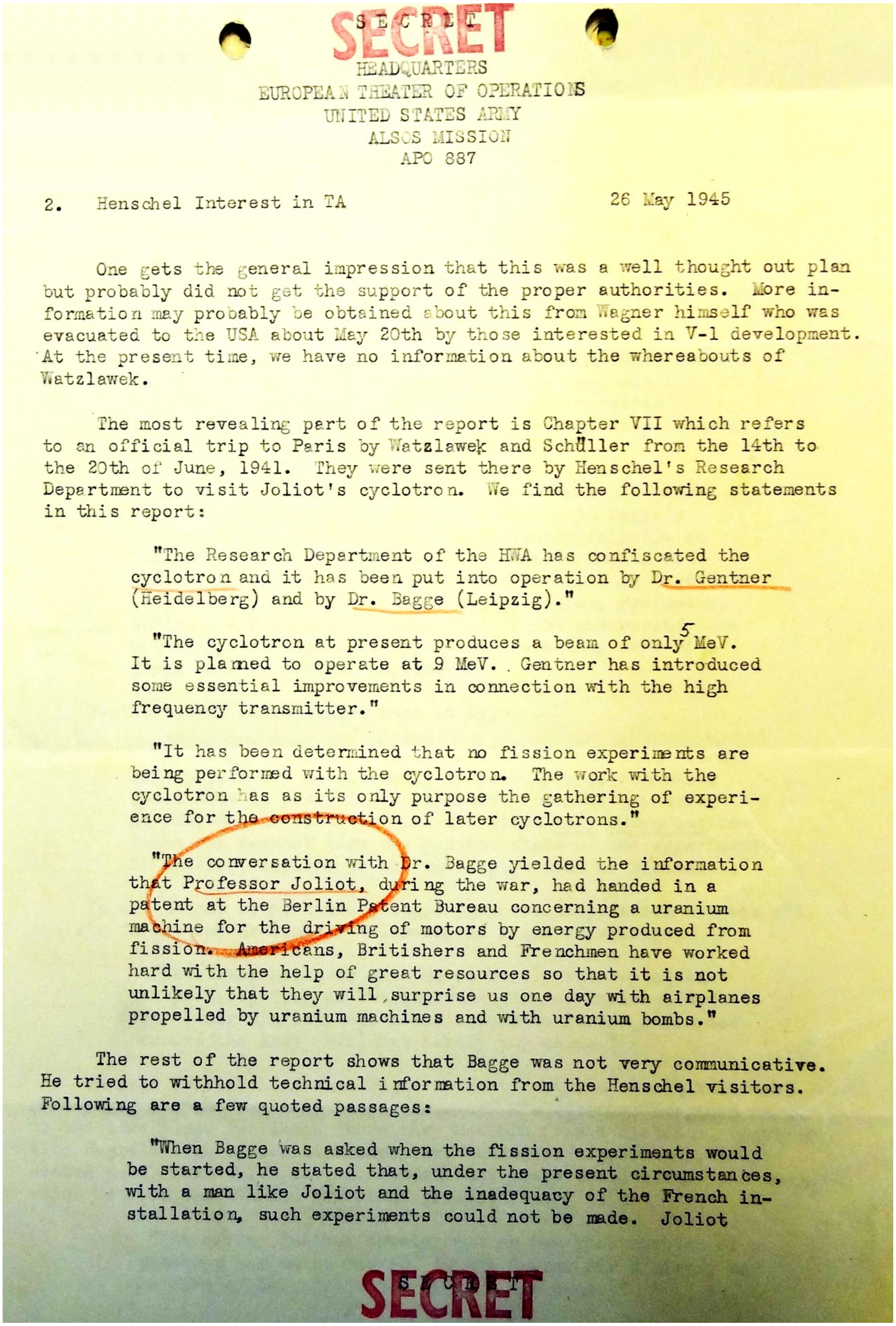
Authority NND 917017



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HEADQUARTERS
EUROPEAN THEATER OF OPERATIONS
UNITED STATES ARMY
ALSOS MISSION
APO 887

2. Henschel Interest in TA 26 May 1945

One gets the general impression that this was a well thought out plan but probably did not get the support of the proper authorities. More information may probably be obtained about this from Wagner himself who was evacuated to the USA about May 20th by those interested in V-1 development. At the present time, we have no information about the whereabouts of Watzlawek.

The most revealing part of the report is Chapter VII which refers to an official trip to Paris by Watzlawek and Schüller from the 14th to the 20th of June, 1941. They were sent there by Henschel's Research Department to visit Joliot's cyclotron. We find the following statements in this report:

> "The Research Department of the HWA has confiscated the cyclotron and it has been put into operation by Dr. Gentner (Heidelberg) and by Dr. Bagge (Leipzig)."
>
> "The cyclotron at present produces a beam of only 5 MeV. It is planned to operate at 9 MeV. Gentner has introduced some essential improvements in connection with the high frequency transmitter."
>
> "It has been determined that no fission experiments are being performed with the cyclotron. The work with the cyclotron has as its only purpose the gathering of experience for the construction of later cyclotrons."
>
> "The conversation with Dr. Bagge yielded the information that Professor Joliot, during the war, had handed in a patent at the Berlin Patent Bureau concerning a uranium machine for the driving of motors by energy produced from fission. Americans, Britishers and Frenchmen have worked hard with the help of great resources so that it is not unlikely that they will surprise us one day with airplanes propelled by uranium machines and with uranium bombs."

The rest of the report shows that Bagge was not very communicative. He tried to withhold technical information from the Henschel visitors. Following are a few quoted passages:

> "When Bagge was asked when the fission experiments would be started, he stated that, under the present circumstances, with a man like Joliot and the inadequacy of the French installation, such experiments could not be made. Joliot

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Figure D.548: Gerard P. Kuiper and Samuel A. Goudsmit. 26 May 1945. SUBJECT: Henschel Interest in TA [NARA RG 77, Entry UD-22A, Box 169, Folder 32.32. Germ. Ind. TA].

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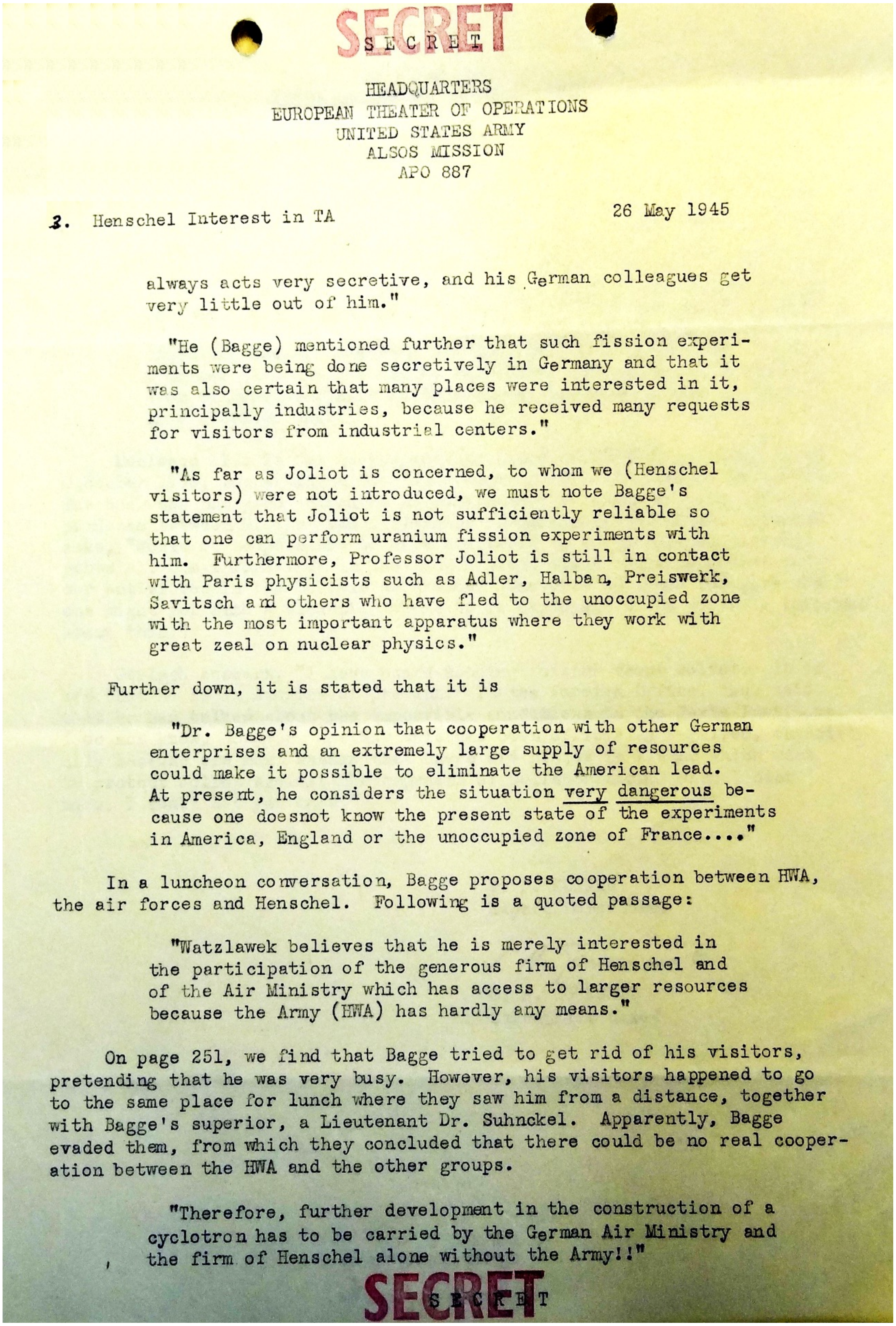

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HEADQUARTERS
EUROPEAN THEATER OF OPERATIONS
UNITED STATES ARMY
ALSOS MISSION
APO 887

3\. Henschel Interest in TA 26 May 1945

always acts very secretive, and his German colleagues get very little out of him."

"He (Bagge) mentioned further that such fission experiments were being done secretively in Germany and that it was also certain that many places were interested in it, principally industries, because he received many requests for visitors from industrial centers."

"As far as Joliot is concerned, to whom we (Henschel visitors) were not introduced, we must note Bagge's statement that Joliot is not sufficiently reliable so that one can perform uranium fission experiments with him. Furthermore, Professor Joliot is still in contact with Paris physicists such as Adler, Halban, Preiswerk, Savitsch and others who have fled to the unoccupied zone with the most important apparatus where they work with great zeal on nuclear physics."

Further down, it is stated that it is

"Dr. Bagge's opinion that cooperation with other German enterprises and an extremely large supply of resources could make it possible to eliminate the American lead. At present, he considers the situation very dangerous because one doesnot know the present state of the experiments in America, England or the unoccupied zone of France...."

In a luncheon conversation, Bagge proposes cooperation between HWA, the air forces and Henschel. Following is a quoted passage:

"Watzlawek believes that he is merely interested in the participation of the generous firm of Henschel and of the Air Ministry which has access to larger resources because the Army (HWA) has hardly any means."

On page 251, we find that Bagge tried to get rid of his visitors, pretending that he was very busy. However, his visitors happened to go to the same place for lunch where they saw him from a distance, together with Bagge's superior, a Lieutenant Dr. Suhnckel. Apparently, Bagge evaded them, from which they concluded that there could be no real cooperation between the HWA and the other groups.

"Therefore, further development in the construction of a cyclotron has to be carried by the German Air Ministry and the firm of Henschel alone without the Army!!"

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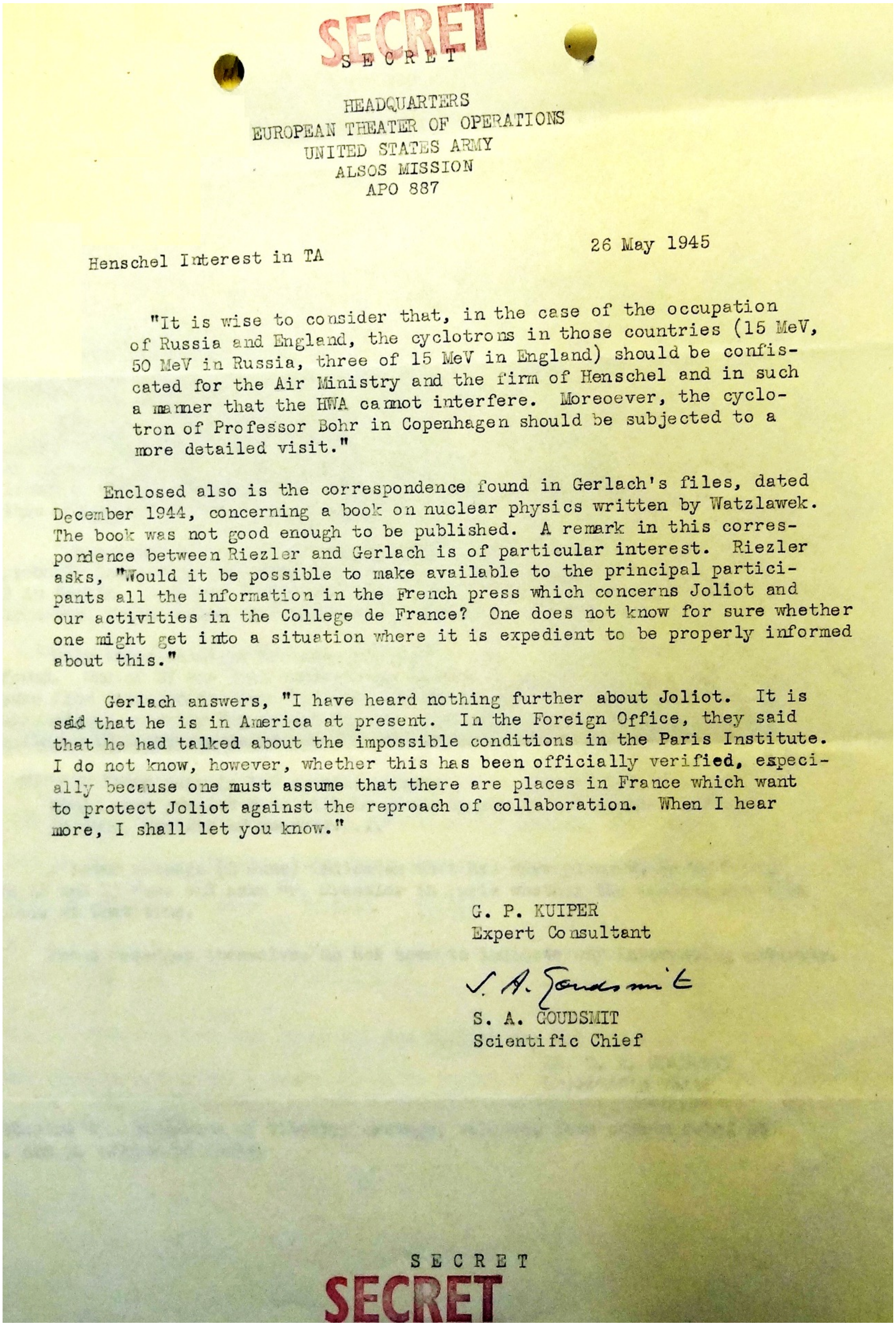
NARA RG 77, Entry UD-22A, Box 169, Folder 32.32. Germ. Ind. TA

Figure D.549: Gerard P. Kuiper and Samuel A. Goudsmit. 26 May 1945. SUBJECT: Henschel Interest in TA [NARA RG 77, Entry UD-22A, Box 169, Folder 32.32. Germ. Ind. TA].



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EUROPEAN THEATER OF OPERATIONS
UNITED STATES ARMY
ALSOS MISSION
APO 887

26 May 1945

Henschel Interest in TA

"It is wise to consider that, in the case of the occupation of Russia and England, the cyclotrons in those countries (15 MeV, 50 MeV in Russia, three of 15 MeV in England) should be confiscated for the Air Ministry and the firm of Henschel and in such a manner that the HWA cannot interfere. Moreoever, the cyclotron of Professor Bohr in Copenhagen should be subjected to a more detailed visit."

Enclosed also is the correspondence found in Gerlach's files, dated December 1944, concerning a book on nuclear physics written by Watzlawek. The book was not good enough to be published. A remark in this correspondence between Riezler and Gerlach is of particular interest. Riezler asks, "Would it be possible to make available to the principal participants all the information in the French press which concerns Joliot and our activities in the College de France? One does not know for sure whether one might get into a situation where it is expedient to be properly informed about this."

Gerlach answers, "I have heard nothing further about Joliot. It is said that he is in America at present. In the Foreign Office, they said that he had talked about the impossible conditions in the Paris Institute. I do not know, however, whether this has been officially verified, especially because one must assume that there are places in France which want to protect Joliot against the reproach of collaboration. When I hear more, I shall let you know."

G. P. KUIPER
Expert Consultant

S. A. Goudsmit
S. A. GOUDSMIT
Scientific Chief

S E C R E T
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NARA RG 77, Entry UD-22A, Box 169, Folder 32.32. Germ. Ind. TA

Figure D.550: Gerard P. Kuiper and Samuel A. Goudsmit. 26 May 1945. SUBJECT: Henschel Interest in TA [NARA RG 77, Entry UD-22A, Box 169, Folder 32.32. Germ. Ind. TA].

Thomas Siemon. 24 July 2014. *Hessen-Niedersächsische Allgemeine.* https://www.hna.de/kassel/henschel-wollte-atombombe-kriegseinsatz-bauen-3727289.html

Pläne aus Zeiten des Zweiten Weltkrieges

Schriftsatz aufgetaucht: Henschel wollte Atombombe für den Kriegseinsatz bauen

Kassel. 1945 sorgten die Atombomben auf Hiroshima und Nagasaki für zehntausende von Opfern und furchbare Zerstörungen. Bereits vier Jahre zuvor gab es bei der Kasseler Firma Henschel konkrete Überlegungen für den Bau einer Nuklearwaffe. Das belegt ein Schriftsatz aus dem Jahr 1941, der jetzt aufgetaucht ist.

Er hat 260 Seiten und liegt der HNA vor.

Mit ganzer Kraft müsse an der Erforschung der Kettenreaktionsvorgänge gearbeitet werden, heißt es da. Zwar wird auch die Nutzung der Atomenergie für den Antrieb von Kampfflugzeugen, U-Booten, die Medizin und zur Stromerzeugung erwähnt. Das klare Ziel der Entwicklung ist aber die "Herstellung einer Uran-Bombe für den jetzigen europäischen Krieg als furchtbarste Waffe".

An der Echtheit der handgebundenen Dokumente besteht kein Zweifel. Helmut Weich, der ehrenamtliche Leiter des Kasseler Henschel- Museums, hat die erwähnten Namen und Örtlichkeiten überprüft. Demnach hat der damalige Chefentwickler der Henschel-Flugzeugwerke in Berlin-Schönfeld, Professor Herbert Wagner, das umfangreiche Dossier mit Unterstützung von weiteren Fachleuten erstellt.

Plans from the times of the Second World War

Written brief found: Henschel wanted to build a nuclear bomb for war use

Kassel. In 1945, the atomic bombs on Hiroshima and Nagasaki caused tens of thousands of victims and terrible destruction. Four years earlier, the Kassel-based company Henschel had already given concrete consideration to the construction of a nuclear weapon. This is documented in a document from 1941, which has now appeared.

It has 260 pages and is available to the HNA.

It says that the research of chain reaction processes has to be done with all one's strength. The use of atomic energy for the propulsion of combat aircraft, submarines, medicine and power generation is also mentioned. But the clear goal of the development is the "production of a uranium bomb for the current European war as the most terrible weapon."

There is no doubt about the authenticity of the hand-bound documents. Helmut Weich, the honorary director of the Henschel Museum in Kassel, has checked the names and locations mentioned above. Accordingly, the then chief developer of the Henschel-Flugzeugwerke in Berlin-Schönfeld, Professor Herbert Wagner, prepared the extensive dossier with the support of other experts.

Henschel war damals nicht die einzige Firma, die sich intensiv mit den Möglichkeiten der Atomenergie beschäftigte. Auch Siemens, die IG Farben und Degussa hatten großes Interesse an diesem Thema.

In der gedruckten Ausgabe am Freitag lesen Sie außerdem:

- Es blieb bei Plänen für die Bombe: Nach 1941 keine weiteren Aktivitäten zur militärischen Nutzung der Kernenergie bei Henschel bekannt

Bekannt ist, dass eine Delegation von Henschel in Paris war, um sich dort über die Forschung zur Kernspaltung mit einem sogenannten Zyklotron zu informieren. Nach Einschätzung von Fachleuten waren weder Henschel noch die anderen Firmen in der Lage, die Bombe wirklich zu bauen. Nach dem Krieg sprachen alle Beteiligten davon, lediglich Grundlagenforschung betrieben zu haben.

Henschel was not the only company at the time to be intensively involved with the possibilities of nuclear energy. Siemens, IG Farben and Degussa were also very interested in this topic.

You can also read in the printed edition on Friday:

- It remained with plans for the bomb: After 1941 no further activities for the military use of nuclear energy known at Henschel.

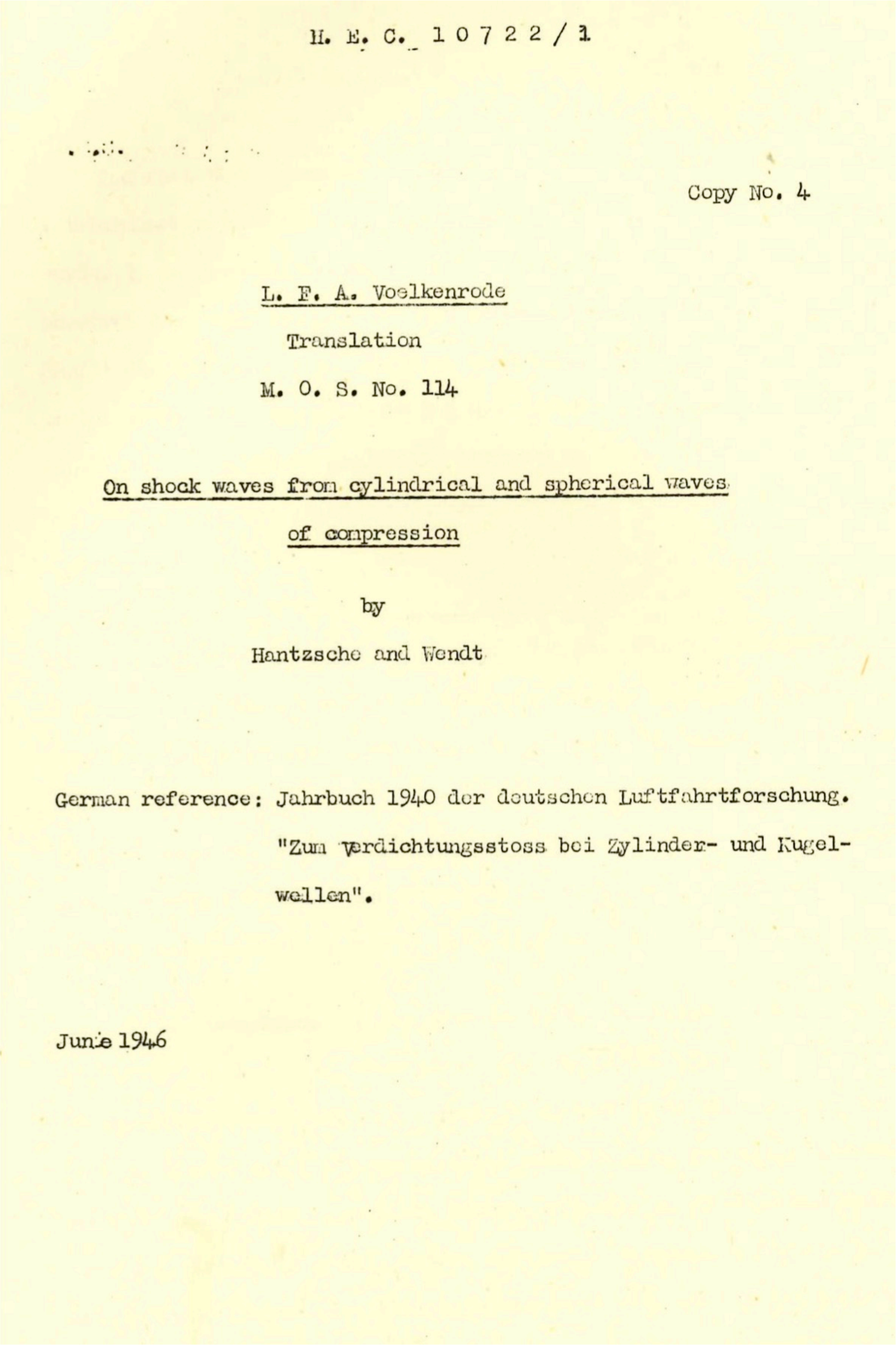
It is known that a delegation of Henschel was in Paris to inform themselves about the research on nuclear fission with a so-called cyclotron. According to experts, neither Henschel nor the other companies were able to really build the bomb. After the war, all those involved said that they had only carried out basic research.

Walter Hantzsche and Hilmar Wendt. 1940. HEC 10722. *On Shock Waves from Cylindrical and Spherical Waves of Compression.* [U.K. Imperial War Museum, Duxford Archive, Halstead Exploitation Centre reports]

We utilize only the equations of motion of an unsteady gas flow, and consider, in the following, a plane, cylindrical and spherical compression wave with a steep velocity front. In the case of the plane wave, a shock wave appears following continuous steepening of the velocity front. For cylindrical and spherical waves, on the other hand, it can happen that a steepening of the velocity front only takes place after a given time. Previously the front becomes flatter, the diminishing of the amplitude through the spreading of the wave, outweighing the steepening caused by the compression. A criterion is established for the onset of a shock wave, which, in the case of the spherical wave, agrees with Burton.

[This report demonstrates that by no later than 1940, German scientists had carried out calculations applicable to both spherical and cylindrical implosion bombs. Gottfried Guderley's more famous 1942 paper with similar calculations is shown on pp. 4170–4171. See also pp. 2127–2129 and 5010.]

Imperial War Museum, Duxford, HEC 10722



H. E. C. 10722/1

Copy No. 4

L. F. A. Voelkenrode

Translation

M. O. S. No. 114

On shock waves from cylindrical and spherical waves of compression

by

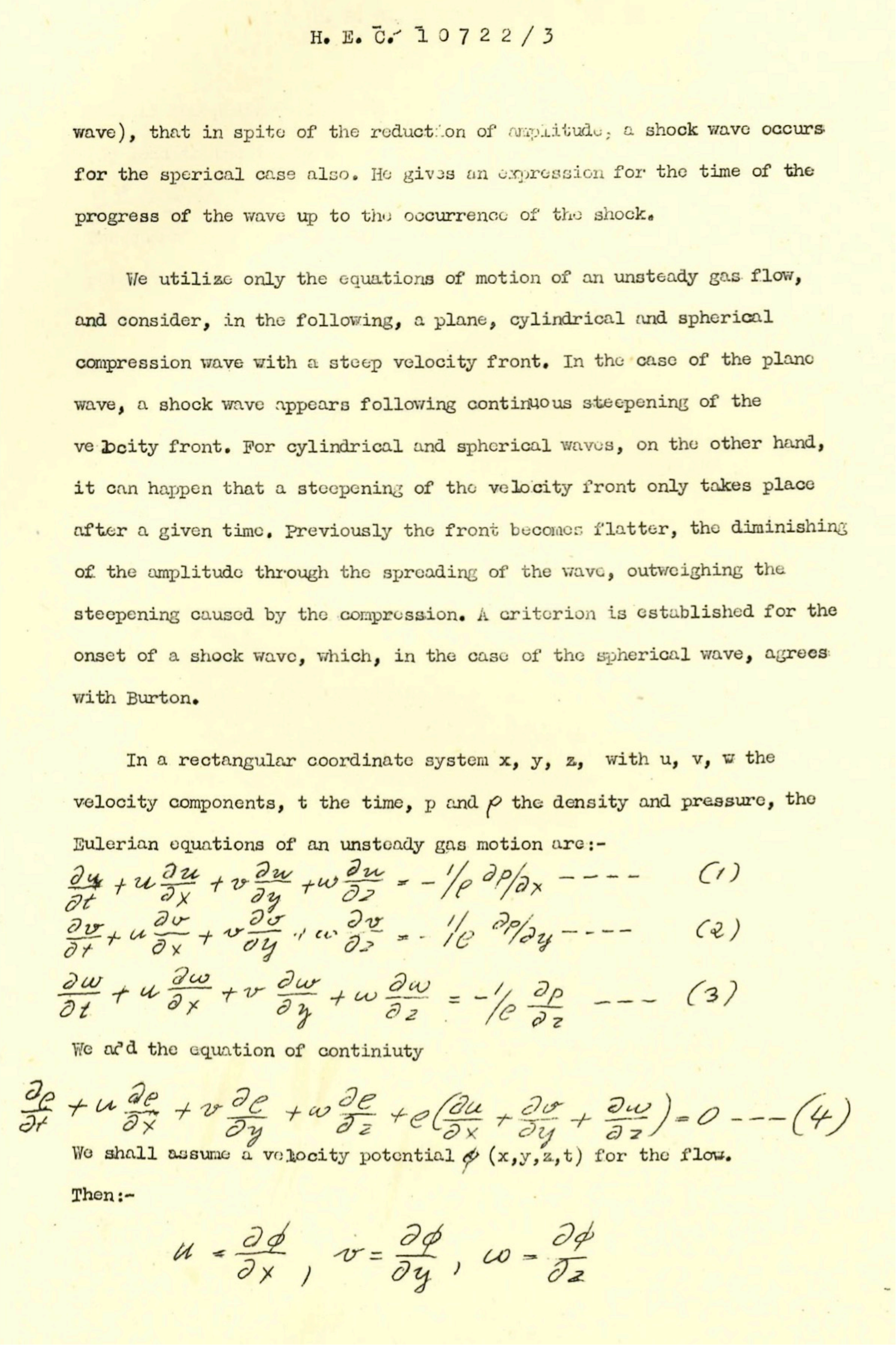
Hantzsche and Wendt

German reference: Jahrbuch 1940 der deutschen Luftfahrtforschung. "Zum Verdichtungsstoss bei Zylinder- und Kugelwellen".

June 1946

Figure D.551: By no later than 1940, Walter Hantzsche and Hilmar Wendt had carried out calculations applicable to both spherical and cylindrical implosion bombs [Halstead Exploitation Centre (HEC) Report 10722, English translation, U.K. Imperial War Museum, Duxford Archive].

Imperial War Museum, Duxford, HEC 10722



H. E. C. 10722/3

wave), that in spite of the reduction of amplitude, a shock wave occurs for the sperical case also. He gives an expression for the time of the progress of the wave up to the occurrence of the shock.

We utilize only the equations of motion of an unsteady gas flow, and consider, in the following, a plane, cylindrical and spherical compression wave with a steep velocity front. In the case of the plane wave, a shock wave appears following continuous steepening of the velocity front. For cylindrical and spherical waves, on the other hand, it can happen that a steepening of the velocity front only takes place after a given time. Previously the front becomes flatter, the diminishing of the amplitude through the spreading of the wave, outweighing the steepening caused by the compression. A criterion is established for the onset of a shock wave, which, in the case of the spherical wave, agrees with Burton.

In a rectangular coordinate system x, y, z, with u, v, w the velocity components, t the time, p and ρ the density and pressure, the Eulerian equations of an unsteady gas motion are:-

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial w}{\partial y} + w\frac{\partial u}{\partial z} = -{}^{1}/_{\rho}\,{}^{\partial p}/_{\partial x} \text{ ---- } (1)$$

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + w\frac{\partial v}{\partial z} = -{}^{1}/_{\rho}\,{}^{\partial p}/_{\partial y} \text{ ---- } (2)$$

$$\frac{\partial w}{\partial t} + u\frac{\partial w}{\partial x} + v\frac{\partial w}{\partial y} + w\frac{\partial w}{\partial z} = -{}^{1}/_{\rho}\,\frac{\partial p}{\partial z} \text{ --- } (3)$$

We add the equation of continiuty

$$\frac{\partial \rho}{\partial t} + u\frac{\partial \rho}{\partial x} + v\frac{\partial \rho}{\partial y} + w\frac{\partial \rho}{\partial z} + \rho\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z}\right) = 0 \text{ --- } (4)$$

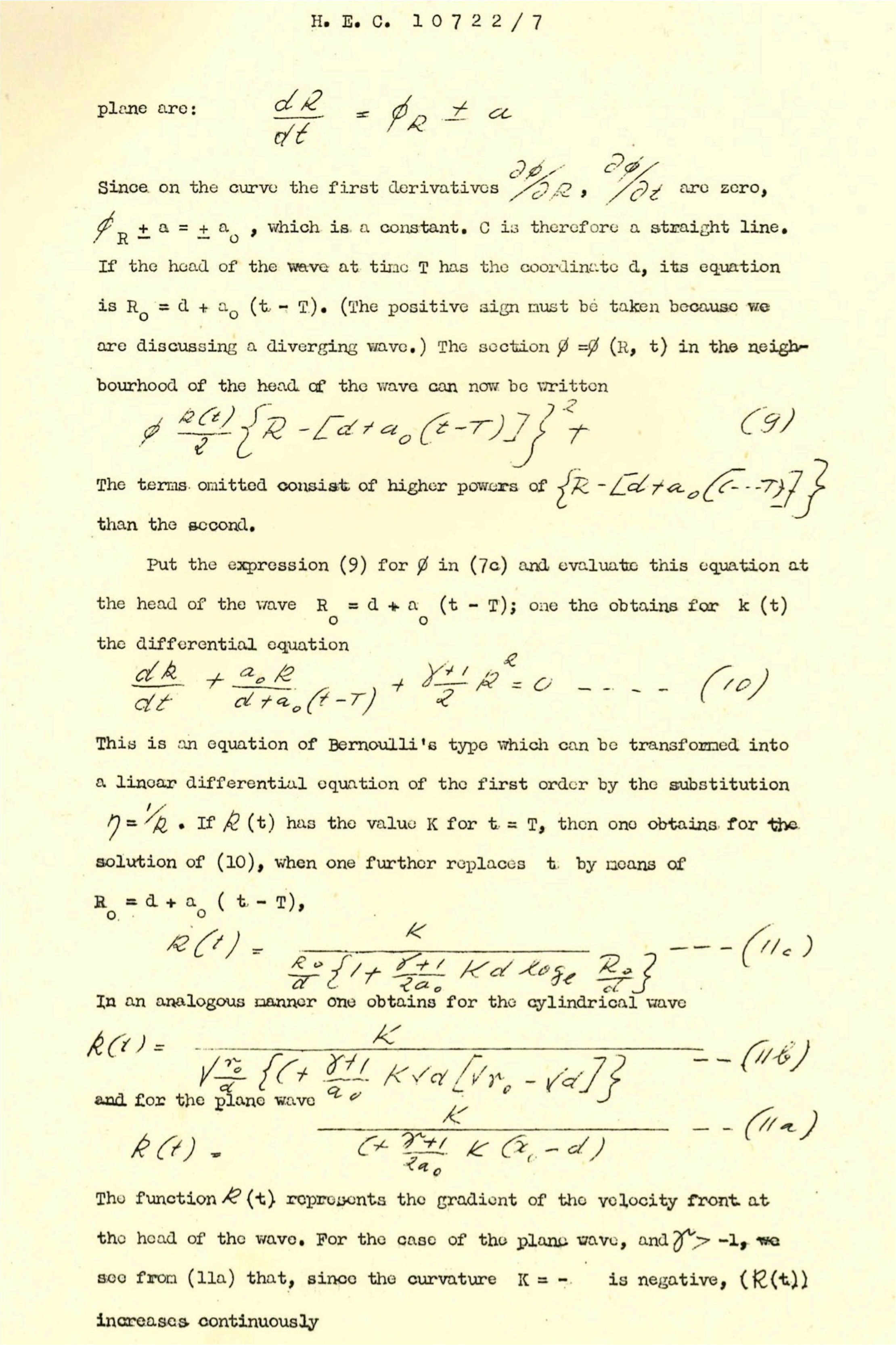
We shall assume a velocity potential ϕ (x,y,z,t) for the flow.

Then:-

$$u = \frac{\partial \phi}{\partial x}, \quad v = \frac{\partial \phi}{\partial y}, \quad w = \frac{\partial \phi}{\partial z}$$

Figure D.552: By no later than 1940, Walter Hantzsche and Hilmar Wendt had carried out calculations applicable to both spherical and cylindrical implosion bombs [Halstead Exploitation Centre (HEC) Report 10722, English translation, U.K. Imperial War Museum, Duxford Archive].

**Imperial War Museum,
Duxford, HEC 10722**



H. E. C. 10722/7

plane are: $\frac{dR}{dt} = \phi_R \pm a$

Since on the curve the first derivatives $\partial\phi/\partial R$, $\partial\phi/\partial t$ are zero, $\phi_R \pm a = \pm a_o$, which is a constant. C is therefore a straight line. If the head of the wave at time T has the coordinate d, its equation is $R_o = d + a_o (t - T)$. (The positive sign must be taken because we are discussing a diverging wave.) The section $\phi = \phi(R, t)$ in the neighbourhood of the head of the wave can now be written

$$\phi \frac{k(t)}{2}\left\{R - [d + a_o(t-T)]\right\}^2 + \qquad (9)$$

The terms omitted consist of higher powers of $\{R - [d + a_o(t - - T)]\}$ than the second.

Put the expression (9) for ϕ in (7c) and evaluate this equation at the head of the wave $R_o = d + a_o (t - T)$; one the obtains for k (t) the differential equation

$$\frac{dk}{dt} + \frac{a_o k}{d + a_o(t-T)} + \frac{\gamma+1}{2} k^2 = 0 \quad ---- \quad (10)$$

This is an equation of Bernoulli's type which can be transformed into a linear differential equation of the first order by the substitution $\eta = 1/k$. If k (t) has the value K for t = T, then one obtains for the solution of (10), when one further replaces t by means of $R_o = d + a_o (t - T)$,

$$k(t) = \frac{K}{\frac{R_o}{d}\left\{1 + \frac{\gamma+1}{2a_o} K d \log_e \frac{R_o}{d}\right\}} \quad --- \quad (11c)$$

In an analogous manner one obtains for the cylindrical wave

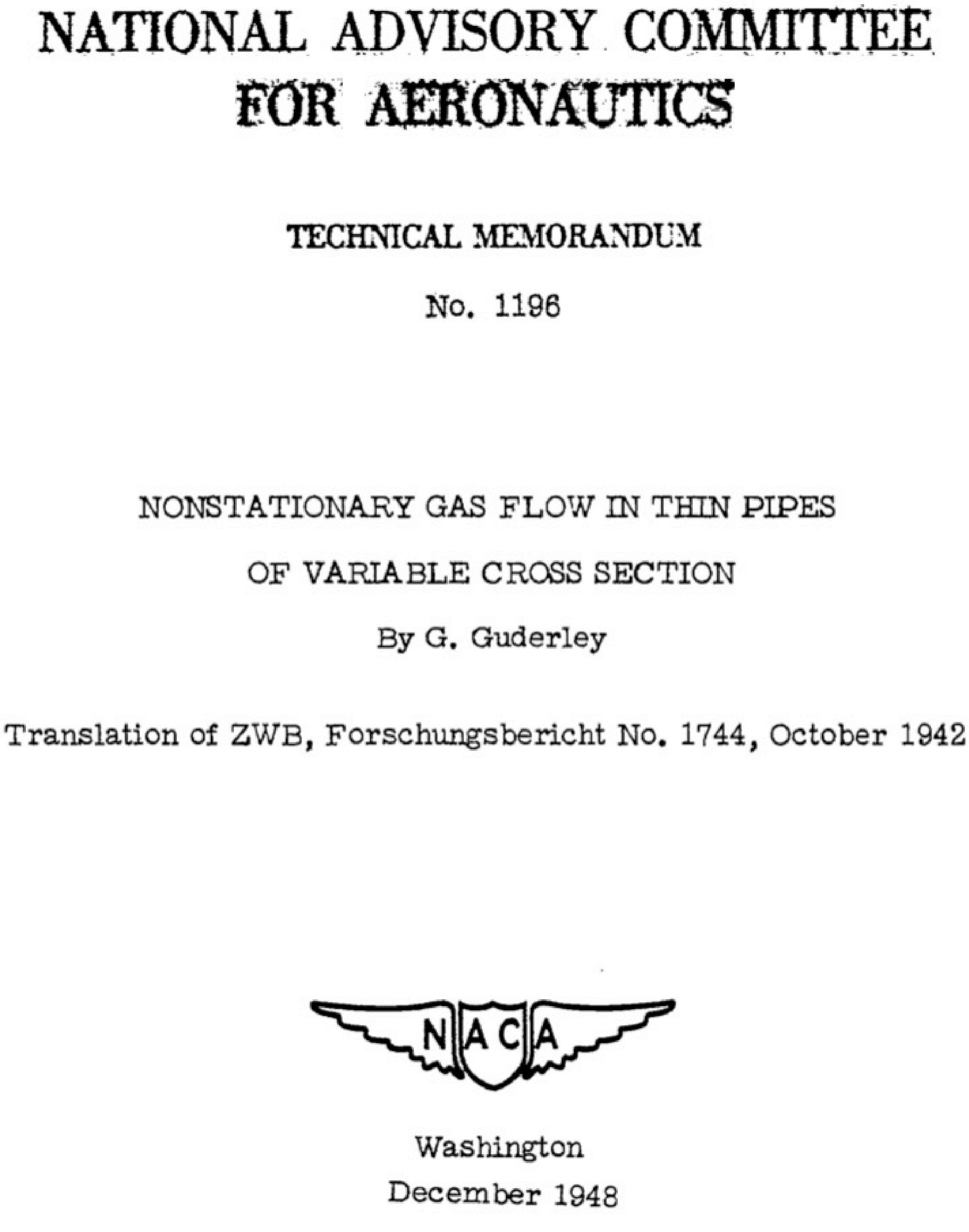
$$k(t) = \frac{K}{\sqrt{\frac{r_o}{d}}\left\{1 + \frac{\gamma+1}{a_o} K \sqrt{d}\left[\sqrt{r_o} - \sqrt{d}\right]\right\}} \quad -- \quad (11b)$$

and for the plane wave

$$k(t) = \frac{K}{1 + \frac{\gamma+1}{2a_o} K (x_o - d)} \quad -- \quad (11a)$$

The function k (t) represents the gradient of the velocity front at the head of the wave. For the case of the plane wave, and $\gamma > -1$, we see from (11a) that, since the curvature K = - is negative, (k(t)) increases continuously

Figure D.553: By no later than 1940, Walter Hantzsche and Hilmar Wendt had carried out calculations applicable to both spherical and cylindrical implosion bombs [Halstead Exploitation Centre (HEC) Report 10722, English translation, U.K. Imperial War Museum, Duxford Archive].



NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS

TECHNICAL MEMORANDUM

No. 1196

NONSTATIONARY GAS FLOW IN THIN PIPES
OF VARIABLE CROSS SECTION

By G. Guderley

Translation of ZWB, Forschungsbericht No. 1744, October 1942

Washington
December 1948

Figure D.554: English translation of 1942 paper by Gottfried Guderley (1910–1997), a hydrodynamics expert working for the German military, predicting the pressure, density, and temperature of highly compressed and accelerated matter in both spherical and cylindrical geometries for power-law equations of state, as would be directly applicable to implosion bombs.

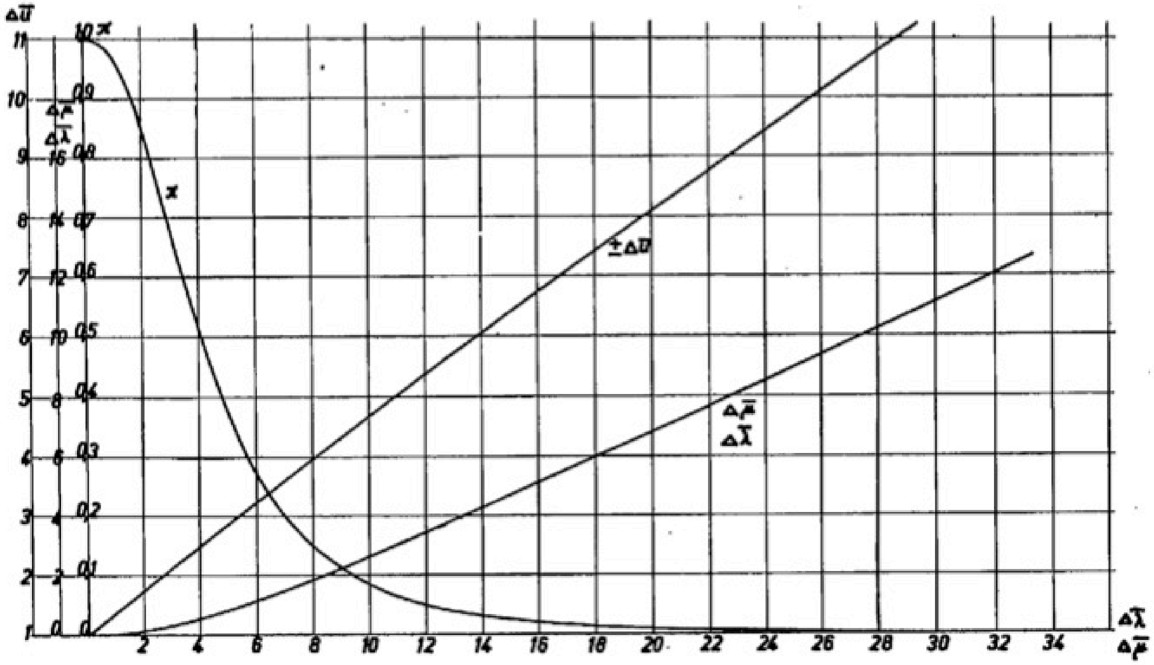


Figure 12a.- Characteristics of compression shocks K = 1.405.

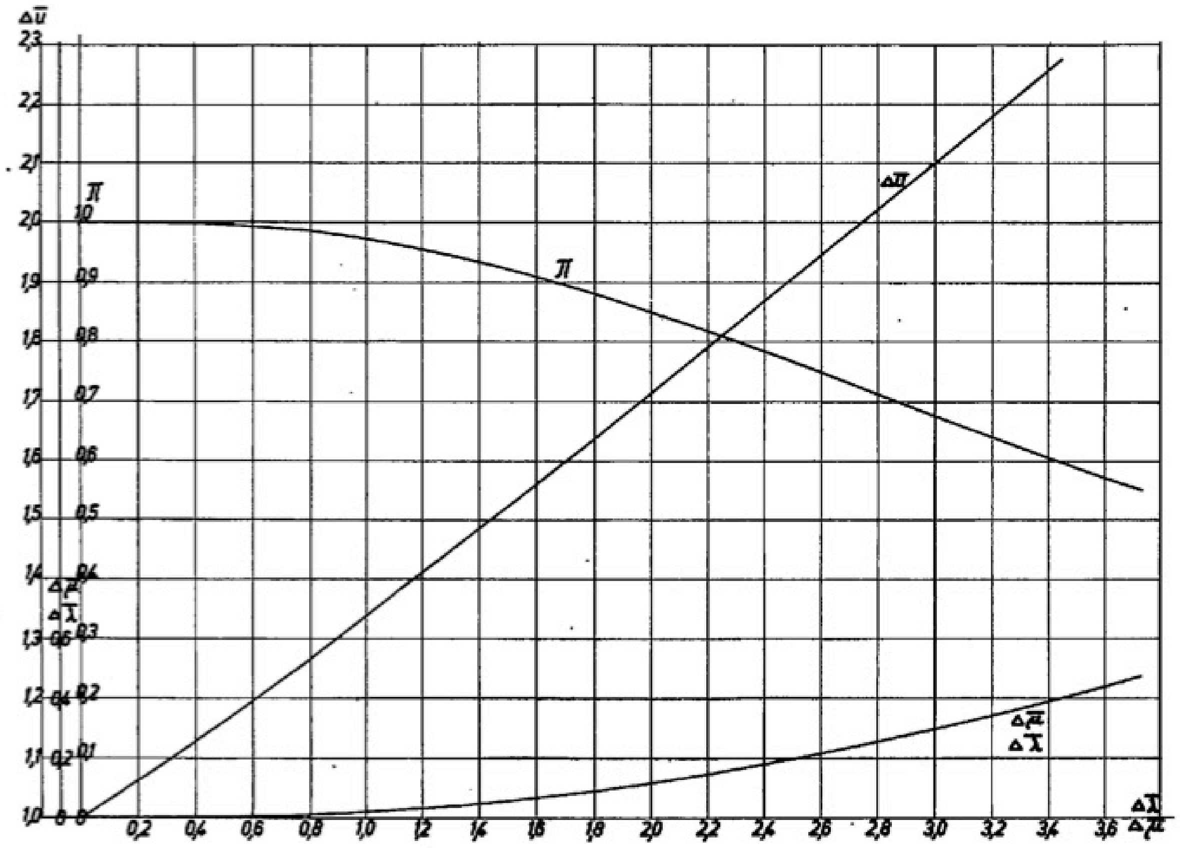
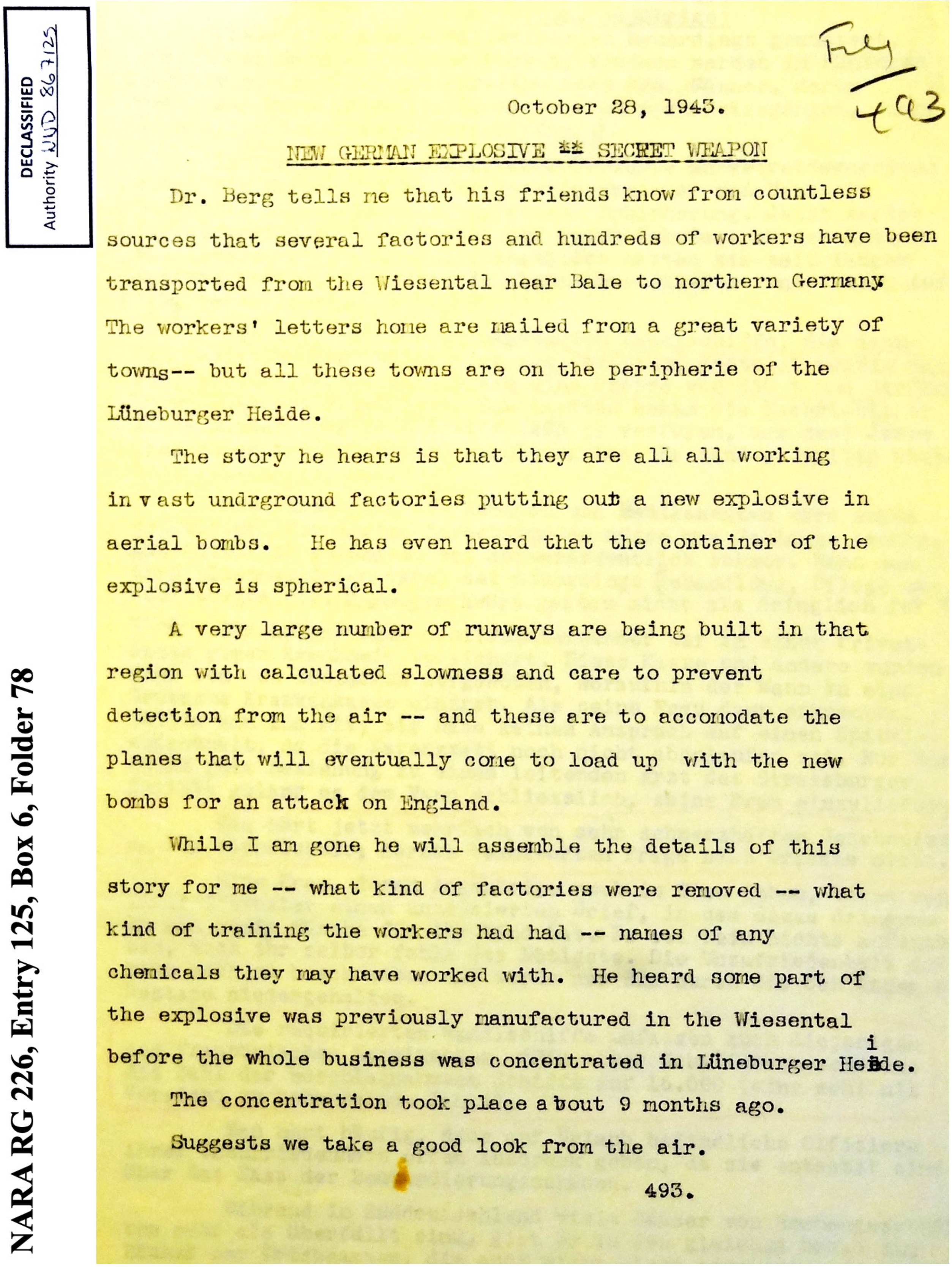


Figure 12b.- Characteristics of compression shocks K = 1.405.

Figure D.555: Detailed 1942 calculations by Gottfried Guderley predicting the pressure, density, and temperature in a spherical implosion bomb (without explicitly calling it that in public).



DECLASSIFIED
Authority NND 867125

NARA RG 226, Entry 125, Box 6, Folder 78

Fry
493

October 28, 1943.

NEW GERMAN EXPLOSIVE ** SECRET WEAPON

Dr. Berg tells me that his friends know from countless sources that several factories and hundreds of workers have been transported from the Wiesental near Bale to northern Germany. The workers' letters home are mailed from a great variety of towns-- but all these towns are on the peripherie of the Lüneburger Heide.

The story he hears is that they are all all working in vast undrground factories putting out a new explosive in aerial bombs. He has even heard that the container of the explosive is spherical.

A very large number of runways are being built in that region with calculated slowness and care to prevent detection from the air -- and these are to accomodate the planes that will eventually come to load up with the new bombs for an attack on England.

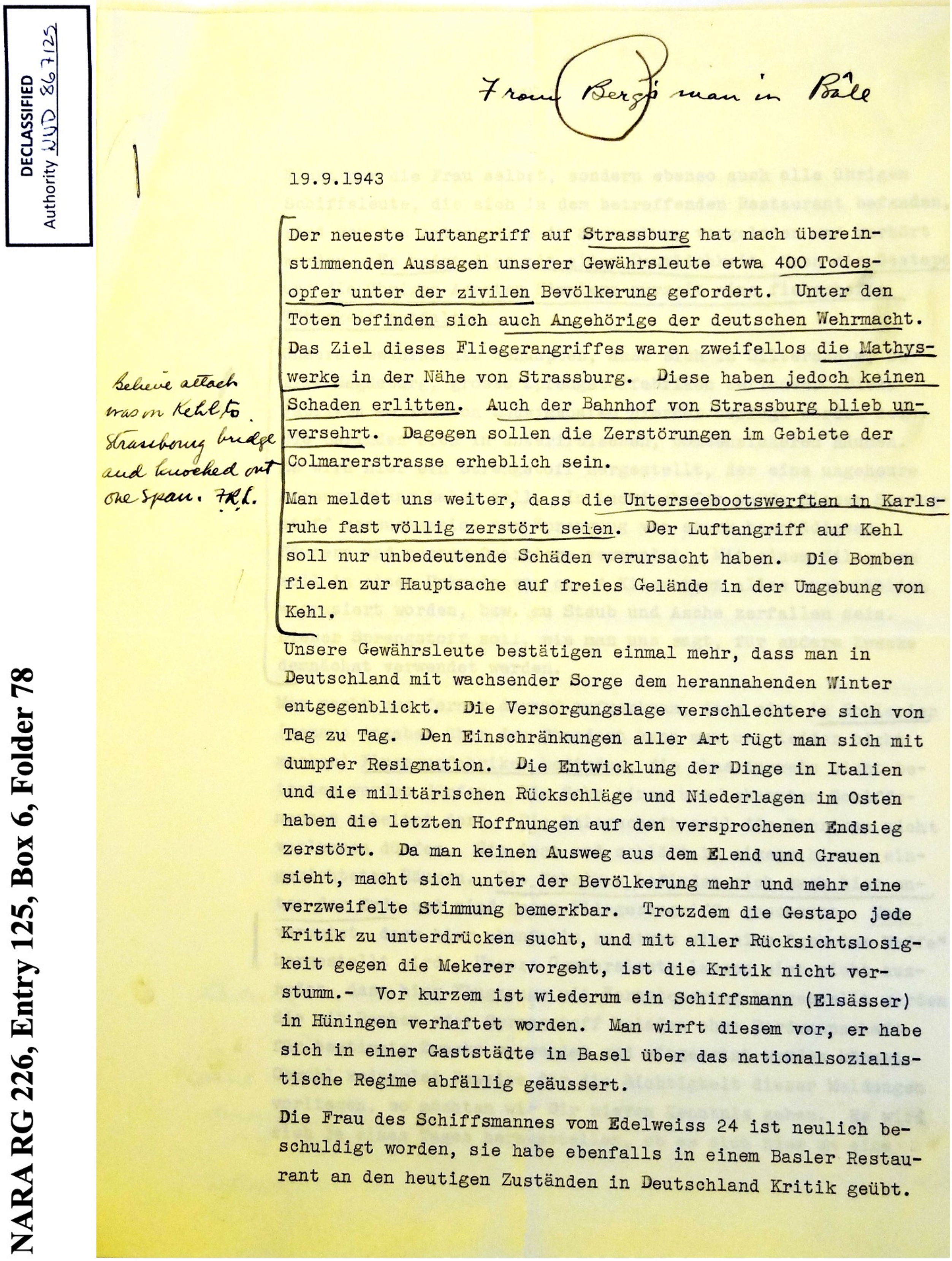
While I am gone he will assemble the details of this story for me -- what kind of factories were removed -- what kind of training the workers had had -- names of any chemicals they may have worked with. He heard some part of the explosive was previously manufactured in the Wiesental before the whole business was concentrated in Lüneburger Heide.

The concentration took place about 9 months ago.

Suggests we take a good look from the air.

493.

Figure D.556: Several documents reported that there was a hidden underground nuclear facility somewhere in the Lüneburger Heide area south of Hamburg. Intelligence via Frederick Loofbourow (OSS agent 493) [NARA RG 226, Entry 125, Box 6, Folder 78].



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Authority NND 867125

NARA RG 226, Entry 125, Box 6, Folder 78

Frau Bergsman in Bâle

19.9.1943

Der neueste Luftangriff auf Strassburg hat nach übereinstimmenden Aussagen unserer Gewährsleute etwa 400 Todesopfer unter der zivilen Bevölkerung gefordert. Unter den Toten befinden sich auch Angehörige der deutschen Wehrmacht. Das Ziel dieses Fliegerangriffes waren zweifellos die Mathyswerke in der Nähe von Strassburg. Diese haben jedoch keinen Schaden erlitten. Auch der Bahnhof von Strassburg blieb unversehrt. Dagegen sollen die Zerstörungen im Gebiete der Colmarerstrasse erheblich sein.

Believe attack was on Kehl to Strasbourg bridge and knocked out one span. FRL.

Man meldet uns weiter, dass die Unterseebootswerften in Karlsruhe fast völlig zerstört seien. Der Luftangriff auf Kehl soll nur unbedeutende Schäden verursacht haben. Die Bomben fielen zur Hauptsache auf freies Gelände in der Umgebung von Kehl.

Unsere Gewährsleute bestätigen einmal mehr, dass man in Deutschland mit wachsender Sorge dem herannahenden Winter entgegenblickt. Die Versorgungslage verschlechtere sich von Tag zu Tag. Den Einschränkungen aller Art fügt man sich mit dumpfer Resignation. Die Entwicklung der Dinge in Italien und die militärischen Rückschläge und Niederlagen im Osten haben die letzten Hoffnungen auf den versprochenen Endsieg zerstört. Da man keinen Ausweg aus dem Elend und Grauen sieht, macht sich unter der Bevölkerung mehr und mehr eine verzweifelte Stimmung bemerkbar. Trotzdem die Gestapo jede Kritik zu unterdrücken sucht, und mit aller Rücksichtslosigkeit gegen die Mekerer vorgeht, ist die Kritik nicht verstumm.- Vor kurzem ist wiederum ein Schiffsmann (Elsässer) in Hüningen verhaftet worden. Man wirft diesem vor, er habe sich in einer Gaststädte in Basel über das nationalsozialistische Regime abfällig geäussert.

Die Frau des Schiffsmannes vom Edelweiss 24 ist neulich beschuldigt worden, sie habe ebenfalls in einem Basler Restaurant an den heutigen Zuständen in Deutschland Kritik geübt.

Figure D.557: Several documents reported that there was a hidden underground nuclear facility somewhere in the Lüneburger Heide area south of Hamburg. Intelligence via Frederick Loofbourow (OSS agent 493) [NARA RG 226, Entry 125, Box 6, Folder 78].

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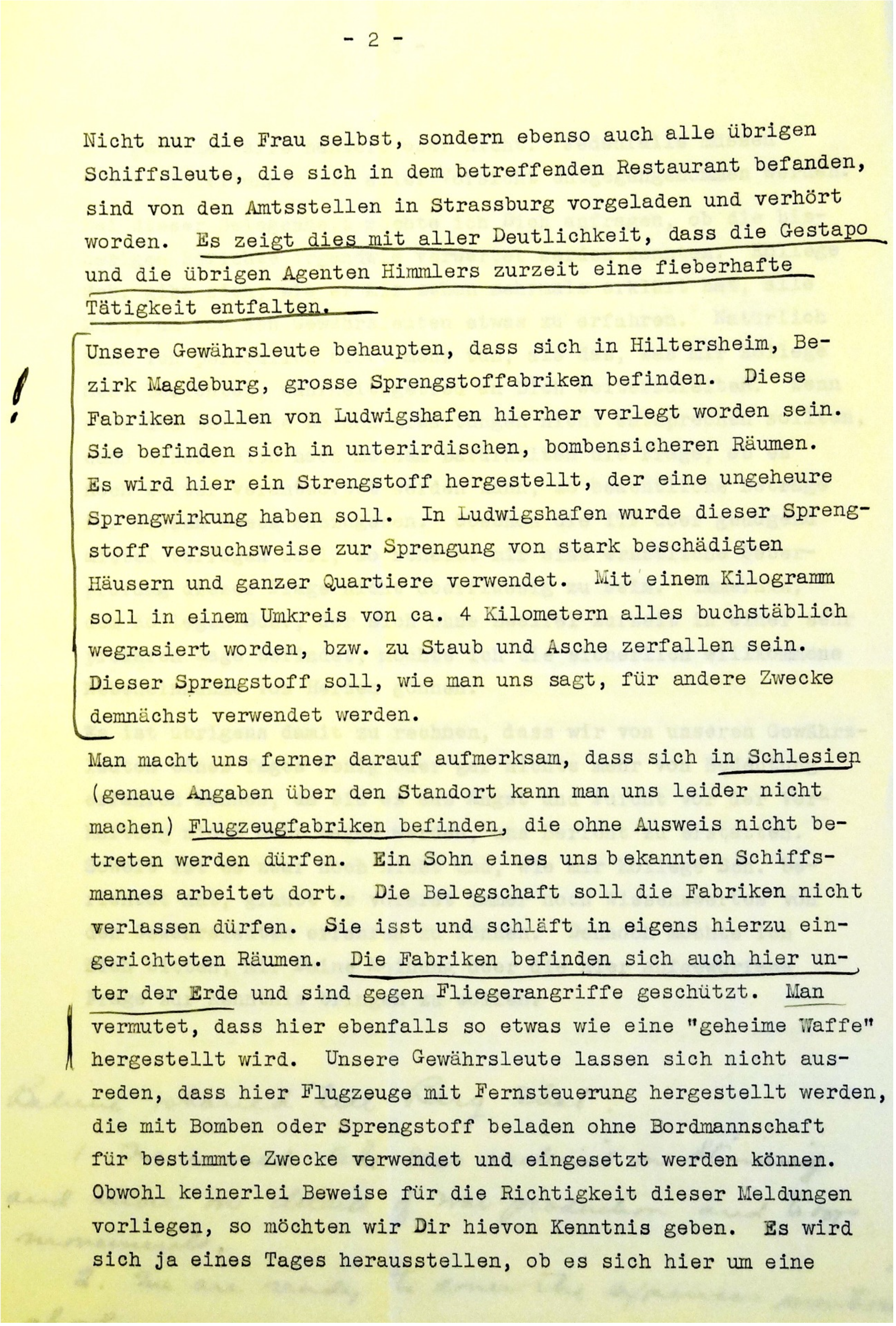
Authority NND 867125



- 2 -

Nicht nur die Frau selbst, sondern ebenso auch alle übrigen Schiffsleute, die sich in dem betreffenden Restaurant befanden, sind von den Amtsstellen in Strassburg vorgeladen und verhört worden. Es zeigt dies mit aller Deutlichkeit, dass die Gestapo und die übrigen Agenten Himmlers zurzeit eine fieberhafte Tätigkeit entfalten.

!

Unsere Gewährsleute behaupten, dass sich in Hiltersheim, Bezirk Magdeburg, grosse Sprengstoffabriken befinden. Diese Fabriken sollen von Ludwigshafen hierher verlegt worden sein. Sie befinden sich in unterirdischen, bombensicheren Räumen. Es wird hier ein Strengstoff hergestellt, der eine ungeheure Sprengwirkung haben soll. In Ludwigshafen wurde dieser Sprengstoff versuchsweise zur Sprengung von stark beschädigten Häusern und ganzer Quartiere verwendet. Mit einem Kilogramm soll in einem Umkreis von ca. 4 Kilometern alles buchstäblich wegrasiert worden, bzw. zu Staub und Asche zerfallen sein. Dieser Sprengstoff soll, wie man uns sagt, für andere Zwecke demnächst verwendet werden.

Man macht uns ferner darauf aufmerksam, dass sich in Schlesien (genaue Angaben über den Standort kann man uns leider nicht machen) Flugzeugfabriken befinden, die ohne Ausweis nicht betreten werden dürfen. Ein Sohn eines uns bekannten Schiffsmannes arbeitet dort. Die Belegschaft soll die Fabriken nicht verlassen dürfen. Sie isst und schläft in eigens hierzu eingerichteten Räumen. Die Fabriken befinden sich auch hier unter der Erde und sind gegen Fliegerangriffe geschützt. Man vermutet, dass hier ebenfalls so etwas wie eine "geheime Waffe" hergestellt wird. Unsere Gewährsleute lassen sich nicht ausreden, dass hier Flugzeuge mit Fernsteuerung hergestellt werden, die mit Bomben oder Sprengstoff beladen ohne Bordmannschaft für bestimmte Zwecke verwendet und eingesetzt werden können. Obwohl keinerlei Beweise für die Richtigkeit dieser Meldungen vorliegen, so möchten wir Dir hievon Kenntnis geben. Es wird sich ja eines Tages herausstellen, ob es sich hier um eine

NARA RG 226, Entry 125, Box 6, Folder 78

Figure D.558: Several documents reported that there was a hidden underground nuclear facility somewhere in the Lüneburger Heide area south of Hamburg. Intelligence via Frederick Loofbourow (OSS agent 493) [NARA RG 226, Entry 125, Box 6, Folder 78].

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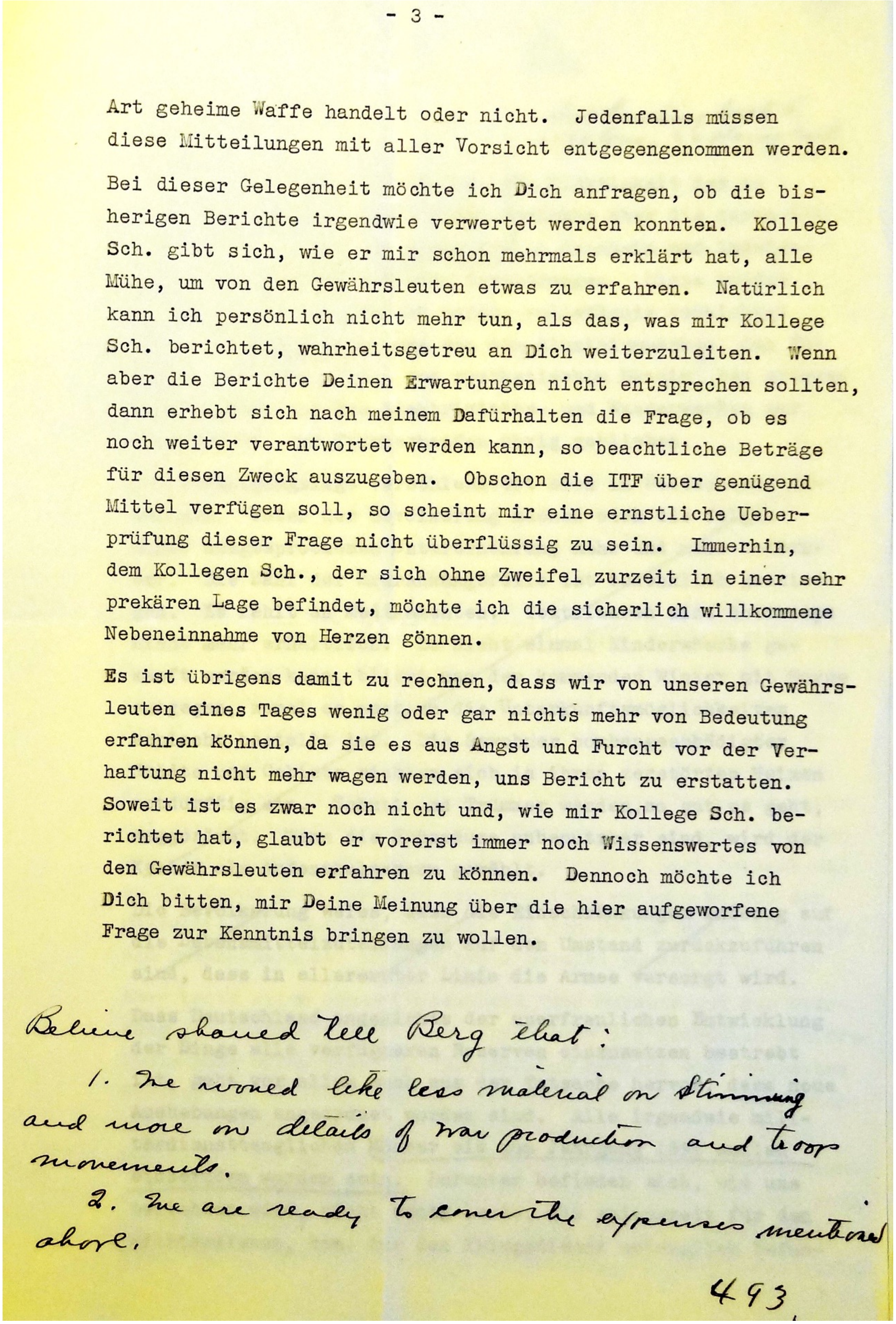


\- 3 -

Art geheime Waffe handelt oder nicht. Jedenfalls müssen diese Mitteilungen mit aller Vorsicht entgegengenommen werden.

Bei dieser Gelegenheit möchte ich Dich anfragen, ob die bisherigen Berichte irgendwie verwertet werden konnten. Kollege Sch. gibt sich, wie er mir schon mehrmals erklärt hat, alle Mühe, um von den Gewährsleuten etwas zu erfahren. Natürlich kann ich persönlich nicht mehr tun, als das, was mir Kollege Sch. berichtet, wahrheitsgetreu an Dich weiterzuleiten. Wenn aber die Berichte Deinen Erwartungen nicht entsprechen sollten, dann erhebt sich nach meinem Dafürhalten die Frage, ob es noch weiter verantwortet werden kann, so beachtliche Beträge für diesen Zweck auszugeben. Obschon die ITF über genügend Mittel verfügen soll, so scheint mir eine ernstliche Ueberprüfung dieser Frage nicht überflüssig zu sein. Immerhin, dem Kollegen Sch., der sich ohne Zweifel zurzeit in einer sehr prekären Lage befindet, möchte ich die sicherlich willkommene Nebeneinnahme von Herzen gönnen.

Es ist übrigens damit zu rechnen, dass wir von unseren Gewährsleuten eines Tages wenig oder gar nichts mehr von Bedeutung erfahren können, da sie es aus Angst und Furcht vor der Verhaftung nicht mehr wagen werden, uns Bericht zu erstatten. Soweit ist es zwar noch nicht und, wie mir Kollege Sch. berichtet hat, glaubt er vorerst immer noch Wissenswertes von den Gewährsleuten erfahren zu können. Dennoch möchte ich Dich bitten, mir Deine Meinung über die hier aufgeworfene Frage zur Kenntnis bringen zu wollen.

Believe should tell Berg that:

1. We would like less material on Stimmung and more on details of war production and troop movements.

2. We are ready to cover the expenses mentioned above.

493

Figure D.559: Several documents reported that there was a hidden underground nuclear facility somewhere in the Lüneburger Heide area south of Hamburg. Intelligence via Frederick Loofbourow (OSS agent 493) [NARA RG 226, Entry 125, Box 6, Folder 78].

Background on Frederick Loofbourow [Powers 1993, p. 271]

Dulles never lacked for reports of new German explosives. One dated October 28, 1943, came from an OSS officer ostensibly serving as a senior economic analyst in the American consulate in Zurich who signed all his reports "493." This was Frederick Read Loofbourow, an executive of the Standard Oil Company of New Jersey, sent to Switzerland in 1942 by the Board of Economic Warfare to gather intelligence on German petroleum production. After the border was closed, Loofbourow was tapped by Dulles for OSS work and given a wide range of jobs through the end of the war.

Intelligence via Frederick Loofbourow [NARA RG 226, Entry 125, Box 6, Folder 78]

[See document photos on pp. 4172–4175.]

October 28, 1943.

NEW GERMAN EXPLOSIVE—SECRET WEAPON

Dr. Berg tells me that his friends know from countless sources that several factories and hundreds of workers have been transported from the Wiesental near Bâle to northern Germany. The workers' letters home are mailed from a great variety of towns—but all these towns are on the periphery of the Lüneburger Heide.

The story he hears is that they are all working in vast underground factories putting out a new explosive in aerial bombs. He has even heard that the container of the explosive is spherical.

A very large number of runways are being built in that region with calculated slowness and care to prevent detection from the air—and these are to accommodate the planes that will eventually come to load up with the new bombs for an attack on England.

While I am gone he will assemble the details of this story for me—what kind of factories were removed—what kind of training the workers had had—names of any chemicals they may have worked with. He heard some part of the explosive was previously manufactured in the Wiesental before the whole business was concentrated in Lüneburger Heide.

The concentration took place about 9 months ago.

Suggests we take a good look from the air.

493.

[Handwritten:] From Berg's man in Bâle [Basel, Switzerland]

19.9.1943

[...] Unsere Gewährsleute behaupten, dass sich in Hiltersheim, Bezirk Magdeburg, grosse Sprengstofffabriken befinden. Diese Fabriken sollen von Ludwigshafen hierher verlegt worden sein. Sie befinden sich in unterirdischen, bombensicheren Räumen. Es wird hier ein Strengstoff [Sprengstoff?] hergestellt, der eine ungeheuere Sprengwirkung haben soll. In Ludwigshafen wurde dieser Sprengstoff versuchsweise zur Sprengung von stark beschädigten Häusern und ganzer Quartiere verwendet. Mit einem Kilogramm soll in einem Umkreis von ca. 4 Kilometern alles buchstäblich wegrasiert worden, bzw. zu Staub und Asche zerfallen sein. Dieser Sprengstoff soll, wie man uns sagt, für andere Zwecke demnächst verwendet werden.

Man macht uns ferner darauf aufmerksam, dass sich in Schlesien (genaue Angaben über den Standort kann man uns leider nicht machen) Flugzeugfabriken befinden, die ohne Ausweis nicht betreten werden dürfen. Ein Sohn eines uns bekannten Schiffsmannes arbeitet dort. Die Belegschaft soll die Fabriken nicht verlassen dürfen. Sie isst und schläft in eigens hierzu eingerichteten Räumen. Die Fabriken befinden sich auch hier unter der Erde und sind gegen Fliegerangriffe geschützt. Man vermutet, dass hier ebenfalls so etwas wie eine "geheime Waffe" hergestellt wird. Unsere Gewährsleute lassen sich nicht ausreden, dass hier Flugzeuge mit Fernsteuerung hergestellt werden, die mit Bomben oder Sprengstoff beladen ohne Bordmannschaft für bestimmte Zwecke verwendet und eingesetzt werden können. Obwohl keinerlei Beweise für die Richtigkeit dieser Meldungen vorliegen, so möchten wir Dir hiervon Kenntnis geben. Es wird sich ja eines Tages herausstellen, ob es sich hier um eine Art geheime Waffe handelt oder nicht. Jedenfalls müssen diese Mitteilungen mit aller Vorsicht entgegengenommen werden. [...]

[...] Our sources claim that there are large explosives factories in Hiltersheim, Magdeburg district. These factories are said to have been moved here from Ludwigshafen. They are located in underground, bomb-proof facilities. A special [[explosive?] substance is produced here which is said to have an enormous explosive effect. In Ludwigshafen, this explosive was used on an experimental basis to blow up severely damaged houses and entire neighborhoods. With one kilogram, everything within a radius of approximately four kilometers should be literally razed away, or disintegrated to dust and ashes. We are told that this explosive will soon be used for other purposes.

We are also informed that there are aircraft factories in Silesia (unfortunately we are not given exact details of the location) which cannot be entered without a pass. A son of a shipman we know works there. The employees are not allowed to leave the factories. They eat and sleep in specially equipped rooms. The factories are also located underground and are protected against air raids. It is suspected that something like a "secret weapon" is also being produced here. Our sources will not be talked out of the fact that remote-controlled airplanes are produced here, which can be loaded with bombs or explosives and used for certain purposes without a crew on board. Although there is no proof that these reports are correct, we would like to inform you of them. One day it will become clear whether this is some kind of secret weapon or not. In any case, these reports must be taken with a grain of salt.

[Loofbourow seemed to have great confidence in his source "Dr. Berg" (not to be confused with Moe Berg, an OSS spy). Would it possible now to trace who that person actually was?

The new explosive reported by Dr. Berg was said to have "an enormous explosive effect" and clearly was not a conventional explosive. A fuel-air explosive (such as was being developed by Mario Zippermayr and others) could have an enormous explosive effect, but it would require on the order of a ton, not a kilogram, of fuel, and the fuel would be coal dust or other relatively well known substances. This report of a new explosive that was special substance that was so powerful that one kilogram of the new explosive could have a blast radius of several kilometers, seems to accurately describe the properties of weapons-grade uranium or plutonium. Dr. Berg reported that large factories with hundreds of people were producing the new explosive, which sounds like a large-scale production operation, not just small-scale lab experiments with minute quantities.

According to Dr. Berg, production began no later than early 1943. Based on current evidence about the technologies that were available in Germany at that time and that would have been suitable for producing fission bomb fuel, one of the most likely production methods would have been electromagnetic separation of uranium-235. That approach would have been highly similar to the U.S. calutrons at Oak Ridge, which also required hundreds of minimally trained workers to operate. Other possibilities would have been gas centrifuges or gaseous diffusion for enriching uranium-235, or a reactor or particle accelerators for breeding plutonium-239 or uranium-233.

For aerodynamic, stability, and targeting reasons, bombs are generally not spherical. The only reason to make a spherical bomb is if the bomb physics compels that choice—a spherical implosion bomb. Actually, this report gives many relevant details. It describes a bomb that:

1. Was spherical in overall shape, which strongly suggests an implosion design.
2. Contained on the order of a kilogram of an unusual material that was a new type of explosive.
3. Required large factories, hundreds of people, and over a year to produce enough of that unusual material.
4. Contained other components that are alluded to but not specified.
5. Had a blast radius of several kilometers.

Those details are highly consistent with others descriptions of a German fission implosion bomb.

The Lüneburger Heide or Heath is an area just south of Hamburg. Note the measures taken to avoid aerial surveillance ("to prevent detection from the air") and aerial bombardment ("vast underground factories," distribution "in a number of towns") of this program. If those measures were successful, and if the equipment was evacuated, blown up, or buried before the end of the war, the whole program could have remained unnoticed by Allied countries, apart from a few intelligence reports such as those of Dr. Berg and the following documents, which do not appear to have been seriously pursued.

See also pp. 4987–4988 for a map and list of known underground facilities including Lüneburger Heide.]

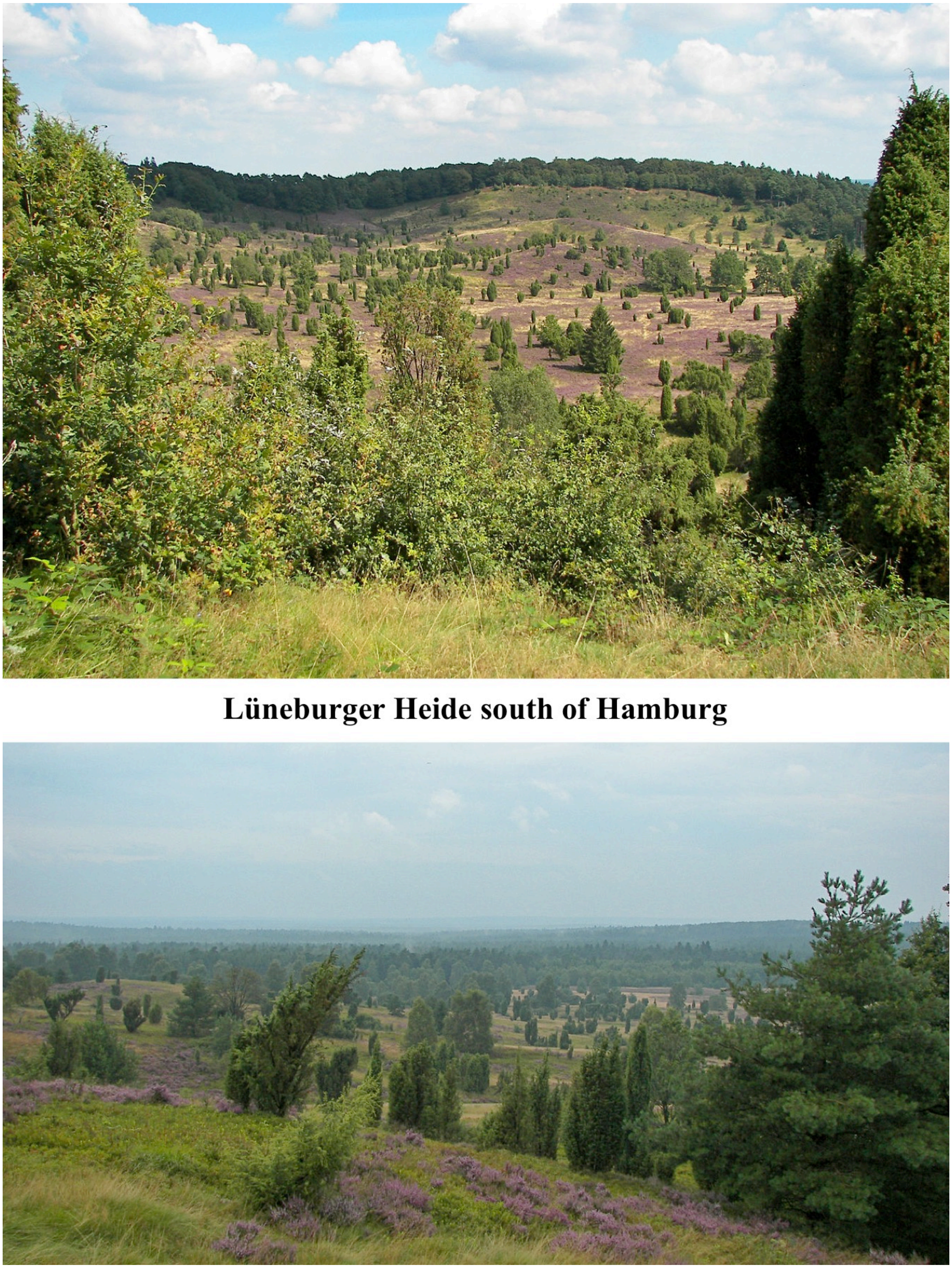


Figure D.560: Several documents reported that there was a hidden underground nuclear facility somewhere in the Lüneburger Heide area south of Hamburg. See also pp. 4987–4988.

From US Military Attaché Madrid Spain to War Department. 21 June 1944. Cable 12547. [NARA RG 165, Entry NM84-489, Box 175, Folder G-2 Book III a (Cables)]

To London and MILID, 12547.

Contact named Handtusch now returned to Germany eval FO states sea pointed last several days is aerial torpedo. Proof fired from Lueneburger Heide in direction Baltic Sea, impact area approximately 100 KM from Kiel. He stated storage depots these torpedos located in Lueneburger Heide near Lueneburg. Manufactured in new underground plants between Rostock and Stralsund.

Sharp.

BIOS 142. *Information Obtained from Targets of Opportunity in the Sonthofen Area.* 1945.

A. The S. S. Hauptamt (information from various sources)

Scientific research on new weapons and the production of armaments in Germany was controlled not only by the established ministries such as the R.L.M. but also by Speer's ministry and by the S. S. Hauptamt. [...]

Obergruppenführer Professor Kammler, one of the directors of the S.S. Hauptamt, was said to have great influence on Himmler and more influence on Hitler than Speer himself; and he was kept informed on all questions concerning armaments. The New Weapons section of the Waffenamt was apparently directed by a man called Bree. Standartenführer Klumm worked in this section and under him Lt. Kreutzfeld, who was interrogated.

One of the functions of the S.S. was to control the work of politically unreliable scientists who were kept in concentration camps. One of these camps was at Oranienburg, and research was done here on new weapons. [...] Another such camp was located at Nordhausen in the Harz, and came under the direct control of Kammler. Here the prisoners worked in an underground factory engaged on production. [...]

B. Information obtained from K. Kreutzfeld [...]

(g) Liquid air bomb

As the research on the atomic bomb under Graf von Ardenne and others was not proceeding as rapidly as had been hoped in 1944, it was decided to proceed with the development of a liquid air bomb. [...]

C. Interrogation of Josef Ernst [...]

(c) Scientific concentration camps

Ernst stated that he had been imprisoned at a concentration camp for politically unreliable scientists called "Camp Mecklenburg" in the Lüneburger Heide. This place was not known to Kreutzfeld, who was however acquainted with the Oranienburg camp. The possibility of bringing Ernst over to Oranienburg was also mentioned in Ernst's personal file, which had been given to him by Kreutzfeld for identification purposes. There was no mention of Camp Mecklenburg in this file. Ernst also stated that there was a similar camp at Maudhausen, near Vienna, but this was also unknown to Kreutzfeld. [...]

(f) Other work at Camp Mecklenburg

Ernst also stated that work was carried out at this camp on a new liquid air bomb, and liquid air gun (?), while trials on some kind of atomic bomb were made at or near the camp.

[The BIOS investigators interrogated Kurt Kreutzfeld, who had apparently been a member of the SS, and Josef Ernst, who had apparently been a "politically unreliable" scientist sentenced to work in concentration camps under the supervision of Kreutzfeld and other SS members. Ernst said he had worked at a concentration camp in the Lüneburger Heide where scientists were developing atomic bombs and other advanced weapons. Kreutzfeld denied that such a place existed and apparently implied to the BIOS investigators that Ernst was crazy. From the report, it seems that the BIOS investigators chose to believe the SS man's denials, and disbelieve the captive scientist's report about atomic bomb development.

The veracity of Ernst's statements is strongly supported by two points he includes that are corroborated by other sources but would have been very far from common knowledge:

- His description of Lüneburger Heide having a very large, very secret facility for the development of an atomic bomb is highly consistent with the statements of Otto Hahn and Frederick Loofbourow's informant, Dr. Berg.
- Ernst said there was another similar concentration camp where scientists were apparently forced to work on atomic bomb development at "Maudhausen, near Vienna." The Mauthausen concentration camp system west of Vienna included Gusen, a large underground complex where nuclear scientists worked on advanced weapons development (see pp. 3882, 4854, 4962ff.).

This report directly links Manfred von Ardenne and the atomic bomb development work, which strongly suggests that one of von Ardenne's specialties, electromagnetic isotope enrichment of uranium-235, was involved in the program. That aligns very well with Dr. Berg's report that many hundreds of workers in the Lüneburger Heide were operating factory equipment to produce small quantities of the special high-density material required by the new type of bomb, very much like the calutron operators at Oak Ridge. For another report linking Lüneburger Heide with atomic bomb development, see p. 4406.

See also: Lüneburger Heide: "Wir wissen nicht genau, was drin ist"—C-Waffen in der Heide aufgetaucht. [Lüneburger Heide: "We don't know exactly what is in there"—chemical weapons appear in the Heide.] *Focus*, 28 March 2017. https://www.focus.de/panorama/welt/lueneburger-heide-wir-wissen-nicht-genau-was-drin-ist-c-waffen-in-der-heide-aufgetaucht_id_6845571.html]

Memo to Lt. Col. P. M. Wilson. Atom-Bomb Specialist. 4 April 1946 [TNA FO 1031/112].

1. The following information has just come to hand and we should be glad if it could be passed on to the appropriate interested agencies.

2. Karl Heinz BOSECK, former Ustuf in the Waffen SS, alleges that he is an Atom-Bomb expert. He is now interned in No. 2 CIC, SANDBOSTEL and his P.O.W. No. is 204526.

[Karl-Heinz Boseck, born in 1915, was a mathematician who studied under Erich Schumann and became a member of the SS [Nagel 2011; Nagel 2012a, pp. 550, 560; Segal 2003, pp. 321–333].

"Atom-Bomb expert" implies much more than just early research. Boseck apparently worked in the SS's nuclear weapons development groups, which remain even more mysterious than other branches of the German nuclear program. Specifically, he helped run the "Mathematical Institute" at the Sachsenhausen concentration camp in Oranienburg [Nagel 2012a, p. 550; Segal 2003, pp. 321–333], an extremely interesting intersection of mathematical calculations, uranium from Auer Gesellschaft in Oranienburg, and slave labor from the concentration camp (perhaps for uranium enrichment?). That also supports Josef Ernst's assertion that the camp at Oranienburg did work related to the nuclear bomb development work at Lüneburger Heide (pp. 4180–4181).

Can other documents from Allied interrogations of Boseck be located, declassified, and released? What other information can be found about Boseck?]

Otto Hahn's autobiography [Otto Hahn 1968, p. 200].

Professor Staudinger schrieb mir, ein Offizier hätte ihm sein Ehrenwort gegeben, daß in der Lüneburger Heide kurz vor Kriegsende drei deutsche Atombomben einsatzbereit gelegen hätten.

Professor Staudinger wrote me that an officer had given him his word of honor that three German nuclear bombs had been ready for deployment in the Lüneburg Heath shortly before the end of the war.

[As Otto Hahn reported in his autobiography, after the war a German military officer in a position to know confirmed that this Lüneburger Heide program did indeed exist and had actually produced three completed fission bombs by the end of the war. With over two years to produce enough material, that could be quite possible. It is also possible that this Lüneburger Heide program produced one or more bombs that were used in the reported late 1944/early 1945 test explosions (Sections D.10–D.12). For a report that appears to link the Lüneburger Heide facility the Baltic atomic bomb test, see p. 4406.

Hermann Staudinger was a Nobel-Prize-winning German chemist just as Otto Hahn was, and of roughly the same age as Hahn. Hahn would have placed great faith in something that Staudinger told him. Since Hahn thought the statement was worthy of inclusion in his autobiography, and since he made no attempt to refute the statement (based on his own knowledge of wartime nuclear work), he seemed to imply that he accepted the statement as credible. Hahn's autobiography was only released after his death.]

Manfred von Ardenne. 1990. *Die Erinnerungen.* 10th ed. Munich: Herbig. p. 159

Bei Besuchen in Dahlem und Lichterfelde hatte ich 1941 Professor Otto Hahn die Frage gestellt, wieviel Gramm des reinen Isotops Uran-235 zur Entfesselung einer momentan ablaufenden Kernkettenreaktion benötigt würden. Er antwortete mir: "Wenige Kilogramm." In diesem absolut vertraulichen Gespräch vertrat ich die Auffassung, es sei technisch durchaus möglich, mit Hilfe hochgezüchteter magnetischer Massentrenner (die wir damals gedanklich und experimentell vorbereitet hatten), Uran-235-Mengen von einigen Kilogramm zu erhalten, wenn man dafür große Elektrokonzerne einsetzen würde.

During visits to Dahlem and Lichterfelde in 1941, I had asked Professor Otto Hahn how many grams of pure uranium-235 would be needed to unleash a nuclear chain reaction in an instant. He answered me: "A few kilograms." In this absolutely confidential conversation, I expressed the opinion that it was technically quite possible to obtain uranium-235 in quantities of a few kilograms with the help of highly sophisticated magnetic mass separators (which we had previously designed and experimentally developed), if large electrical corporations were used for this purpose.

Thomas Powers. 1993. *Heisenberg's War: The Secret History of the German Bomb.* New York: Alfred A. Knopf. p. 513, note 21.

In a letter to Rolf Hochhuth, June 27, 1988, Ardenne cites the conversation with Hahn on December 10, 1941, and quotes the answer of 1 to 2 kilograms. [...] Ardenne confirmed these conversations with me in an interview in Dresden, May 17, 1989, and showed me the signatures of Hahn and Heisenberg in his guest book.

Cable IN 5937 from Bern, Switzerland to Office of Strategic Services Director. 24 March 1944 [NARA RG 226, Entry A1-134, Box 219, Folder IN AZUSA Nov. '43 Sept. '45]

#2576-2581. AZUSA. [...]

The following is a report secured from Flute [Paul Scherrer] by 493: [...]

A super-Nazi, Lorens [Manfred von Ardenne] of Berlin-Lichterfelde-Ost is a financial and scientific swindler. He boasts of constructing an uranium bomb but he does not have adequate equipment. Lorens' associate is Breit [Fritz Houtermans] who was previously a Communist, was apprehended in Russia, but released in 1939 after which he turned into a fervent Nazi. Breit's work is in nuclear physics.

[Paul Scherrer's depiction of the personalities of Manfred von Ardenne and Fritz Houtermans is distorted by Scherrer's scientific jealousy, but Scherrer reported that von Ardenne stated very clearly during the war that he was producing uranium for a fission bomb.]

[According to conventional histories, Otto Hahn was not involved with the German nuclear weapons program. The above sources show that he actually had close ties to the program during the war. This strengthens the credibility of other information from Hahn (pp. 4182, 4460).

The above also shows that a priority of the program was to produce highly enriched uranium-235, especially using von Ardenne's calutron-like electromagnetic isotope separators (Section D.4.3).

The above also demonstrates that the program was focused on producing nuclear devices that would use "1 to 2 kilograms" or "a few kilograms" of uranium-235 to create a chain reaction "in an instant." A reactor would use a much larger quantity of unenriched or low-enriched uranium to produce a continuous, slow reaction, so the devices they were trying to build must have been bombs.

For a sphere of pure uranium-235, the critical mass is ∼46 kg without compression or a surrounding neutron reflector, but only ∼0.36–2.9 kg with compression and a neutron reflector (p. 5162). Thus the information from Hahn and von Ardenne appears to indicate that in 1941 there was an excellent understanding of these numbers and plans to use a bomb design with spherical implosion.

One electromagnetic isotope separator in von Ardenne's personal lab could not produce enough uranium-235 within a reasonable period of time (Section D.15.2), so in 1941 von Ardenne advocated to have many separators built by "large electrical corporations" and then operated in parallel at some other location.

Thus the information above is in excellent agreement with the reports of p. 4176: "vast underground factories" (at a location known to Otto Hahn, p. 4182) with "hundreds of workers" going into operation in 1942, using machines to produce a special material such that "with one kilogram, everything within a radius of approximately four kilometers should be literally razed away, or disintegrated to dust and ashes," when used in uniquely designed "aerial bombs" in which "the container of the explosive is spherical."]

Harry Vosser. Germans Are Still Striving to Perfect New V Weapons. *New York Times*. 22 October 1944, p. E5. [See more on p. 5321.]

V-3 is reported to be the atom bomb. [...] An electric shock from a small instrument set to operate at a given time detonates explosive and atom simultaneously. The expansion caused by a normal explosive substance, such as dynamite when it becomes a gas, is increased by the force of the disintegrating atoms.

V-3? *Time*, 27 November 1944, p. 88.

The terrible novelty of V-2 had by no means worn off yet, but London last week was already abuzz with speculation about V-3—supposedly an atomic bomb. [...]

The speculative London report suggested that the Nazis are using the same pressure principle to crush atoms. The crusher: A "Neuman" demolition charge, which explodes inward instead of outward. Used in a sphere, the Neuman charge might develop pressures of tens of thousands of tons per square inch at the center, perhaps enough to disintegrate an unstable atom such as uranium and release its explosive atomic energy.

[Egon Neumann developed sophisticated shaped charge explosives in 1910 [George Brown 1998, p. 166; Walters and Zukas 1989, pp. 12–13]. His name was presumably attached here to describe the general principle, not to imply that he was directly involved in the reported wartime atomic bomb development.

This article appears to describe the Schumann-Trinks implosion bombs or very similar work, and it supports the view that the work described in the postwar writings of Schumann and Trinks was indeed carried out during the war.]

Leslie R. Groves. 1962. *Now It Can Be Told: The Story of the Manhattan Project*. pp. 147–148.

Another incident that concerned us greatly was the appearance in a national magazine of an article hinting at the theory of implosion. While it did not violate any rules, it was most disturbing. A thorough investigation indicated that it resulted from the work of an alert and inquisitive reporter in another country.

[Clippings in a file at the Franklin Delano Roosevelt Library in Hyde Park, New York [Small Collections, Box 1, Folder 3, ATOMIC BOMB FILE] specifically link this comment from Leslie Groves to the 27 November 1944 article in *Time*. As Groves wrote, it would be quite concerning that any discussion of the implosion bomb design appeared in public at that time. What probably concerned him even more, although he did not mention that in his book, is that the *Time* article said the implosion bomb design details came from the German nuclear program, not the U.S. nuclear program. This evidence strongly supports the conclusion that Germany indeed had an advanced program developing nuclear weapons, and moreover that Leslie Groves knew the German nuclear program was much more advanced than he ever admitted in public.]

General Ivan Ilyichev. Intelligence reports to General Antonov and Joseph Stalin (15 November 1944 and 23 March 1945). Archive of the President of the Russian Federation, 93-81 (45) 37. [For these very important documents on the design and testing of the German fission implosion bomb, see pp. 4481–4485.]

Ordnance Technical Intelligence press release. August 1945. [NARA RG 498, Microfilm MP63-9_0137, Frames 623–624]

Ordnance OTI
For Immediate Release

For over two years, "detectives" of the Army Ordnance Department kept close tabs on German progress in the development of atomic weapons, it was revealed today by Lt. Col. John A. Keck, Chief Enemy Technical Intelligence Branch, Technical Division, Ordnance Service, TSFET.

"This shadowing of German science began in 1942," said Col. Keck, "when several Ordnance Officers, including myself, commenced work with British Intelligence in the United Kingdom. During the period before D-Day, allied agents on the continent were able to obtain from German proving grounds and research laboratories, information which gave definite evidence of steady progress in the atomic field. For some time, the race between German and American science was a close one, and had the Nazis been able to reach their goal, the outcome of the European war might have been entirely different."

Atoms had top priority on Col. Keck's list when he arrived in France with the 1st Army on D-Day. Information at his disposal gave several leads to the location of experimental stations in this line, but in the process of following them up, he hit several discouraging blind alleys. The first road took him to Cherbourg, where the absence of atomic proving grounds was somewhat compensated by the discovery of V-Bomb launching sites. Throughout the Normandy and Northern France campaigns, his searches gave little in the way of results. However, when the breakthrough in Germany got underway, the evidence began to pile up, culminating in the discovery of the great Nazi proving ground at Hillersleben. Here, it was learned that the Germans had gone far in the development of atomic bombs.

"However," said Col. Keck, "they weren't able to go far enough for several reasons, particularly the fact that they didn't have the facilities with which to conduct their experiments, and that our saturation bombing raids would throw their program far behind schedule. Nevertheless their progress was considerable and indicated that they were coming very close to the solution of the problem."

We were fully aware of their plans in this field, for sometimes whatever information we got from our agents went to the proper authorities in the States. This information was undoubtedly put at the disposal of our own scientists. However, it's interesting to note that our knowledge of enemy experiments in the atomic field far exceeded our knowledge of the closely-guarded experiments in the United States.

[The U.S. Army Ordnance Technical Intelligence office publicly stated that evidence proved "the Germans had gone far in the development of atomic bombs." What information were "allied agents on the continent... able to obtain from German proving grounds and research laboratories" during the war? What nuclear-related work was discovered at Hillersleben at the end of the war? Can the relevant U.S. reports be found at NARA or elsewhere?

Keck and the Ordnance Technical Intelligence office described an extended program to monitor German nuclear progress and gave accurate information about Hillersleben, Erich Schumann, and other aspects of German research in this and other press releases. As shown on the next pages, other U.S. government officials later forced them to deny all of that.]

Ordnance Technical Intelligence press release. August 1945. [NARA RG 498, Microfilm MP63-9_0137, Frames 625–626]

Ordnance OTI
For Immediate Release

"If the power of the Army's new atomic bomb is equal to that of 20,000 tons of TNT, its area of destruction would be a circle approximately one mile in diameter," said Colonel Leslie E. Simon, Director of the U.S. Army Ordnance Ballistics Research Center, Aberdeen Proving Ground, Md. Colonel Simon, who was interviewed shortly after release of information on the Army's latest secret weapon, has been in this theater on a special mission which included a 10,000 mile tour of German Ordnance installations and proving grounds. [...]

When asked of the extent to which the Germans had gone in the development of atom bombs, Colonel Simon said that several groups of German scientists had made some progress, but that they had not equalled our developments. He added, however, that they were definitely on the right track and it was a matter of time before they would be able to work something out.

One of the chief experts in this field, he said, was a Dr. Schumann, who was in charge of the research group of the Waffenamt (ordnance) in Berlin. With several other brilliant scientists, Dr. Schumann did much outstanding work, but, according to Colonel Simon, the Germans lagged behind us.

Colonel Simon said he did not believe that any German scientists had gone to Japan to continue their work, chiefly because they would be obliged to leave their laboratory facilities.

[Colonel Leslie Simon conducted extensive on-site visits and wrote detailed reports on German research facilities [Simon 1947a, 1947b, 1971]. He and the U.S. Army Ordnance Technical Intelligence office publicly stated that Erich Schumann (German, 1898–1985) was a "brilliant scientist" who "did much outstanding work," and that "the Germans had gone far in the development of atomic bombs." That view appears to be strongly supported by documentation about Schumann's wartime work (p. 4229). However, the Alsos Mission publicly declared that Schumann was only a "second-rate physicist" whose "main interest was the physics of piano strings" (p. 3297), and threatened the Ordnance Technical Intelligence office "against making further statements on this subject" (see below). This same microfilm MP63-9_0137 contains additional background information on the Hillersleben testing ground and U.S. colonels Keck and Simon—see for example frames 621–622, 638–646.]

Samuel Goudsmit to R. G. Ham. 10 August 1945 [NARA RG GOUDS, Entry UD-7420, Box 3, Folder "Historian's Office Inventory Control Job Goudsmit Box 4 Folder 6"].

The new outbursts of the 'omniscient' Colonel Keck... are deplorable and damaging. Please do something about this situation at once...

The German public opinion about the atomic bomb is as follows: They now believe that Hitler was not lying when he told them that he had a terrible weapon in store...

The following TA scientists have gone to work for the Russians...:

1) Dr. Riehl from Auer...

2) von Ardenne (cyclotron expert, etc.).

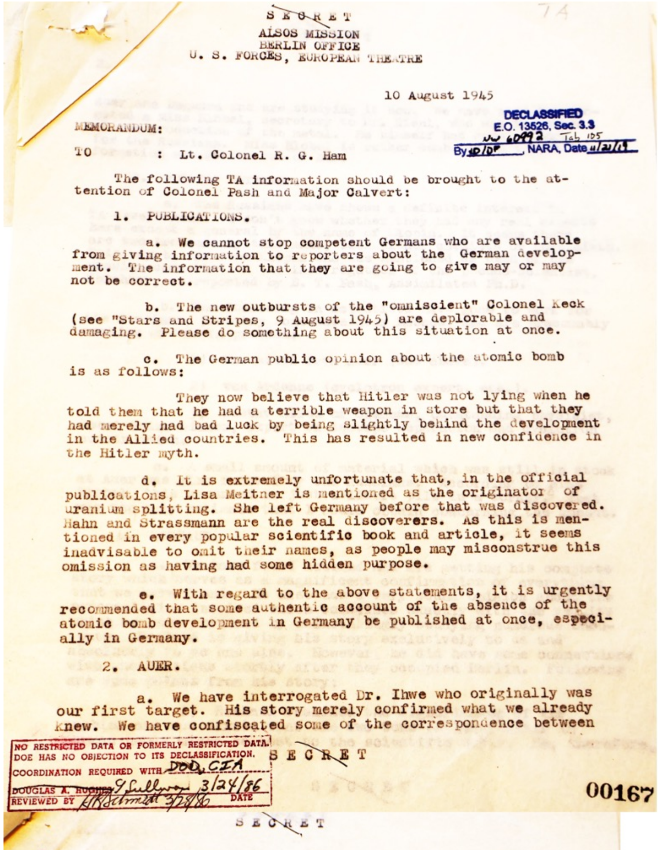
3) Gustav Hertz of Siemens, outstanding physicist, Nobel Prize winner, expert on isotope separation and cyclotron construction.

[See document photo on p. 4189.]

Monthly Intelligence Summary. July–August 1945. [NARA RG 77, Entry UD-22A, Box 168, Folder 202.3-1 LONDON OFFICE: Combined Intell Rpts.]

IX CENSORSHIP. [...]

e. The first wave of publicity after the use of the atom bomb brought forth a story from Lt. Col. John A. KECK, Chief of the Enemy Technical Intelligence Branch Ordnance Services, ETO, in which KECK purports to have conducted intelligence operations to determine the scope of enemy work on an atomic bomb. Col. KECK was interviewed by a representative of this office and admitted that he had not performed such a mission but denied having given the story to the Press. KECK stated that the story was released by the Public Relations Section of the Ordnance Services. Both KECK and the PRO were warned against making further statements on this subject.



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ALSOS MISSION
BERLIN OFFICE
U. S. FORCES, EUROPEAN THEATRE

7A

10 August 1945

DECLASSIFIED
E.O. 13526, Sec. 3.3
NW 60992 Tab 105
By JD/DP, NARA, Date 11/21/19

MEMORANDUM:

TO : Lt. Colonel R. G. Ham

The following TA information should be brought to the attention of Colonel Pash and Major Calvert:

1. PUBLICATIONS.

a. We cannot stop competent Germans who are available from giving information to reporters about the German development. The information that they are going to give may or may not be correct.

b. The new outbursts of the "omniscient" Colonel Keck (see "Stars and Stripes, 9 August 1945) are deplorable and damaging. Please do something about this situation at once.

c. The German public opinion about the atomic bomb is as follows:

They now believe that Hitler was not lying when he told them that he had a terrible weapon in store but that they had merely had bad luck by being slightly behind the development in the Allied countries. This has resulted in new confidence in the Hitler myth.

d. It is extremely unfortunate that, in the official publications, Lisa Meitner is mentioned as the originator of uranium splitting. She left Germany before that was discovered. Hahn and Strassmann are the real discoverers. As this is mentioned in every popular scientific book and article, it seems inadvisable to omit their names, as people may misconstrue this omission as having had some hidden purpose.

e. With regard to the above statements, it is urgently recommended that some authentic account of the absence of the atomic bomb development in Germany be published at once, especially in Germany.

2. AUER.

a. We have interrogated Dr. Ihwe who originally was our first target. His story merely confirmed what we already knew. We have confiscated some of the correspondence between

NO RESTRICTED DATA OR FORMERLY RESTRICTED DATA.
DOE HAS NO OBJECTION TO ITS DECLASSIFICATION.
COORDINATION REQUIRED WITH DOD, CIA
~~DOUGLAS A. HUGHES~~ G Sullivan 3/24/86
REVIEWED BY HRSchmidt 3/28/86 DATE

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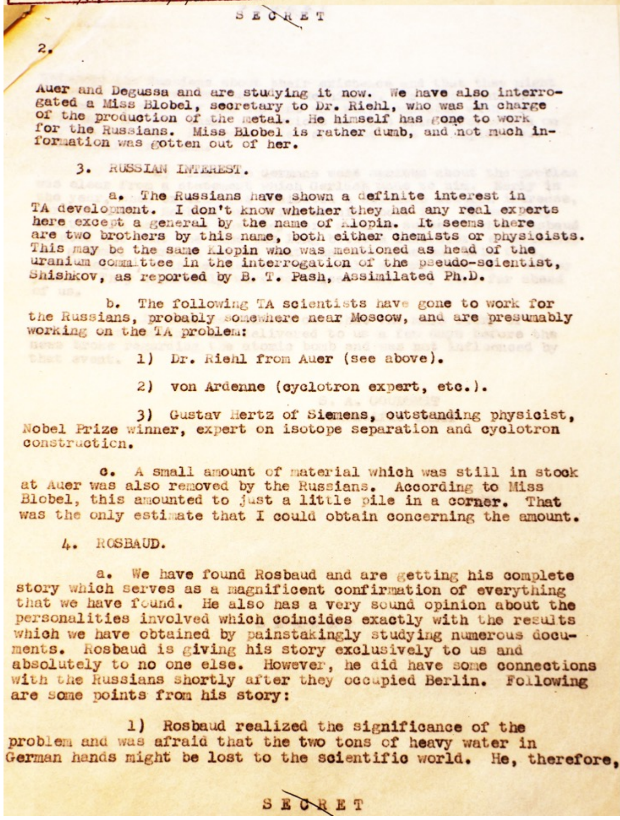

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2.

Auer and Degussa and are studying it now. We have also interrogated a Miss Blobel, secretary to Dr. Riehl, who was in charge of the production of the metal. He himself has gone to work for the Russians. Miss Blobel is rather dumb, and not much information was gotten out of her.

3. RUSSIAN INTEREST.

a. The Russians have shown a definite interest in TA development. I don't know whether they had any real experts here except a general by the name of Klopin. It seems there are two brothers by this name, both either chemists or physicists. This may be the same Klopin who was mentioned as head of the uranium committee in the interrogation of the pseudo-scientist, Shishkov, as reported by B. T. Pash, Assimilated Ph.D.

b. The following TA scientists have gone to work for the Russians, probably somewhere near Moscow, and are presumably working on the TA problem:

1) Dr. Riehl from Auer (see above).

2) von Ardenne (cyclotron expert, etc.).

3) Gustav Hertz of Siemens, outstanding physicist, Nobel Prize winner, expert on isotope separation and cyclotron construction.

c. A small amount of material which was still in stock at Auer was also removed by the Russians. According to Miss Blobel, this amounted to just a little pile in a corner. That was the only estimate that I could obtain concerning the amount.

4. ROSBAUD.

a. We have found Rosbaud and are getting his complete story which serves as a magnificent confirmation of everything that we have found. He also has a very sound opinion about the personalities involved which coincides exactly with the results which we have obtained by painstakingly studying numerous documents. Rosbaud is giving his story exclusively to us and absolutely to no one else. However, he did have some connections with the Russians shortly after they occupied Berlin. Following are some points from his story:

1) Rosbaud realized the significance of the problem and was afraid that the two tons of heavy water in German hands might be lost to the scientific world. He, therefore,

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NARA RG GOUDS, Entry UD-7420, Box 3, Folder "Historian's Office Inventory Control Job Goudsmit Box 4 Folder 6"

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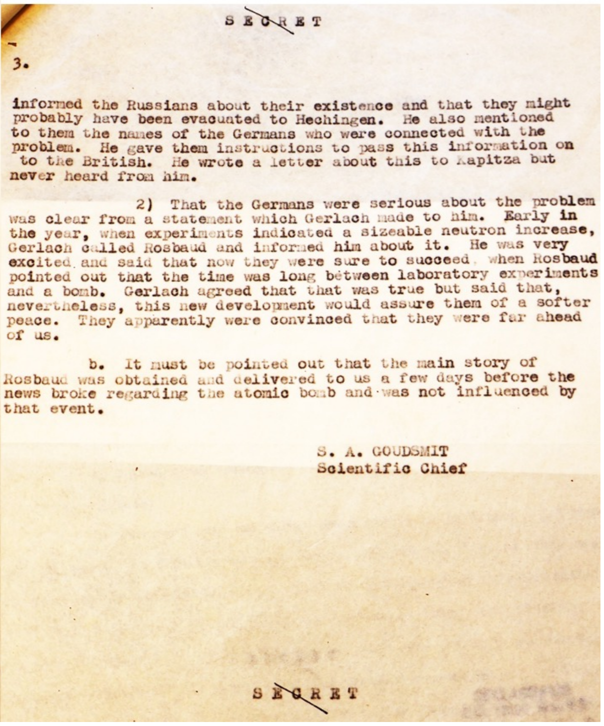

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3.

informed the Russians about their existence and that they might probably have been evacuated to Hechingen. He also mentioned to them the names of the Germans who were connected with the problem. He gave them instructions to pass this information on to the British. He wrote a letter about this to Kapitza but never heard from him.

2) That the Germans were serious about the problem was clear from a statement which Gerlach made to him. Early in the year, when experiments indicated a sizeable neutron increase, Gerlach called Rosbaud and informed him about it. He was very excited and said that now they were sure to succeed. When Rosbaud pointed out that the time was long between laboratory experiments and a bomb. Gerlach agreed that that was true but said that, nevertheless, this new development would assure them of a softer peace. They apparently were convinced that they were far ahead of us.

b. It must be pointed out that the main story of Rosbaud was obtained and delivered to us a few days before the news broke regarding the atomic bomb and was not influenced by that event.

S. A. GOUDSMIT
Scientific Chief

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Figure D.561: Samuel Goudsmit to R. G. Ham. 10 August 1945 [NARA RG GOUDS, Entry UD-7420, Box 3, Folder "Historian's Office Inventory Control Job Goudsmit Box 4 Folder 6"]. "The new outbursts of the 'omniscient' Colonel Keck... are deplorable and damaging. Please do something about this situation at once... The German public opinion about the atomic bomb is as follows: They now believe that Hitler was not lying when he told them that he had a terrible weapon in store... The following TA scientists have gone to work for the Russians...: 1) Dr. Riehl from Auer... 2) von Ardenne (cyclotron expert, etc.). 3) Gustav Hertz of Siemens, outstanding physicist, Nobel Prize winner, expert on isotope separation and cyclotron construction."

J. C. Clark. 18 September 1945. Development and Use of Röntgenblitz Technique by the German Scientists during Period 1938–45. Alsos Intelligence Report KO-29365 [AFHRA Folder 170.2279E 18 SEP 1945; AFHRA B1763 frames 0252–0259. Also NARA RG 77, Entry UD-22A, Box 165, Folder ALSOS MATERIAL].

This report is based upon the interrogation of German scientists and scientific reports recovered during the period within a few months after the cessation of hostilities in the E.T.O. Unfortunately the men who apparently did most of the research and development work on the Röntgenblitz equipment, namely Dr. Steenbeck and possibly Dr. Mühlenpfordt working under Dr. Gustav Hertz at Siemens, Berlin, had already gone to Moscow to continue their work, and were not available in Germany for interrogation. However, Dr. Thomer, now working with Prof. H. Schardin at the French Laboratory at Leichtmetall Werke, St. Louis, Alsace, was available for questioning and was well acquainted with the equipment. [...]

Dr. Thomer got his degree at Leipzig in 1936 and worked at Siemens with Dr. Hertz from 1936 until 1938 when he left to go with Prof. Schardin at the Physikalisches Institut der Luftkriegs-Akademie, Berlin-Gatow. Here he used the Röntgenblitz technique for ballistic studies. [...]

By 1941 the Forschungslaboratory acquired high vacuum metal Röntgenblitz tubes from the research laboratory #2 of Siemenswerke for use in multiple flash x-ray studies. This tube and the auxillary circuit is the type which was used for the remainder of the work carried on by Prof. Schardin's workers as well as Dr. Rudi Schall, working under Dr. Erich Schumann at the WaF (research) Division of the Waffenamt, in Berlin. [...]

The uses to which the Germans put the Röntgenblitz equipment were learned by examining captured documents and by interrogation. These applications cover (a) target cavitation produced by projectiles passing through wooden blocks and water targets, (b) the smashing of a lead bullet upon impact with various targets, (c) cavity charge phenomena studies, (d) detonation phenomena studies and (e) an interesting study of the arming of a nose fuze a short distance in front of the muzzle of the gun. With the exception of the studies on detonation of an explosive charge done by Dr. Rudi Schall, all work with the Röntgenblitz equipment was done by Schardin's group, working principally with Dr. Thomer. Only a few German documents covering the above work were available for examination by the author during the investigation of this subject, but it is believed that a complete series of the reports of both Prof. H. Schardin's and Dr. Erich Schumann's groups have been recovered and forwarded through the proper military channels for filing and examination (see Col. L. E. Simon's U.S. Ord. Dept. report).

It was, however, definitively ascertained that the experimental techniques utilized to obtain flash radiographs of cavity charges and high explosive specimens were sensibly the same as those familiar to U.S. research workers. The German scientific groups recognized the value of this technique because it was learned that at least eight more Röntgenblitz units were under construction at the Siemenswerke, Berlin.

[Erich Schumann and Hubert Schardin led groups that conducted detailed research, development, and testing programs for implosion bombs. According to this document, the United States acquired "a complete series of the reports of both Prof. H. Schardin's and Dr. Erich Schumann's groups" and followed up with interrogations of personnel from those groups for several months after the war. Can all of that information be located and declassified now?]

Figure D.562: Historisch-Technisches Museum Versuchsstelle Kummersdorf: Apparent testing area for implosion designs; note numerous ports for mounting diagnostic equipment.

U.S. military intelligence card entry for Erich Schumann. Undated but apparently last updated summer 1945. [NARA RG 319, Entry A1-134B, Box ??, Folder XE170590 Schumann, Erich]

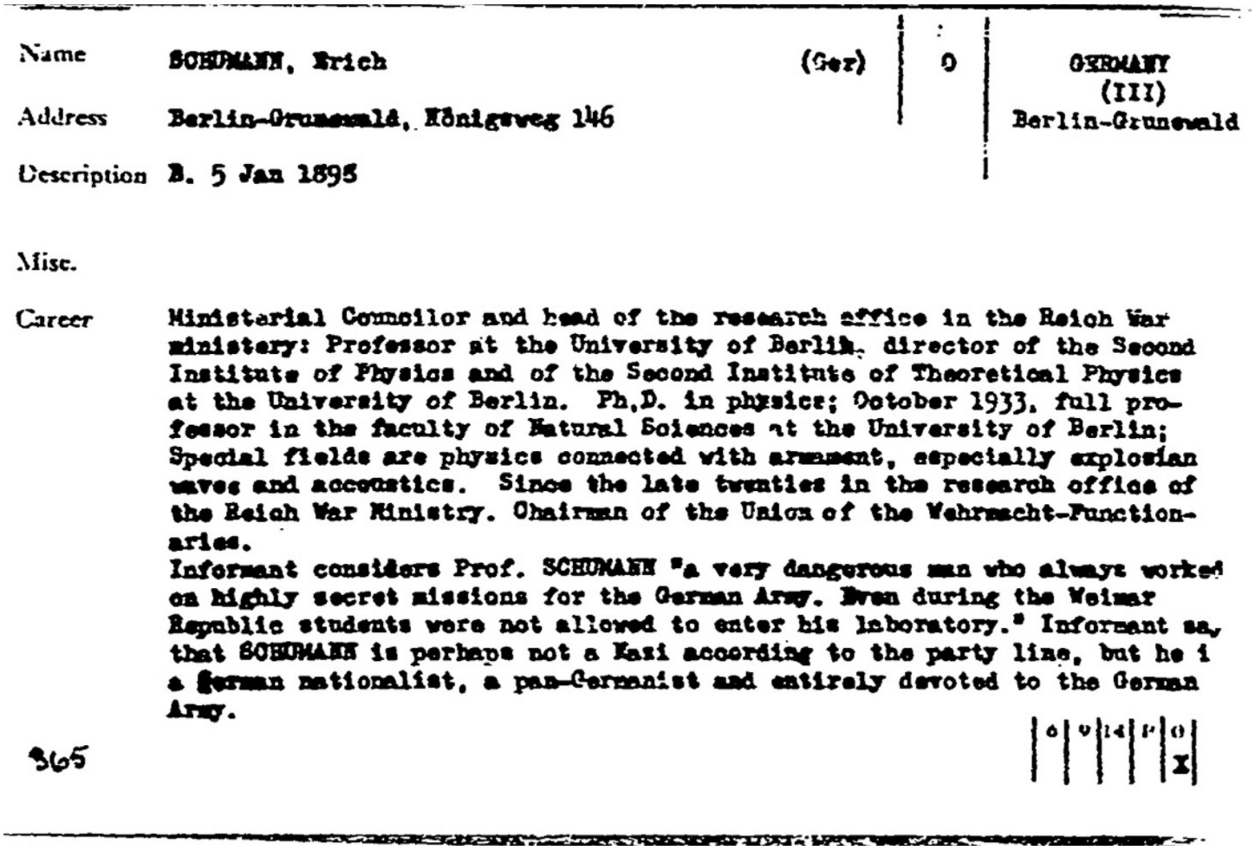
Ministerial Councilor and head of the research office in the Reich War ministry: Professor at the University of Berlin, director of the Second Institute of Physics and of the Second Institute of Theoretical Physics at the University of Berlin. Ph.D. in physics; October 1933, full professor in the faculty of Natural Sciences at the University of Berlin; Special fields are physics connected with armament, especially explosion waves and acoustics. Since the late twenties in the research office of the Reich War Ministry. Chairman of the Union of the Wehrmacht-Functionaries.

Informant considers Prof. SCHUMANN "a very dangerous man who always worked on highly secret missions for the German Army. Even during the Weimar Republic students were not allowed to enter his laboratory." Informant says that SCHUMANN is perhaps not a Nazi according to the party line, but he is a German nationalist, a pan-Germanist and entirely devoted to the German Army.

[This file is further evidence that U.S. investigators were very well aware of how important and how potentially dangerous Erich Schumann's wartime work was.

Yet the office of Leslie Groves tried to hide this information from the public (p. 4187), and Samuel Goudsmit knowingly gave false testimony to the U.S. Senate in which he claimed that Schumann was only a "second-rate physicist" whose "main interest was the physics of piano strings" (p. 3297).]

NARA RG 319,
Entry A1-134B, Box ??,
Folder XE170590
Schumann, Erich



Name	SCHUMANN, Erich	(Ger)	0	GERMANY (III) Berlin-Grunewald
Address	Berlin-Grunewald, Königsweg 146			
Description	B. 5 Jan 1895			

Misc.

Career Ministerial Councilor and head of the research office in the Reich War ministery: Professor at the University of Berlin, director of the Second Institute of Physics and of the Second Institute of Theoretical Physics at the University of Berlin. Ph.D. in physics; October 1933, full professor in the faculty of Natural Sciences at the University of Berlin; Special fields are physics connected with armament, especially explosian waves and accoustics. Since the late twenties in the research office of the Reich War Ministry. Chairman of the Union of the Wehrmacht-Functionaries.

Informant considers Prof. SCHUMANN "a very dangerous man who always worked on highly secret missions for the German Army. Even during the Weimar Republic students were not allowed to enter his laboratory." Informant sa that SCHUMANN is perhaps not a Nazi according to the party line, but he i a German nationalist, a pan-Germanist and entirely devoted to the German Army.

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Figure D.563: U.S. military intelligence card entry for Erich Schumann. Undated but apparently last updated summer 1945. [NARA RG 319, Entry A1-134B, Box ??, Folder XE170590 Schumann, Erich]

Erwin Respondek. 6 November 1945. [NARA RG 226, Entry A1-210, Box 447, Folder WN 16162–16171]

Übersicht des Standes der wissenschaftlichen Arbeiten in Deutschland zur Atom-Bombe (bis Mai 1945)

[...] Prof. Schumann äusserte etwa 1944, dass das Problem der Uran-Bombe gelöst sei. Die Bombe solle an einem Fallschirm abgeworfen werden. Die Zündvorrichtung sei in technisch einfacher Form gelöst worden. Hierzu diene eine Neutronenquelle. Prof. Schumann sagte aber zugleich, dass es bisher nicht gelungen sei, das Uran zum explosiven Spontanzerfall zu bringen. [...]

Overview of the State of Scientific Work in Germany on the Atomic Bomb (until May 1945).

[...] Prof. Schumann stated around 1944 that the problem of the uranium bomb had been solved. The bomb should be dropped on a parachute. The ignition device was solved in a technically simple form. For this purpose, a neutron source is used. At the same time, however, Prof. Schumann said that so far it had not been possible to bring about the explosive spontaneous disintegration of uranium. [...]

[See document photos on pp. 4195–4198. Erwin Respondek (1894–1971) was a German economist who secretly passed information to the United States throughout the 1940s [Dippel 1992]. Despite the juicy title of Respondek's report, he appears to have been most familiar with the well-known basic nuclear research of the Kaiser Wilhelm Institute, to which he devoted most of the report.

However, he did include one intriguing paragraph about the development of an actual German atomic bomb. According to Respondek, the bomb:

- Involved Erich Schumann in its design, which strongly suggests that the bomb design employed shaped charges and implosion, Schumann's area of technical expertise.
- Used uranium as the fission fuel.
- Used a parachute. (This agrees with other accounts—see for example p. 4436.)
- Was intended to be dropped by an aircraft, at least up until 1944 (based on the parachute).
- Used a neutron source to initiate fission reactions at the right time. (That would be during implosion, and is consistent with the other accounts of the bomb design—see for example p. 4485.)
- Had been completed but not yet successfully tested, as of sometime in 1944. (That is consistent with the first successful test(s) being in late 1944/early 1945—see Sections D.10–D.12.)
- Was separate from and much more secret than the Kaiser Wilhelm Institute program (based on how much less Respondek knew about it).

There is also some evidence that information from Respondek led to the December 1943 Allied bombing of an important site associated with the German nuclear program [Dippel 1992, pp. 111–113]. Can more information on that incident be located in archives? Where was the site? What sort of work was actually being conducted at the site? What intelligence led to the bombing?]

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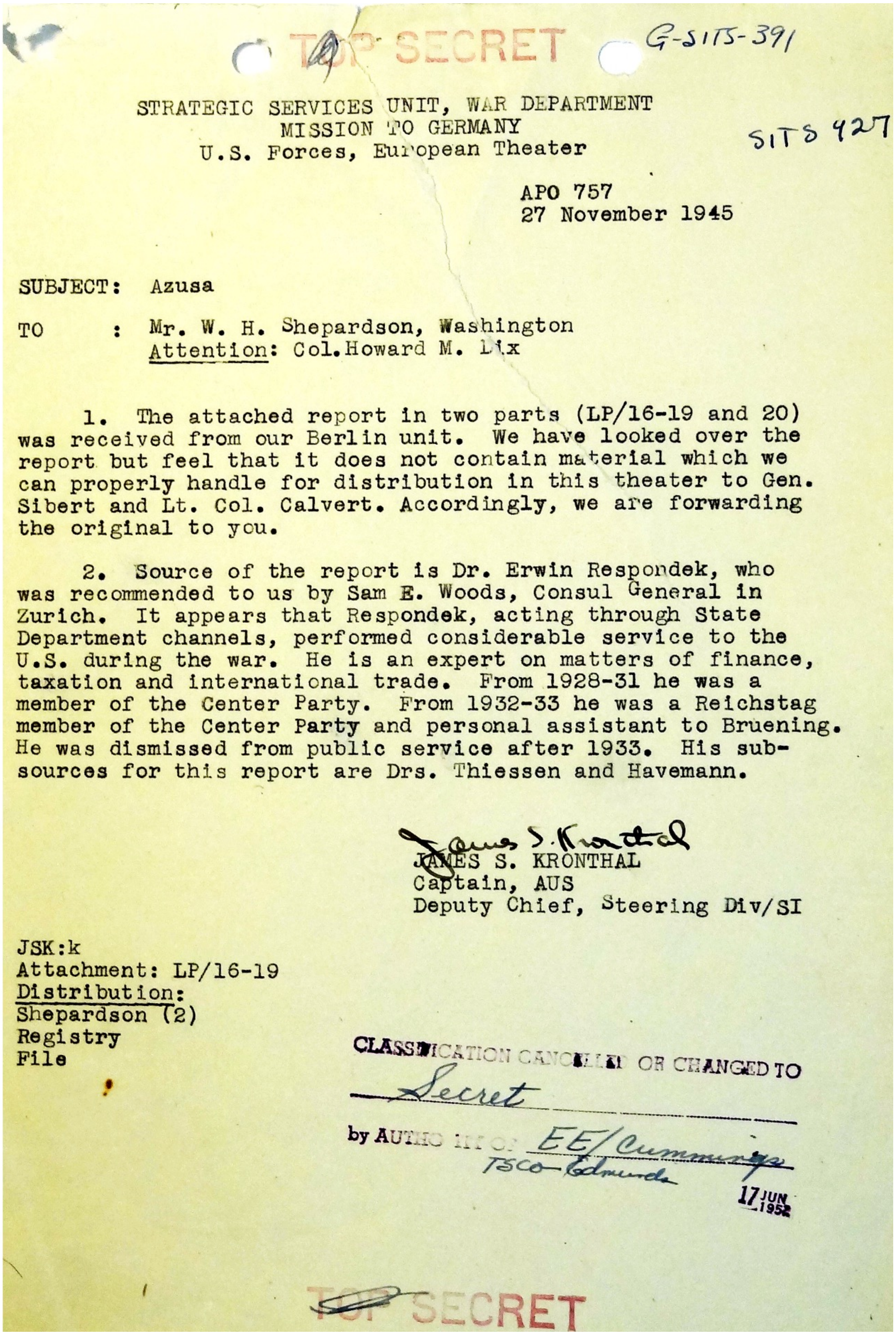
NARA RG 226}, Entry A1-210, Box 447, Folder WN 16162-16171



TOP SECRET G-SITS-391

STRATEGIC SERVICES UNIT, WAR DEPARTMENT
MISSION TO GERMANY
U.S. Forces, European Theater

SITS 427

APO 757
27 November 1945

SUBJECT: Azusa

TO : Mr. W. H. Shepardson, Washington
Attention: Col. Howard M. Dix

1. The attached report in two parts (LP/16-19 and 20) was received from our Berlin unit. We have looked over the report but feel that it does not contain material which we can properly handle for distribution in this theater to Gen. Sibert and Lt. Col. Calvert. Accordingly, we are forwarding the original to you.

2. Source of the report is Dr. Erwin Respondek, who was recommended to us by Sam E. Woods, Consul General in Zurich. It appears that Respondek, acting through State Department channels, performed considerable service to the U.S. during the war. He is an expert on matters of finance, taxation and international trade. From 1928-31 he was a member of the Center Party. From 1932-33 he was a Reichstag member of the Center Party and personal assistant to Bruening. He was dismissed from public service after 1933. His sub-sources for this report are Drs. Thiessen and Havemann.

James S. Kronthal
JAMES S. KRONTHAL
Captain, AUS
Deputy Chief, Steering Div/SI

JSK:k
Attachment: LP/16-19
Distribution:
Shepardson (2)
Registry
File

CLASSIFICATION CANCELLED OR CHANGED TO
Secret
by AUTHORITY OF EE/Cummings
TSCO-Edmunds
17 JUN 1952

TOP SECRET

Figure D.564: James S. Kronthal to W. H. Shepardson and Howard M. Dix. 27 November 1945 [NARA RG 226, Entry A1-210, Box 447, Folder WN 16162–16171].

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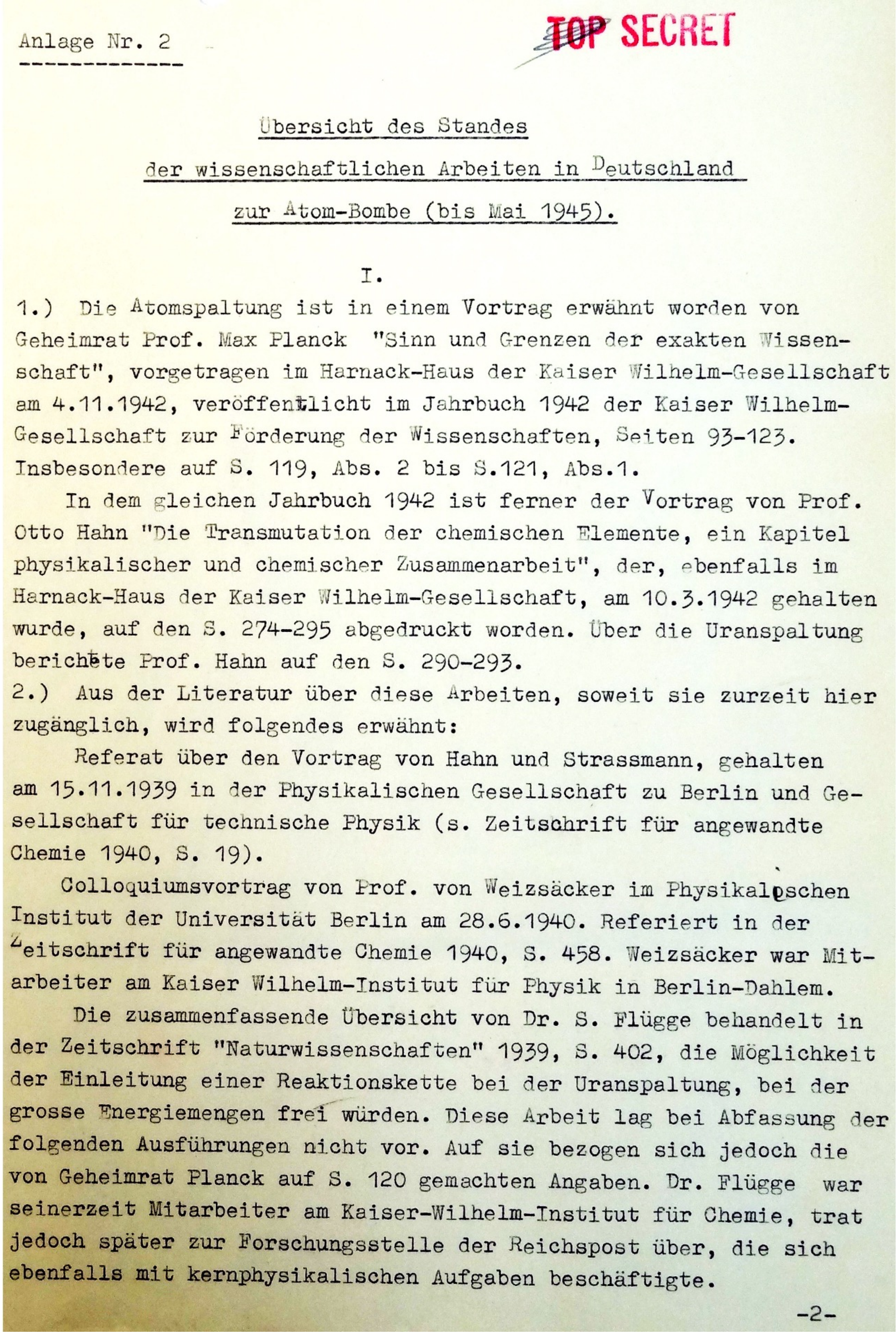


Anlage Nr. 2

TOP SECRET

Übersicht des Standes der wissenschaftlichen Arbeiten in Deutschland zur Atom-Bombe (bis Mai 1945).

I.

1.) Die Atomspaltung ist in einem Vortrag erwähnt worden von Geheimrat Prof. Max Planck "Sinn und Grenzen der exakten Wissenschaft", vorgetragen im Harnack-Haus der Kaiser Wilhelm-Gesellschaft am 4.11.1942, veröffentlicht im Jahrbuch 1942 der Kaiser Wilhelm-Gesellschaft zur Förderung der Wissenschaften, Seiten 93-123. Insbesondere auf S. 119, Abs. 2 bis S.121, Abs.1.

In dem gleichen Jahrbuch 1942 ist ferner der Vortrag von Prof. Otto Hahn "Die Transmutation der chemischen Elemente, ein Kapitel physikalischer und chemischer Zusammenarbeit", der, ebenfalls im Harnack-Haus der Kaiser Wilhelm-Gesellschaft, am 10.3.1942 gehalten wurde, auf den S. 274-295 abgedruckt worden. Über die Uranspaltung berichtete Prof. Hahn auf den S. 290-293.

2.) Aus der Literatur über diese Arbeiten, soweit sie zurzeit hier zugänglich, wird folgendes erwähnt:

Referat über den Vortrag von Hahn und Strassmann, gehalten am 15.11.1939 in der Physikalischen Gesellschaft zu Berlin und Gesellschaft für technische Physik (s. Zeitschrift für angewandte Chemie 1940, S. 19).

Colloquiumsvortrag von Prof. von Weizsäcker im Physikalischen Institut der Universität Berlin am 28.6.1940. Referiert in der Zeitschrift für angewandte Chemie 1940, S. 458. Weizsäcker war Mitarbeiter am Kaiser Wilhelm-Institut für Physik in Berlin-Dahlem.

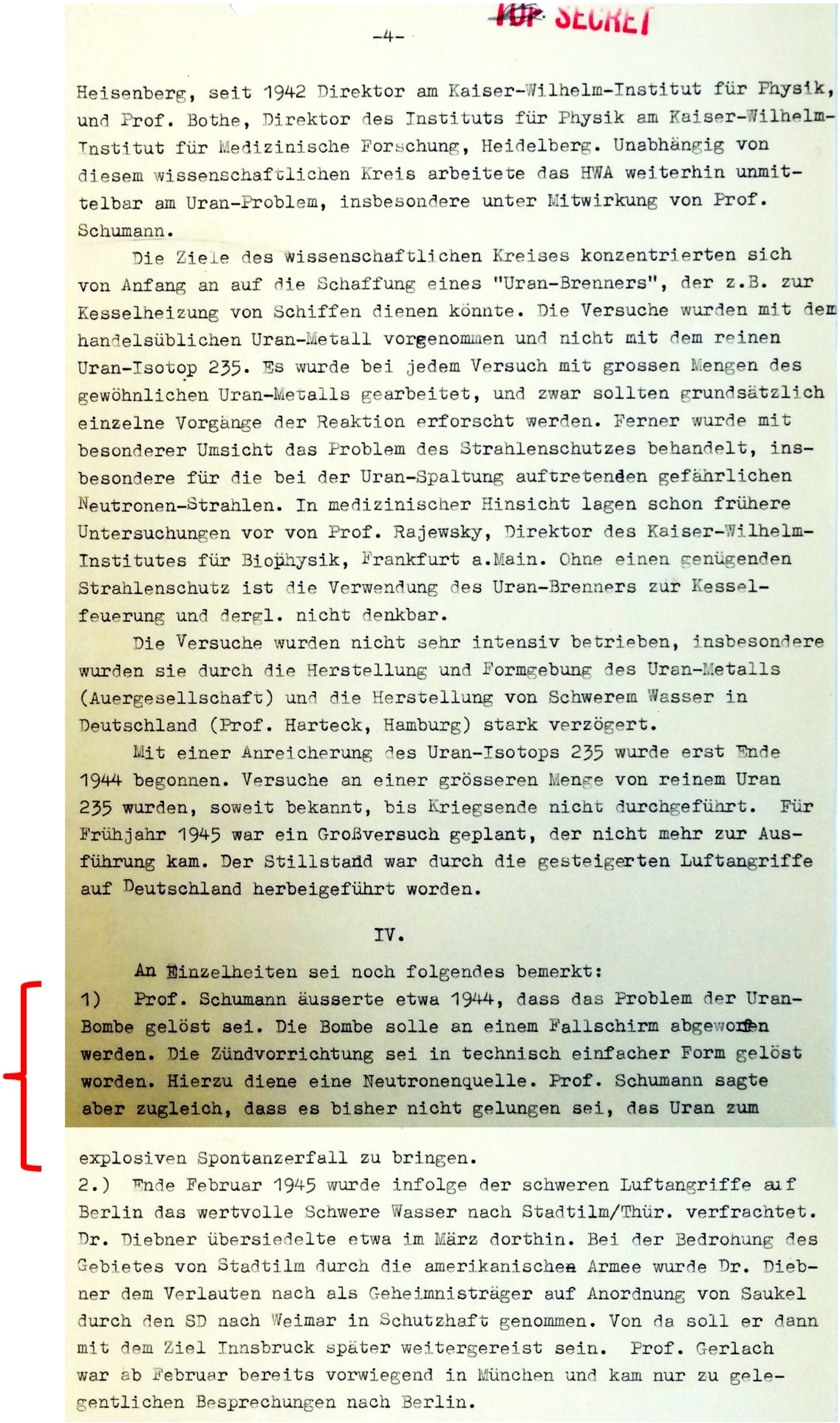
Die zusammenfassende Übersicht von Dr. S. Flügge behandelt in der Zeitschrift "Naturwissenschaften" 1939, S. 402, die Möglichkeit der Einleitung einer Reaktionskette bei der Uranspaltung, bei der grosse Energiemengen frei würden. Diese Arbeit lag bei Abfassung der folgenden Ausführungen nicht vor. Auf sie bezogen sich jedoch die von Geheimrat Planck auf S. 120 gemachten Angaben. Dr. Flügge war seinerzeit Mitarbeiter am Kaiser-Wilhelm-Institut für Chemie, trat jedoch später zur Forschungsstelle der Reichspost über, die sich ebenfalls mit kernphysikalischen Aufgaben beschäftigte.

-2-

Figure D.565: Erwin Respondek. 6 November 1945 [NARA RG 226, Entry A1-210, Box 447, Folder WN 16162–16171].

DECLASSIFIED
Authority NND974345

NARA RG 226}, Entry A1-210, Box 447, Folder WN 16162-16171



-4- TOP SECRET

Heisenberg, seit 1942 Direktor am Kaiser-Wilhelm-Institut für Physik, und Prof. Bothe, Direktor des Instituts für Physik am Kaiser-Wilhelm-Institut für Medizinische Forschung, Heidelberg. Unabhängig von diesem wissenschaftlichen Kreis arbeitete das HWA weiterhin unmittelbar am Uran-Problem, insbesondere unter Mitwirkung von Prof. Schumann.

Die Ziele des wissenschaftlichen Kreises konzentrierten sich von Anfang an auf die Schaffung eines "Uran-Brenners", der z.B. zur Kesselheizung von Schiffen dienen könnte. Die Versuche wurden mit dem handelsüblichen Uran-Metall vorgenommen und nicht mit dem reinen Uran-Isotop 235. Es wurde bei jedem Versuch mit grossen Mengen des gewöhnlichen Uran-Metalls gearbeitet, und zwar sollten grundsätzlich einzelne Vorgänge der Reaktion erforscht werden. Ferner wurde mit besonderer Umsicht das Problem des Strahlenschutzes behandelt, insbesondere für die bei der Uran-Spaltung auftretenden gefährlichen Neutronen-Strahlen. In medizinischer Hinsicht lagen schon frühere Untersuchungen vor von Prof. Rajewsky, Direktor des Kaiser-Wilhelm-Institutes für Biophysik, Frankfurt a.Main. Ohne einen genügenden Strahlenschutz ist die Verwendung des Uran-Brenners zur Kesselfeuerung und dergl. nicht denkbar.

Die Versuche wurden nicht sehr intensiv betrieben, insbesondere wurden sie durch die Herstellung und Formgebung des Uran-Metalls (Auergesellschaft) und die Herstellung von Schwerem Wasser in Deutschland (Prof. Harteck, Hamburg) stark verzögert.

Mit einer Anreicherung des Uran-Isotops 235 wurde erst Ende 1944 begonnen. Versuche an einer grösseren Menge von reinem Uran 235 wurden, soweit bekannt, bis Kriegsende nicht durchgeführt. Für Frühjahr 1945 war ein Großversuch geplant, der nicht mehr zur Ausführung kam. Der Stillstand war durch die gesteigerten Luftangriffe auf Deutschland herbeigeführt worden.

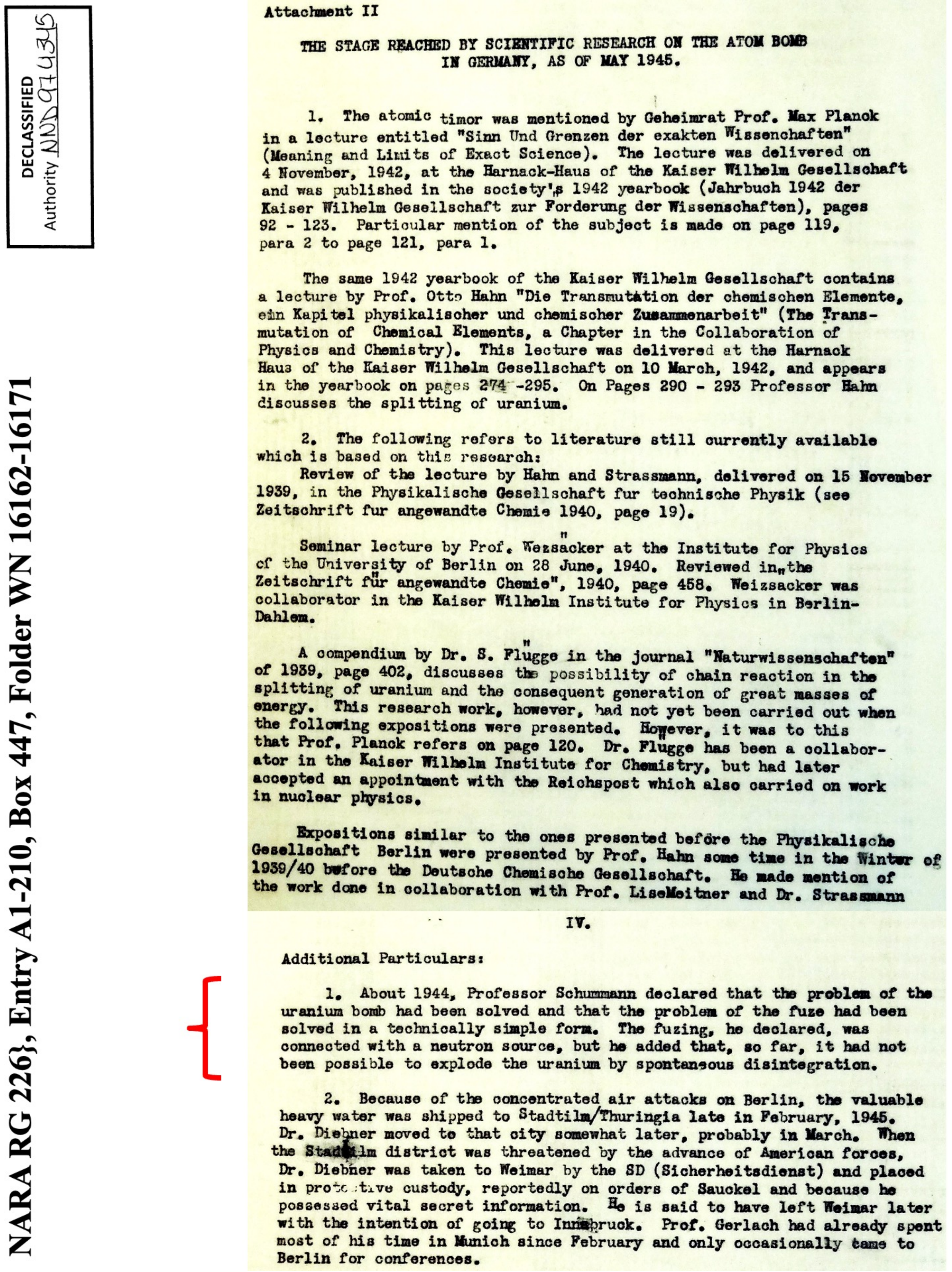
IV.

An Einzelheiten sei noch folgendes bemerkt:

1) Prof. Schumann äusserte etwa 1944, dass das Problem der Uran-Bombe gelöst sei. Die Bombe solle an einem Fallschirm abgeworfen werden. Die Zündvorrichtung sei in technisch einfacher Form gelöst worden. Hierzu diene eine Neutronenquelle. Prof. Schumann sagte aber zugleich, dass es bisher nicht gelungen sei, das Uran zum explosiven Spontanzerfall zu bringen.

2.) Ende Februar 1945 wurde infolge der schweren Luftangriffe auf Berlin das wertvolle Schwere Wasser nach Stadtilm/Thür. verfrachtet. Dr. Diebner übersiedelte etwa im März dorthin. Bei der Bedrohung des Gebietes von Stadtilm durch die amerikanischen Armee wurde Dr. Diebner dem Verlauten nach als Geheimnisträger auf Anordnung von Saukel durch den SD nach Weimar in Schutzhaft genommen. Von da soll er dann mit dem Ziel Innsbruck später weitergereist sein. Prof. Gerlach war ab Februar bereits vorwiegend in München und kam nur zu gelegentlichen Besprechungen nach Berlin.

Figure D.566: Erwin Respondek. 6 November 1945 [NARA RG 226, Entry A1-210, Box 447, Folder WN 16162–16171].



Attachment II

THE STAGE REACHED BY SCIENTIFIC RESEARCH ON THE ATOM BOMB IN GERMANY, AS OF MAY 1945.

1. The atomic timor was mentioned by Geheimrat Prof. Max Planck in a lecture entitled "Sinn Und Grenzen der exakten Wissenchaften" (Meaning and Limits of Exact Science). The lecture was delivered on 4 November, 1942, at the Harnack-Haus of the Kaiser Wilhelm Gesellschaft and was published in the society's 1942 yearbook (Jahrbuch 1942 der Kaiser Wilhelm Gesellschaft zur Forderung der Wissenschaften), pages 92 - 123. Particular mention of the subject is made on page 119, para 2 to page 121, para 1.

The same 1942 yearbook of the Kaiser Wilhelm Gesellschaft contains a lecture by Prof. Otto Hahn "Die Transmutation der chemischen Elemente, ein Kapitel physikalischer und chemischer Zusammenarbeit" (The Transmutation of Chemical Elements, a Chapter in the Collaboration of Physics and Chemistry). This lecture was delivered at the Harnack Haus of the Kaiser Wilhelm Gesellschaft on 10 March, 1942, and appears in the yearbook on pages 274 -295. On Pages 290 - 293 Professor Hahn discusses the splitting of uranium.

2. The following refers to literature still currently available which is based on this research:

Review of the lecture by Hahn and Strassmann, delivered on 15 November 1939, in the Physikalische Gesellschaft fur technische Physik (see Zeitschrift fur angewandte Chemie 1940, page 19).

Seminar lecture by Prof. Wezsäcker at the Institute for Physics of the University of Berlin on 28 June, 1940. Reviewed in "the Zeitschrift für angewandte Chemie", 1940, page 458. Weizsacker was collaborator in the Kaiser Wilhelm Institute for Physics in Berlin-Dahlem.

A compendium by Dr. S. Flügge in the journal "Naturwissenschaften" of 1939, page 402, discusses the possibility of chain reaction in the splitting of uranium and the consequent generation of great masses of energy. This research work, however, had not yet been carried out when the following expositions were presented. However, it was to this that Prof. Planck refers on page 120. Dr. Flügge has been a collaborator in the Kaiser Wilhelm Institute for Chemistry, but had later accepted an appointment with the Reichspost which also carried on work in nuclear physics.

Expositions similar to the ones presented before the Physikalische Gesellschaft Berlin were presented by Prof. Hahn some time in the Winter of 1939/40 before the Deutsche Chemische Gesellschaft. He made mention of the work done in collaboration with Prof. LiseMeitner and Dr. Strassmann

IV.

Additional Particulars:

1. About 1944, Professor Schummann declared that the problem of the uranium bomb had been solved and that the problem of the fuze had been solved in a technically simple form. The fuzing, he declared, was connected with a neutron source, but he added that, so far, it had not been possible to explode the uranium by spontaneous disintegration.

2. Because of the concentrated air attacks on Berlin, the valuable heavy water was shipped to Stadtilm/Thuringia late in February, 1945. Dr. Diebner moved to that city somewhat later, probably in March. When the Stadtilm district was threatened by the advance of American forces, Dr. Diebner was taken to Weimar by the SD (Sicherheitsdienst) and placed in protective custody, reportedly on orders of Sauckel and because he possessed vital secret information. He is said to have left Weimar later with the intention of going to Innsbruck. Prof. Gerlach had already spent most of his time in Munich since February and only occasionally came to Berlin for conferences.

Figure D.567: Erwin Respondek. 6 November 1945 [NARA RG 226, Entry A1-210, Box 447, Folder WN 16162–16171].

Erich Schumann. 2 October 1940. Unclassified draft article on explosives research for popular publication [Bundesarchiv Militärarchiv Freiburg N822/17].

[Erich Schumann (German, 1898–1985) was a high-ranking physicist in the wartime German Army Ordnance Office. He was an expert on conventional explosives and on using shaped explosive charges in a wide variety of geometries for different purposes. At the end of the war, almost all of his wartime papers were destroyed by the Germans or captured and classified by the Allies. However, there is strong evidence from multiple postwar sources that Schumann designed and demonstrated large, highly sophisticated, spherical implosion bombs during the war. If furnished with fission fuel in the center, such spherical implosion designs would have been quite suitable for nuclear weapons.

One of the few surviving and relevant wartime documents is this 2 October 1940 draft article on explosives research that Schumann was preparing for publication. Because the article was intended for unclassified publication, it omitted or downplayed many important aspects. Yet it did make clear that no later than September 1940, Schumann and his coworkers:

- Knew that nuclear explosives could potentially be a million times more powerful than chemical explosives (explosive energies up to megatons of TNT equivalent).
- Wanted to use the shock waves produced by chemical explosives to produce the highest possible pressures and temperatures (which immediately suggests a spherical implosion, from basic physical principles).
- Were keenly interested in using (implosive) shock waves from chemical explosives to trigger nuclear reactions.
- Were trying to make the production of suitable shock waves highly precise and "mathematically controlled."
- Could not discuss the details in an unclassified article "because of the significance of special arrangements in terms of weapons technology."

See pp. 4204–4206 for photographs of some pages from this document.]

[...] Der Zustand der Detonation ist dadurch gekennzeichnet, dass die Aktivierungsenergie dem Sprengstoff durch eine Stosswelle zugeführt wird, wobei die beim Zerfall des Stoffes freiwerdende Energie das Fortschreiten der Stosswelle unterstützt. Es ist leicht einzusehen, dass bei der gegenseitigen Kopplung von Wellenausbreitung und Sprengstoffzerfall sich in einem genügend ausgedehnten Sprengkörper ein stationärer Zustand herausbildet, der für die gesamten detonativen Erscheinungen charakteristisch ist.

Die Fortpflanzungsgeschwindigkeit dieser stationären Zersetzung heisst Detonationsgeschwindigkeit. Da diese verhältnismässig einfach messbar ist, liegt für sie ein umfangreiches Messmaterial vor, das zum wertvollsten Besitz der experimentellen Sprengstoffphysik gehört, stellt doch die Detonationsgeschwindigkeit die einzige wirklich physikalische Messgrösse dar, mit der heute ein Sprengstoff charakterisiert werden kann.

[...] The state of detonation is characterized by the fact that the activation energy is supplied to the explosive by a shock wave, whereby the energy released during the decay of the substance supports the progression of the shock wave. It is easy to see that in a sufficiently large explosive device, when the wave propagation and explosive decay are coupled together, a steady state is formed which is characteristic of all detonative phenomena.

The propagation velocity of this stationary decomposition is called the detonation velocity. Since it is relatively easy to measure, there is extensive measured information available for it, which is one of the most valuable possessions of experimental explosives physics, since the detonation velocity is the only really physical major measurement which can be used today to characterize an explosive.

Die geschilderten energetischen Verhältnisse im molekularen Verband der Sprengstoffe sind grundsätzlich die gleichen, wie wir sie vom korpuskularen Verband des Atomkerns kennen. Obgleich beim Kernzerfall eine sehr grosse Energie frei wird, besitzt der Atomkern doch eine grosse Stabilität, weil zur Einleitung des Zerfalls eine erhebliche Aktivierungsarbeit geleistet werden muss. Die heute möglichen Kernzertrümmerungen entsprechen bei diesem Vergleich, der sich nur auf die qualitativen energetischen Verhältnisse erstreckt, vollständig dem stillen Zerfall von Sprengstoffmolekülen. Da die Kernenergien den chemischen Bindungsenergien, aus denen die Sprengstoffe ihre Leistungsfähigkeit schöpfen, um mindestens 6 Grössenordnungen überlegen sind, würde durch die Kernreaktionen die Möglichkeit von Sprengstoffen unvorstellbar grosser Brisanz gegeben sein, wenn es gelingen würde, die Kernreaktion detonativ, d.h. durch Stosswellen, auszulösen. Ganz abgesehen von der geschichtlich einschneidenden Bedeutung einer solchen Möglichkeit, einen Stoff von wirklich gigantischer Zerstörungskraft in menschliche Hände zu geben, würden wir damit die Materie unter thermodynamischen Bedingungen vorzuliegen haben, wie sie sonst nur an ganz wenigen Stellen des Universums vorkommen. Fraglos wäre der kernreaktionäre Sprengstoff physikalische Realität, wenn es gelänge, eine Stosswelle genügender Intensität zu erzeugen, die einen Kernzerfall einleiten könnte. Da jedoch selbst bei den schwereren, am wenigsten stabilen Atomen die Aktivierungsenergie noch nach Millionenvolt gemessen wird, besitzen wir keine Möglichkeit, eine solch intensiv Stosswelle zu erzeugen. Es fehlt bei den Kernreaktionen eben die Abstufung der Aktivierungsarbeiten, wie sie bei den Sprengstoffen von den Initial- bis zu den Sicherheitssprengstoffen gegeben ist; durch diese ist es möglich, durch fast beliebig kleine Impulse über die Initialstoffe äusserst stabile chemische Verbindungen zum detonativen Zerfall zu bringen. [...]

The described energetic conditions in the molecular bond of explosives are basically the same as we know them from the nuclear bond of the atomic nucleus. Although a very large amount of energy is released during nuclear disintegration, the atomic nucleus has great stability, because a considerable amount of activation work must be done to initiate disintegration. In this comparison, which only covers the qualitative energetic conditions, the nuclear disintegration possible today corresponds completely to the simple disintegration of explosive molecules. Since nuclear energies are at least 6 orders of magnitude greater than the chemical binding energies from which explosives derive their power, nuclear reactions would be unimaginably explosive if it were possible to trigger the nuclear reaction via detonations, i.e. by shock waves. Quite apart from the historically far-reaching significance of such a possibility of putting a substance of truly gigantic destructive power into human hands, we would then be able to produce matter under thermodynamic conditions that otherwise occur only in very few places in the universe. There is no doubt that the nuclear-reactive explosive would be a physical reality if it were possible to generate a shock wave of sufficient intensity to initiate nuclear disintegration. However, since the activation energy of even the heaviest, least stable atoms is still measured in millions of volts, we have no way of generating such an intense shock wave. The nuclear reactions lack the gradation of activation energy that is present in explosives, from early explosives to safety explosives; this makes it possible to cause extremely stable chemical compounds to undergo detonative decay by means of almost arbitrarily small impulses via the initial substances. [...]

Für die Sprengwirkung sind nun nicht allein die thermodynamischen Zustandsgrössen an der Unstetigkeitsstelle, die die Detonationsfront kennzeichnet, massgebend, sondern in entscheidendem Masse ihr weiterer räumlicher Verlauf. Für die Berechnung von räumlichen Feldern der in den Schwaden herrschenden Zustandsgrössen liegen jedoch keine genügenden theoretischen Grundlagen vor. Glücklicherweise liefert nun die Röntgenblitztechnik auf experimentellem Wege den Feldverlauf einer der wichtigsten Zustandsgrössen, nämlich der Gasdichte der Schwaden. Dadurch, dass der Dichtesprung an der Detonationsfront durch die Röntgenblitzmethode der Messung zugänglich ist, erhält man nicht nur einen Einblick in der Zerfallsprozess, sondern durch den weiteren räumlichen Dichteverlauf auch in die für die Wirkung entscheidenden Schwadenströmungserscheinungen. Das Arbeitsvermögen der Schwaden ist nämlich nicht allein durch den Drucksprung in der Detonationsfront bestimmt, sondern wesentlich durch den zeitlichen Druckverlauf an der Sprengstoffoberfläche. Dieser ist jedoch durch die Strömungsvorgänge der Schwaden gegeben, die sich auf Grund von Röntgenblitzaufnahmen verfolgen lassen. Fraglos werden sich die thermodynamischen Kenntnisse, die zu einer Berechnung der Strömungsvorgänge bei den in den Schwaden vorliegenden Drucken von über 100 000 atm und Gasdichten in der Grössenordnung derjenigen fester Körper bisher fehlten, aus den nach der Röntgenblitzmethode gewonnenen experimentellen Ergebnissen gewinnen lassen. Damit dürfte die Einführung der Röntgenblitzmethode in die Sprengstoffphysik, die ebenfalls meinem Institute entstammt1), über den engeren Rahmen der Sprengstoffforschung hinaus für die gesamte Physik der Materie bei extremen Bedingungen von fruchttragender Bedeutung sein.

For the blast effect, not only the thermodynamic state variables at the discontinuity point, which characterizes the detonation front, are decisive, but also to a decisive extent its further spatial course. However, there is no sufficient theoretical basis for the calculation of spatial fields of the state variables prevailing in the windrows. Fortunately, the X-ray flash technique now provides the field progression of one of the most important state variables, namely the gas density of the plume, by experimental means. Since the density jump at the detonation front is accessible by the X-ray flash method of measurement, one does not only get an insight in the disintegration process, but also, through the further spatial density course, into the vapor flow phenomena which are decisive for the effect. The working capacity of the vapors is not only determined by the pressure jump in the detonation front, but essentially by the pressure curve over time at the surface of the explosive. However, this is given by the flow processes of the vapors, which can be followed on the basis of X-ray flash photographs. There is no doubt that the experimental results obtained using the X-ray flash method will provide the thermodynamic knowledge needed to calculate the flow processes at pressures of over 100,000 atm and gas densities of the order of magnitude of those of solid bodies in the vapors. Thus, the introduction of the X-ray flash method into explosives physics, which also originates from my institute1), should be of fruitful importance beyond the narrower framework of explosives research for the entire physics of matter under extreme conditions.

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1) Eine sprengstoffphysikalische Röntgenblitzarbeit wird erstmalig in dem vorliegenden Heft veröffentlicht (Arbeit Schall)

1) An X-ray flash study on the physics of explosives is published for the first time in this issue (work of Schall)

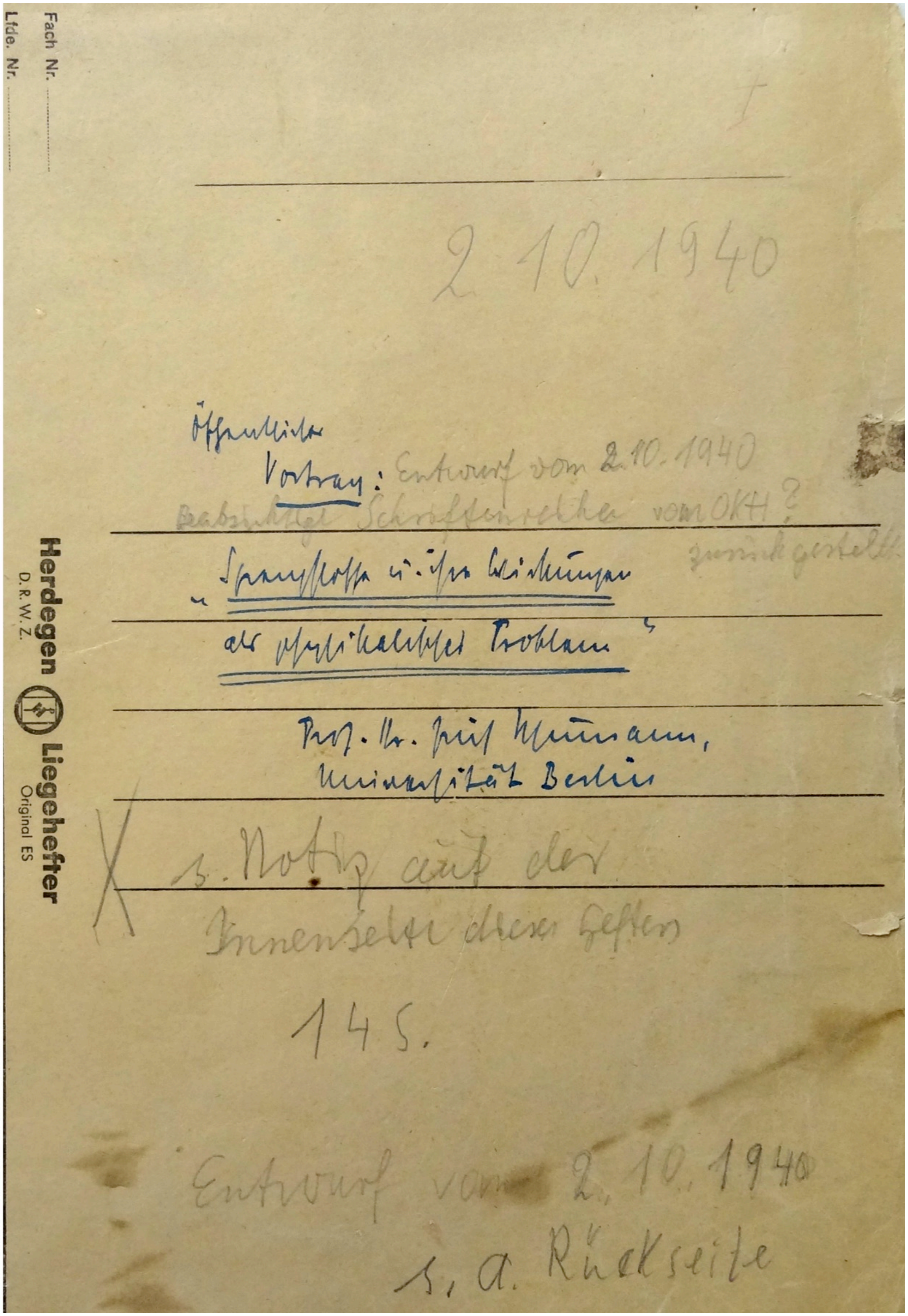
[...] Die soeben bei der Erläuterung des Brisanzbegriffes geäusserten Gedanken deuten bereits eine Theorie der gesamten Sprengstoffwirkung an. Eine solche allgemeine Theorie hat jedoch nicht nur die Vorgänge an der Sprengstoffoberfläche selbst, sondern auch Einwirkungen auf weiter entfernt liegende Punkte zu erfassen. Als Ursache solcher mittelbarer Sprengstoffwirkungen kommen neben der direkten Schwadeneinwirkung die Stosswelle im an den Sprengstoff angrenzenden Medium oder an der Sprengstoffoberfläche beschleunigte und dann ballistisch wirkende Materialteile in Betracht. Die bei den je nach der beabsichtigten Wirkung verschiedenen Anordnungen der Sprengobjekte auftretenden Fragen hier näher zu erörtern, verbietet sich bei der waffentechnischen Bedeutung spezieller Anordnungen von selbst. Auch bei mittelbaren Wirkungen werden die Vorgänge an der Sprengstoffoberfläche als in jedem Falle entscheidende Kraftquelle Ausgangspunkt weiterer Untersuchungen sein müssen.

Das Ergebnis der vorstehenden Überlegungen kann dahin zusammengefasst werden, dass Wege aufgezeigt und Untersuchungsmethoden angegeben werden, die detonativen Erscheinungen in den allgemeinen Rahmen der Physik einzuordnen. Eine solche Behandlung von Sprengstofffragen nach rein physikalischen Gesichtspunkten hat die Schaffung physikalischer Messmethoden für die die Wirkung und Handhabung bestimmenden Grössen zur notwendigen primären Folge. Die weitere Verfolgung dieser Methoden muss zu einer allgemeinen Theorie der Sprengwirkungen führen, die Ablauf und Auswirkung jeder Sprenganordnung rechnerisch zu beherrschen erlaubt und damit der Sprengtechnik wertvollste Unterlagen schafft. Rückwirkend auf die allgemeine Physik werden die sprengstoffphysikalischen Ergebnisse wieder dieser neue Erkenntnisse bringen, liegt doch im Detonationsvorgang die Materie unter Bedingungen vor, wie sie bei anderen physikalischen Erscheinungen experimentell nicht zu verwirklichen sind.

[...] The thoughts just expressed in the explanation of the explosive concept already suggest a theory of the entire effect of explosives. However, such a general theory must not only cover the processes on the surface of the explosive itself, but also effects at points further away. In addition to the direct effect of vapor, the cause of such indirect explosive effects can be the shock wave in the medium adjacent to the explosive or on the explosive surface, which accelerates and then causes ballistically acting matter components. The questions arising from the different arrangements of the explosives depending on the intended effect cannot be discussed here in detail because of the significance of special arrangements in terms of weapons technology. Even in the case of indirect effects, the processes on the surface of the explosives, as the decisive source of power in any case, will have to be the starting point for further investigations.

The result of the above considerations can be summarized as showing ways and indicating investigation methods to classify the detonative phenomena within the general framework of physics. Such a treatment of explosives issues from a purely physical point of view has the necessary primary consequence of creating physical measuring methods for the variables determining the effect and handling. The further pursuit of these methods must lead to a general theory of blasting effects which allows the sequence and effects of each blasting arrangement to be controlled mathematically and thus provides the blasting technique with valuable documentation. Retrospectively on the general physics, the results of blasting physics will again bring new insights, since in the detonation process, matter is present under conditions that cannot be experimentally realized in other physical phenomena.

Bundesarchiv Militärarchiv Freiburg N822/17. Erich Schumann. 2 October 1940.
Unclassified draft article on explosives research for popular publication.



Fach Nr. ....
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2.10.1940

Öffentlicher
Vortrag: Entwurf vom 2.10.1940
beabsichtigt Schriftenreihe vom OKH? zurückgestellt

„Sprengstoffe u. ihre Wirkungen
als physikalisches Problem"

Prof. Dr. Erich Schumann,
Universität Berlin

s. Notiz auf der
Innenseite dieses Heftes

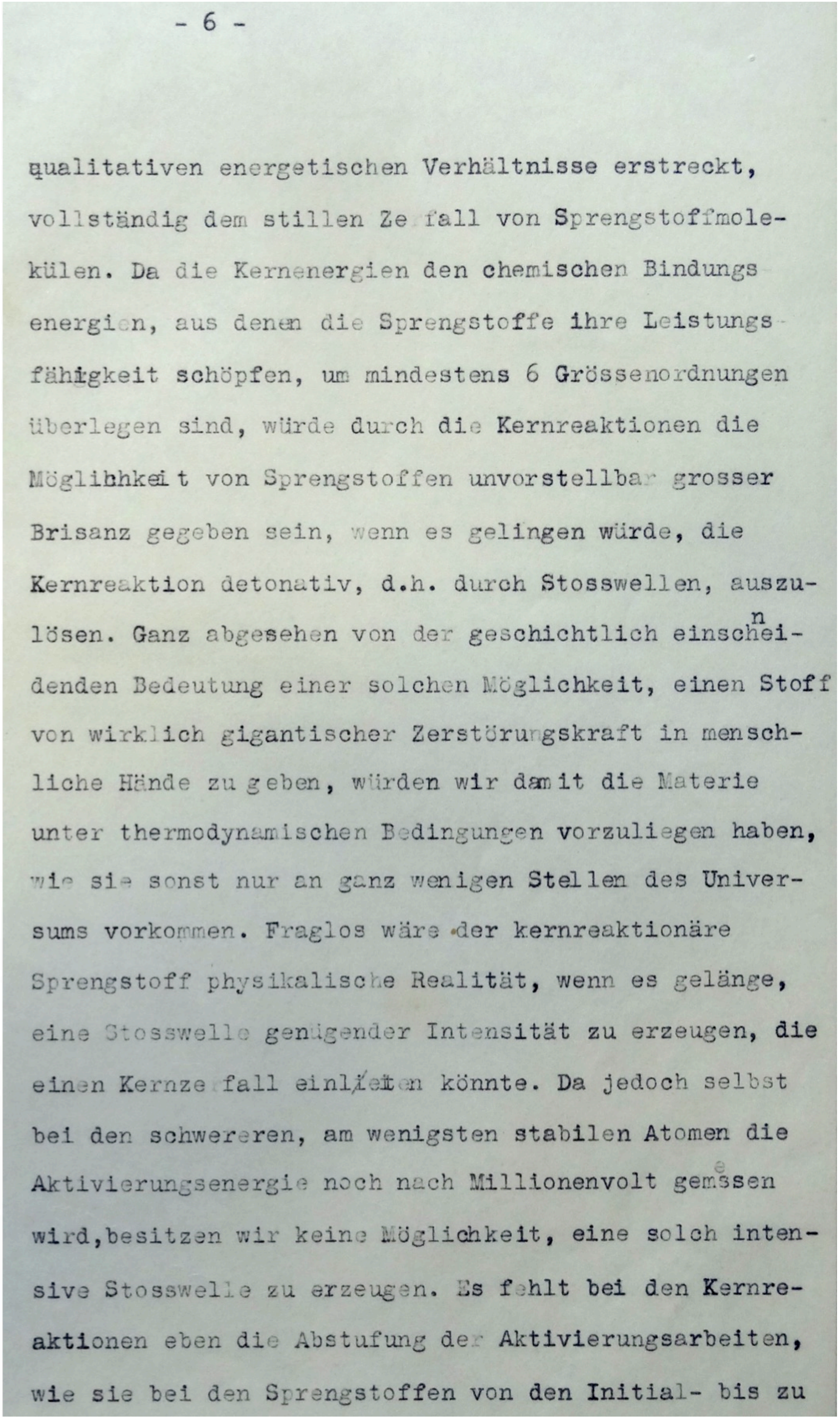
145.

Entwurf vom 2.10.1940
s. a. Rückseite

Herdegen D.R.W.Z. **Liegehefter** Original ES

Figure D.568: Pages from Erich Schumann's 2 October 1940 unclassified draft article on explosives research, intended for popular publication but never published, mentioning an ongoing German military program on nuclear bombs using implosion [Bundesarchiv Militärarchiv Freiburg N822/17].

Bundesarchiv Militärarchiv Freiburg N822/17. Erich Schumann. 2 October 1940.
Unclassified draft article on explosives research for popular publication.



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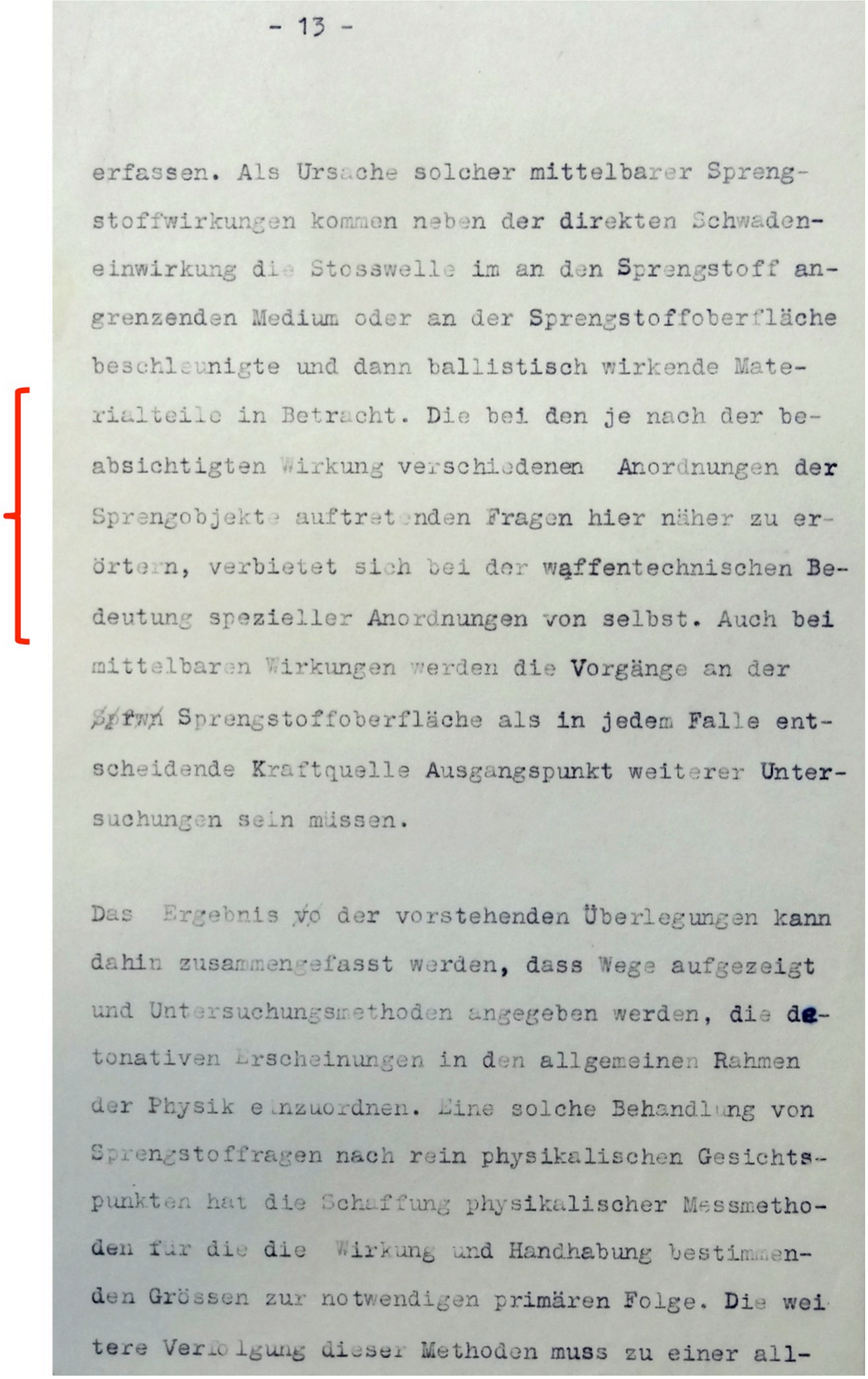
qualitativen energetischen Verhältnisse erstreckt, vollständig dem stillen Zerfall von Sprengstoffmolekülen. Da die Kernenergien den chemischen Bindungsenergien, aus denen die Sprengstoffe ihre Leistungsfähigkeit schöpfen, um mindestens 6 Grössenordnungen überlegen sind, würde durch die Kernreaktionen die Möglichkeit von Sprengstoffen unvorstellbar grosser Brisanz gegeben sein, wenn es gelingen würde, die Kernreaktion detonativ, d.h. durch Stosswellen, auszulösen. Ganz abgesehen von der geschichtlich einschneidenden Bedeutung einer solchen Möglichkeit, einen Stoff von wirklich gigantischer Zerstörungskraft in menschliche Hände zu geben, würden wir damit die Materie unter thermodynamischen Bedingungen vorzuliegen haben, wie sie sonst nur an ganz wenigen Stellen des Universums vorkommen. Fraglos wäre der kernreaktionäre Sprengstoff physikalische Realität, wenn es gelänge, eine Stosswelle genügender Intensität zu erzeugen, die einen Kernzerfall einleiten könnte. Da jedoch selbst bei den schwereren, am wenigsten stabilen Atomen die Aktivierungsenergie noch nach Millionenvolt gemessen wird, besitzen wir keine Möglichkeit, eine solch intensive Stosswelle zu erzeugen. Es fehlt bei den Kernreaktionen eben die Abstufung der Aktivierungsarbeiten, wie sie bei den Sprengstoffen von den Initial- bis zu

Figure D.569: Pages from Erich Schumann's 2 October 1940 unclassified draft article on explosives research, intended for popular publication but never published, mentioning an ongoing German military program on nuclear bombs using implosion [Bundesarchiv Militärarchiv Freiburg N822/17].

Bundesarchiv Militärarchiv Freiburg N822/17. Erich Schumann. 2 October 1940.
Unclassified draft article on explosives research for popular publication.



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erfassen. Als Ursache solcher mittelbarer Sprengstoffwirkungen kommen neben der direkten Schwadeneinwirkung die Stosswelle im an den Sprengstoff angrenzenden Medium oder an der Sprengstoffoberfläche beschleunigte und dann ballistisch wirkende Materialteile in Betracht. Die bei den je nach der beabsichtigten Wirkung verschiedenen Anordnungen der Sprengobjekte auftretenden Fragen hier näher zu erörtern, verbietet sich bei der waffentechnischen Bedeutung spezieller Anordnungen von selbst. Auch bei mittelbaren Wirkungen werden die Vorgänge an der ~~Spfwn~~ Sprengstoffoberfläche als in jedem Falle entscheidende Kraftquelle Ausgangspunkt weiterer Untersuchungen sein müssen.

Das Ergebnis ~~vo~~ der vorstehenden Überlegungen kann dahin zusammengefasst werden, dass Wege aufgezeigt und Untersuchungsmethoden angegeben werden, die detonativen Erscheinungen in den allgemeinen Rahmen der Physik einzuordnen. Eine solche Behandlung von Sprengstoffragen nach rein physikalischen Gesichtspunkten hat die Schaffung physikalischer Messmethoden für die die Wirkung und Handhabung bestimmenden Grössen zur notwendigen primären Folge. Die weitere Verfolgung dieser Methoden muss zu einer all-

Figure D.570: Pages from Erich Schumann's 2 October 1940 unclassified draft article on explosives research, intended for popular publication but never published, mentioning an ongoing German military program on nuclear bombs using implosion [Bundesarchiv Militärarchiv Freiburg N822/17].

Erich Schumann, Kurt Diebner, et al. February 1942 [1941 data]. ***Energiegewinnung aus Uran: Ergebnisse der vom Heereswaffenamt veranlassten Forschungsarbeiten zur Nutzbarmachung von Atomkernenergien.*** **Archiv der Max-Planck-Gesellschaft, I. Abteilung, Rep. 34, Nr. 105. See photos of a few pages on pp. 4208–4210.**

b. Sprengstoff. Die störende Wirkung von U$_{238}$ nimmt mit wachsender Temperatur zu. Ein Sprengstoff würde daher höchstens sehr kleine Mengen von U$_{238}$ erhalten dürfen. Außer der vollständigen Isotopentrennung, die grundsätzlich sicher durchführbar, aber technisch sehr schwierig ist, kommen wir heute theoretisch einen zweiten Web zur Herstellung eines Sprengstoffs, der aber erst erprobt werden kann, wenn eine Uranmaschine läuft. Aus U$_{238}$ bildet sich nämlich durch die Absorption von Neutronen ein Stoff ("Element 94"), der noch leichter spaltbar sein muss als U$_{235}$. Da dieser Stoff chemisch von Uran verschieden ist, muss man ihn aus dem Uran einer stillgelegten Maschine leicht abtrennen können. Doch kennen wir heute weder die Menge, in der er entsteht, noch seine Eigenschaften genau genug für eine ganz sichere Voraussage.

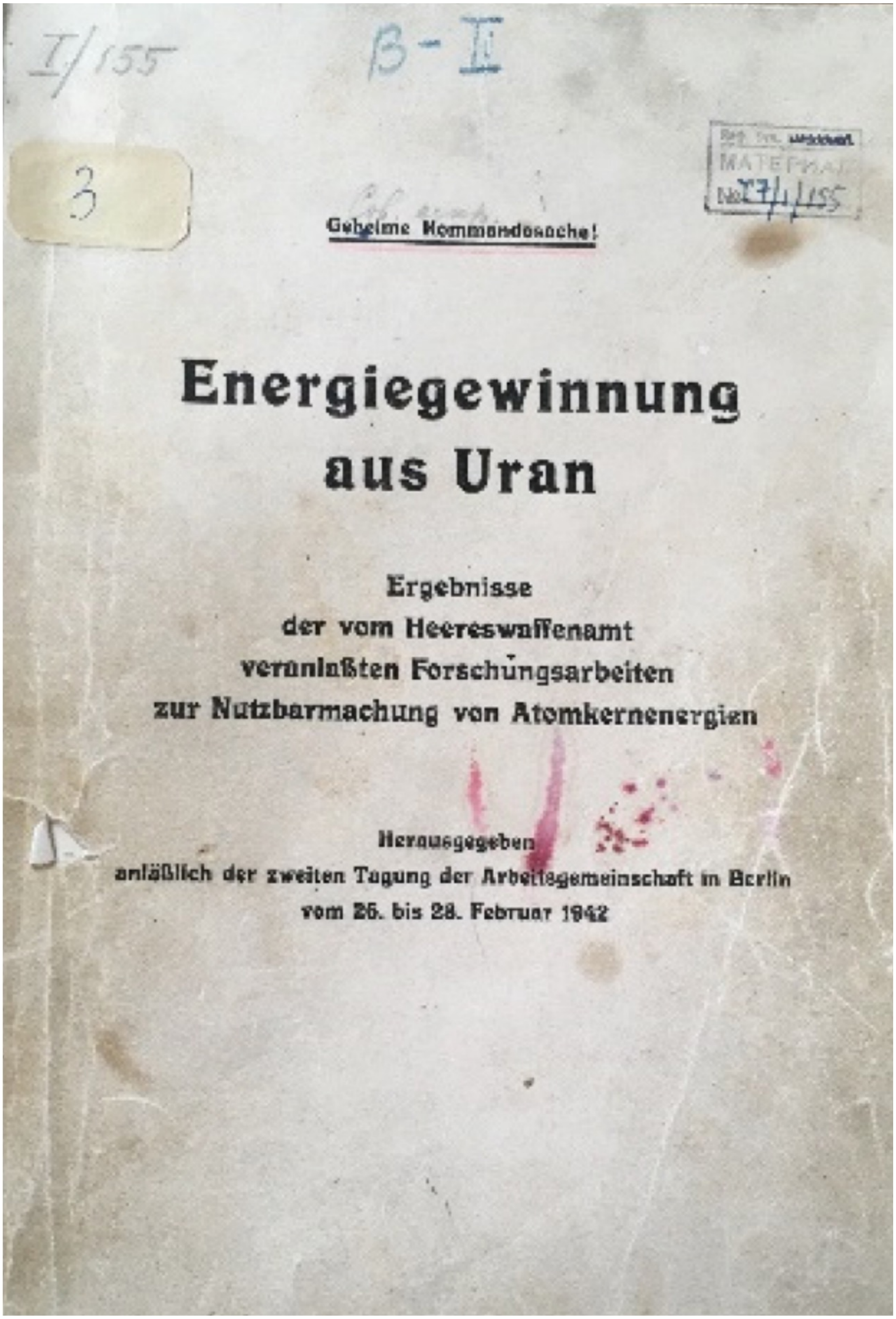
Da sich in jeder Substanz einige freie Neutronen befinden, würde es zur Entzündung des Sprengstoffs genügen, eine hinreichende Menge (vermutlich etwa 10–100 kg) räumlich zu vereinigen.

b. Explosive. The disruptive effect of U$_{238}$ increases with increasing temperature. An explosive would therefore only be allowed to contain very small quantities of U$_{238}$ at most. Apart from the complete separation of isotopes, which can be carried out safely in principle but is technically very difficult, we now have a second theoretical way of producing an explosive, but this can only be tested when a uranium machine is running. From U$_{238}$ a substance ("element 94") is formed by the absorption of neutrons, which must be even easier to fission than U$_{235}$. Since this substance is chemically different from uranium, it must be possible to separate it easily from the uranium of a previously operating machine [used reactor fuel]. But today we know neither the amount in which it is produced nor its properties precisely enough for a completely safe prediction.

Since there are some free neutrons in each substance, it would be enough to spatially combine a sufficient amount (probably about 10–100 kg) to ignite the explosive.

[Erich Schumann and his colleagues at the Heereswaffenamt (including Kurt Diebner) created this secret compendium and presented it to the German government in February 1942. Thus the major results in it are from 1941 or earlier. This document demonstrates that as of 1941, German scientists:

- Were actively working to develop a fission bomb, not just a reactor.
- Knew that ^{235}U could be separated from ^{238}U and that highly enriched ^{235}U would be quite suitable for use in a fission bomb.
- Knew that plutonium-239 (element 94) could be bred from ^{238}U in a fission reactor, could be chemically separated from the remaining uranium afterward, and would be highly suitable for use in a fission bomb.
- Knew that 10–100 kg of sufficiently pure fission fuel should be enough for a fission bomb. This is a very early and excellent conservative estimate of the required mass (compare the values in the table on p. 5162 for the case of no compression, no reflector, and no fusion boosting). It clearly disproves postwar historical myths claiming that Germans did not know the required mass or mistakenly believed it to be several tons.
- Knew that a bomb would need to "spatially combine" that fission fuel on a sufficiently rapid timescale before the explosion. That seems to be a clear connection to the work on implosion designs that Schumann and his colleagues had already been developing for quite some time.]



I/155

B-II

3

[illegible]
МАТЕРИАЛ
№ I7/1/155

Geheime Kommandosache!

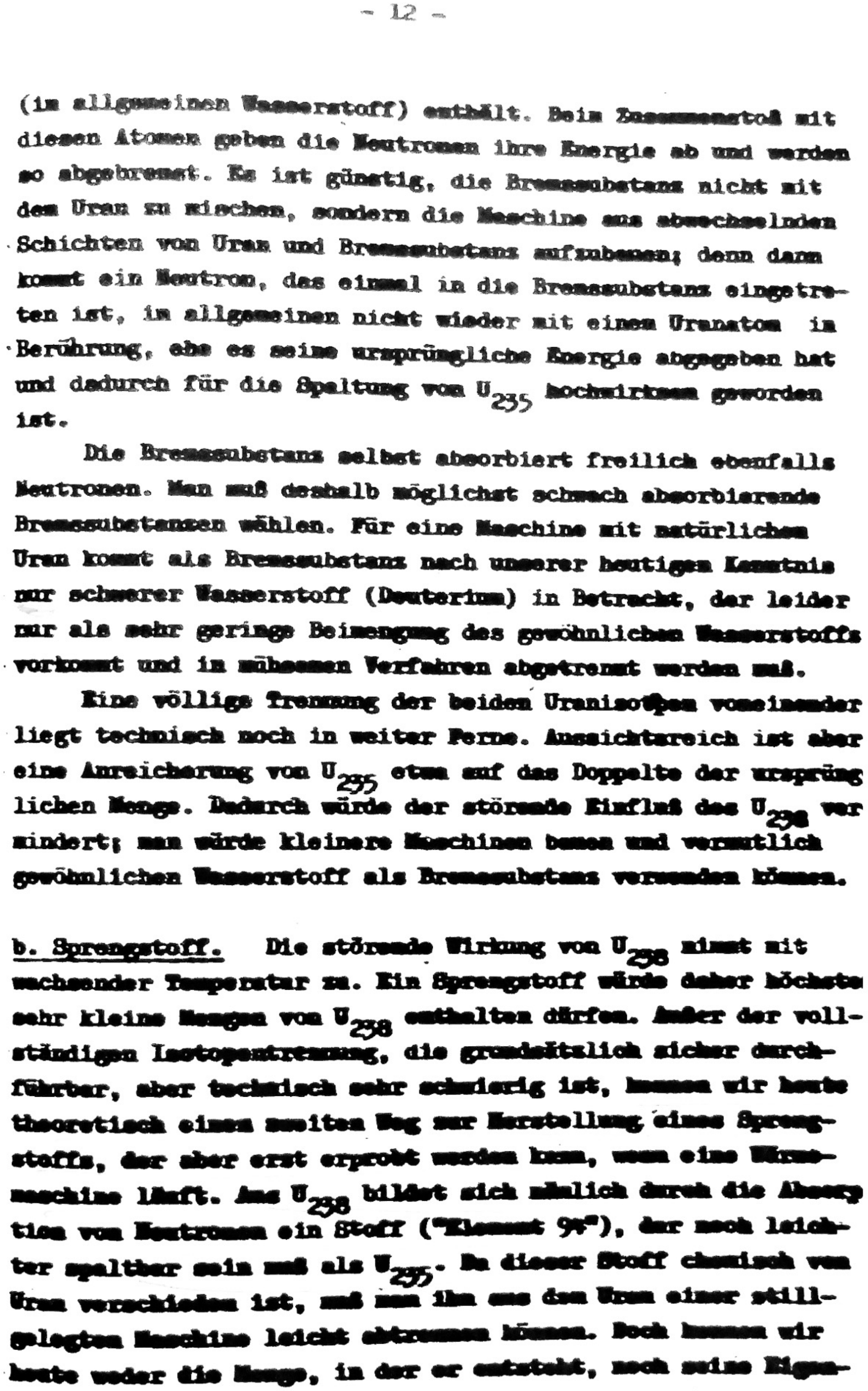
Energiegewinnung aus Uran

Ergebnisse
der vom Heereswaffenamt
veranlaßten Forschungsarbeiten
zur Nutzbarmachung von Atomkernenergien

Herausgegeben
anläßlich der zweiten Tagung der Arbeitsgemeinschaft in Berlin
vom 26. bis 28. Februar 1942

Archiv der Max-Planck-Gesellschaft, I. Abteilung, Rep. 34, Nr. 105

Figure D.571: Pages from Erich Schumann's February 1942 compendium, *Energiegewinnung aus Uran: Ergebnisse der vom Heereswaffenamt veranlassten Forschungsarbeiten zur Nutzbarmachung von Atomkernenergien*, informing the German government that an atomic bomb can be made with 10–100 kg of fissile material [Archiv der Max-Planck-Gesellschaft, I. Abteilung, Rep. 34, Nr. 105].



- 12 -

(im allgemeinen Wasserstoff) enthält. Beim Zusammenstoß mit diesen Atomen geben die Neutronen ihre Energie ab und werden so abgebremst. Es ist günstig, die Bremssubstanz nicht mit dem Uran zu mischen, sondern die Maschine aus abwechselnden Schichten von Uran und Bremssubstanz aufzubauen; denn dann kommt ein Neutron, das einmal in die Bremssubstanz eingetreten ist, im allgemeinen nicht wieder mit einem Uranatom in Berührung, ehe es seine ursprüngliche Energie abgegeben hat und dadurch für die Spaltung von U_{235} hochwirksam geworden ist.

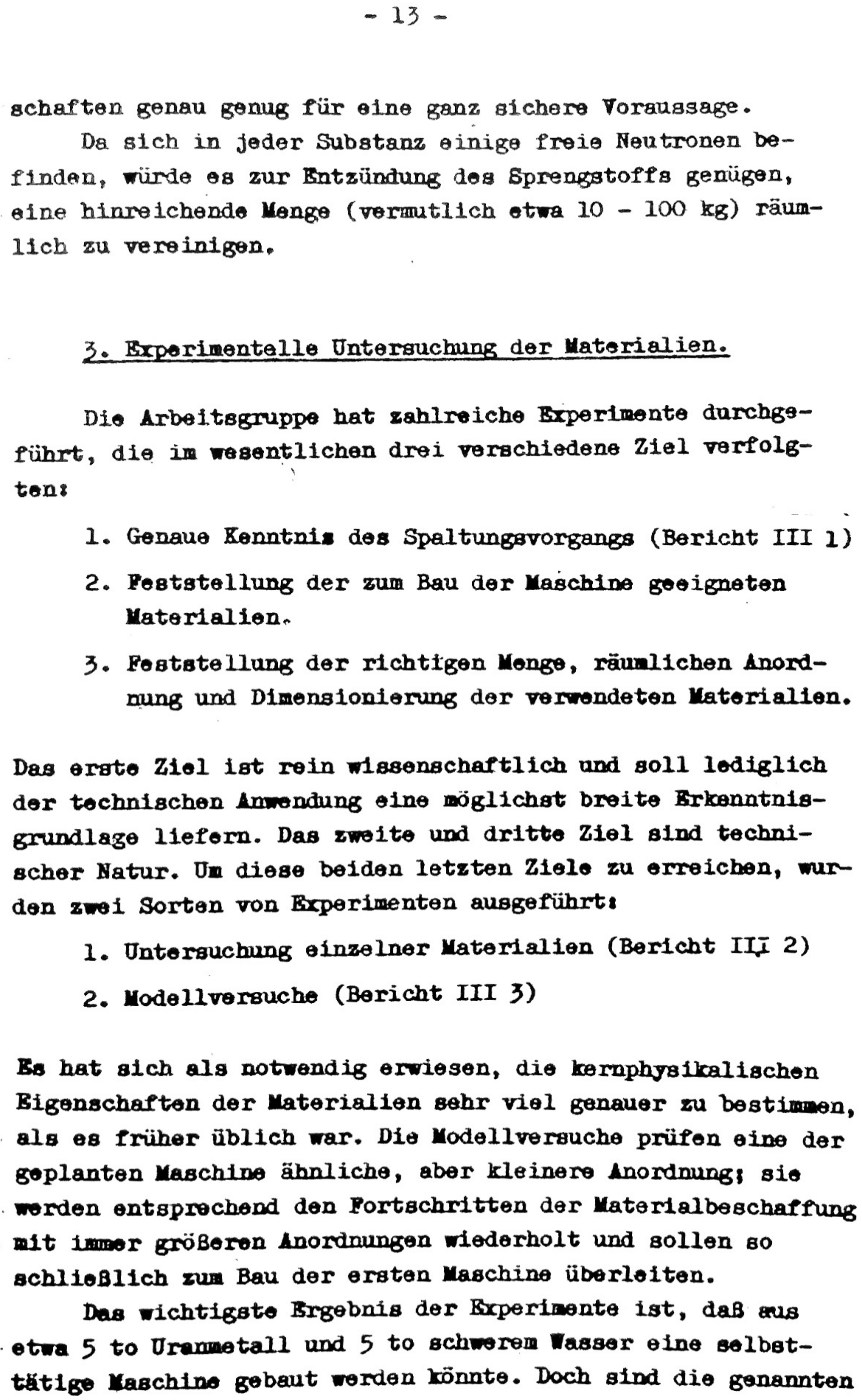
Die Bremssubstanz selbst absorbiert freilich ebenfalls Neutronen. Man muß deshalb möglichst schwach absorbierende Bremssubstanzen wählen. Für eine Maschine mit natürlichem Uran kommt als Bremssubstanz nach unserer heutigen Kenntnis nur schwerer Wasserstoff (Deuterium) in Betracht, der leider nur als sehr geringe Beimengung des gewöhnlichen Wasserstoffs vorkommt und in mühsamen Verfahren abgetrennt werden muß.

Eine völlige Trennung der beiden Uranisotopen voneinander liegt technisch noch in weiter Ferne. Aussichtsreich ist aber eine Anreicherung von U_{235} etwa auf das Doppelte der ursprünglichen Menge. Dadurch würde der störende Einfluß des U_{238} vermindert; man würde kleinere Maschinen bauen und vermutlich gewöhnlichen Wasserstoff als Bremssubstanz verwenden können.

<u>b. Sprengstoff.</u> Die störende Wirkung von U_{238} nimmt mit wachsender Temperatur zu. Ein Sprengstoff würde daher höchste sehr kleine Mengen von U_{238} enthalten dürfen. Außer der vollständigen Isotopentrennung, die grundsätzlich sicher durchführbar, aber technisch sehr schwierig ist, kennen wir heute theoretisch einen zweiten Weg zur Herstellung eines Sprengstoffs, der aber erst erprobt werden kann, wenn eine Wärmemaschine läuft. Aus U_{238} bildet sich nämlich durch die Absorption von Neutronen ein Stoff ("Element 94"), der noch leichter spaltbar sein muß als U_{235}. Da dieser Stoff chemisch vom Uran verschieden ist, muß man ihn aus dem Uran einer stillgelegten Maschine leicht abtrennen können. Doch kennen wir heute weder die Menge, in der er entsteht, noch seine Eigen-

Archiv der Max-Planck-Gesellschaft, I. Abteilung, Rep. 34, Nr. 105

Figure D.572: Pages from Erich Schumann's February 1942 compendium, *Energiegewinnung aus Uran: Ergebnisse der vom Heereswaffenamt veranlassten Forschungsarbeiten zur Nutzbarmachung von Atomkernenergien*, informing the German government that an atomic bomb can be made with 10–100 kg of fissile material [Archiv der Max-Planck-Gesellschaft, I. Abteilung, Rep. 34, Nr. 105].



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schaften genau genug für eine ganz sichere Voraussage.

Da sich in jeder Substanz einige freie Neutronen befinden, würde es zur Entzündung des Sprengstoffs genügen, eine hinreichende Menge (vermutlich etwa 10 - 100 kg) räumlich zu vereinigen.

3. Experimentelle Untersuchung der Materialien.

Die Arbeitsgruppe hat zahlreiche Experimente durchgeführt, die im wesentlichen drei verschiedene Ziel verfolgten:

1. Genaue Kenntnis des Spaltungsvorgangs (Bericht III 1)
2. Feststellung der zum Bau der Maschine geeigneten Materialien.
3. Feststellung der richtigen Menge, räumlichen Anordnung und Dimensionierung der verwendeten Materialien.

Das erste Ziel ist rein wissenschaftlich und soll lediglich der technischen Anwendung eine möglichst breite Erkenntnisgrundlage liefern. Das zweite und dritte Ziel sind technischer Natur. Um diese beiden letzten Ziele zu erreichen, wurden zwei Sorten von Experimenten ausgeführt:

1. Untersuchung einzelner Materialien (Bericht III 2)
2. Modellversuche (Bericht III 3)

Es hat sich als notwendig erwiesen, die kernphysikalischen Eigenschaften der Materialien sehr viel genauer zu bestimmen, als es früher üblich war. Die Modellversuche prüfen eine der geplanten Maschine ähnliche, aber kleinere Anordnung; sie werden entsprechend den Fortschritten der Materialbeschaffung mit immer größeren Anordnungen wiederholt und sollen so schließlich zum Bau der ersten Maschine überleiten.

Das wichtigste Ergebnis der Experimente ist, daß aus etwa 5 to Uranmetall und 5 to schwerem Wasser eine selbsttätige Maschine gebaut werden könnte. Doch sind die genannten

Archiv der Max-Planck-Gesellschaft, I. Abteilung, Rep. 34, Nr. 105

Figure D.573: Pages from Erich Schumann's February 1942 compendium, *Energiegewinnung aus Uran: Ergebnisse der vom Heereswaffenamt veranlassten Forschungsarbeiten zur Nutzbarmachung von Atomkernenergien*, informing the German government that an atomic bomb can be made with 10–100 kg of fissile material [Archiv der Max-Planck-Gesellschaft, I. Abteilung, Rep. 34, Nr. 105].

Erich Schumann and Gerd Hinrichs. March 1943. HEC 2590. *On the Increase of the Effect of Hollow Explosive Slabs Caused by Control of Ignition (Lenses).* English translation. U.K. Imperial War Museum, Duxford Archive. For photos of some pages, see pp. 4212–4217.

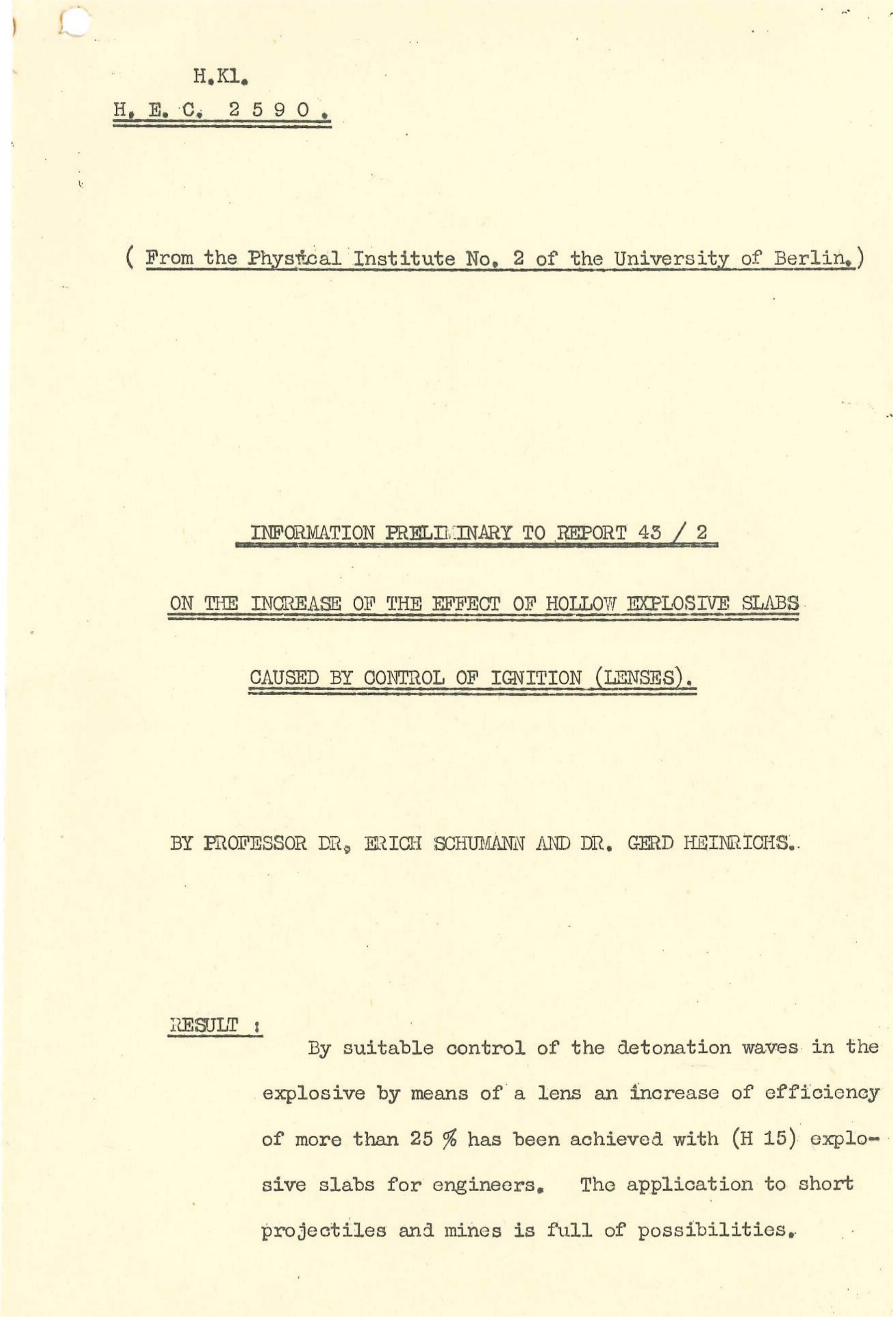
By suitable control of the detonation waves in the explosive by means of a lens an increase of efficiency of more than 25% has been achieved with (H 15) explosive slabs for engineers. The application to short projectiles and mines is full of possibilities.

Extensive experiments on explosions have shown in the course of the last year that the effect of the hollow explosive slab can be substantially increased, especially in the case of a hemispherical hollow space, by suitable control of the detonation wave. This shaping of the detonation wave, also called ignition control, makes it possible to influence within certain limits the shaping of the covering material. the most successful means of assisting this is the "lens".

Erich Schumann. 1943. HEC 5919. *The Scientific Basis of the Hollow Charge Effect.* English translation. U.K. Imperial War Museum, Duxford Archive. For photos of some pages, see pp. 4218–4219.

In the g. Kdos. 229/41 Wa F (most secret document) such ignition guides, made of explosives of suitable detonation velocity and interlaid as lens shaped bodies between the ignition point and the hollow space were suggested by myself. [...]

I predicted the possibility of such an effect at the conference of the Academy of Aeronautical Research on 25.10.40[....]



H.Kl.
H. E. C. 2 5 9 0 .

(From the Physical Institute No. 2 of the University of Berlin.)

INFORMATION PRELIMINARY TO REPORT 43 / 2

ON THE INCREASE OF THE EFFECT OF HOLLOW EXPLOSIVE SLABS

CAUSED BY CONTROL OF IGNITION (LENSES).

BY PROFESSOR DR. ERICH SCHUMANN AND DR. GERD HEINRICHS.

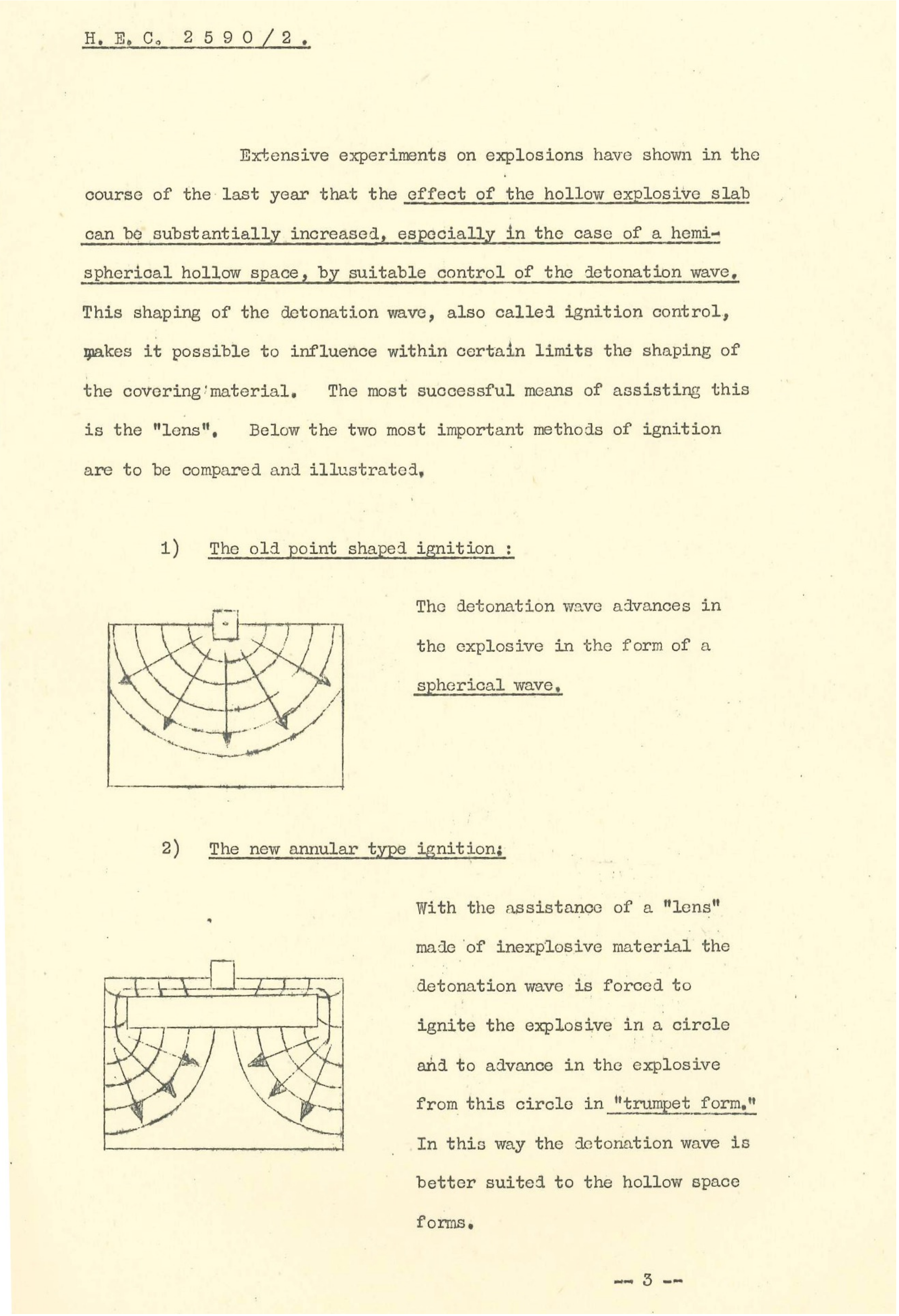
RESULT :

By suitable control of the detonation waves in the explosive by means of a lens an increase of efficiency of more than 25 % has been achieved with (H 15) explosive slabs for engineers. The application to short projectiles and mines is full of possibilities.

HEC 2590 (English translation). Erich Schumann and Gerd Hinrichs. March 1943.
Report on tests of explosive lenses. Imperial War Museum, Duxford Archive.

Figure D.574: Excerpts from a March 1943 report by Erich Schumann and Gerd Hinrichs showing the design and successful experimental demonstration of explosive lenses [HEC 2590, English translation, U.K. Imperial War Museum, Duxford Archive].

HEC 2590 (English translation). Erich Schumann and Gerd Hinrichs. March 1943. Report on tests of explosive lenses. Imperial War Museum, Duxford Archive.



H. E. C. 2590/2.

Extensive experiments on explosions have shown in the course of the last year that the effect of the hollow explosive slab can be substantially increased, especially in the case of a hemispherical hollow space, by suitable control of the detonation wave. This shaping of the detonation wave, also called ignition control, makes it possible to influence within certain limits the shaping of the covering material. The most successful means of assisting this is the "lens". Below the two most important methods of ignition are to be compared and illustrated.

1) The old point shaped ignition :

The detonation wave advances in the explosive in the form of a spherical wave.

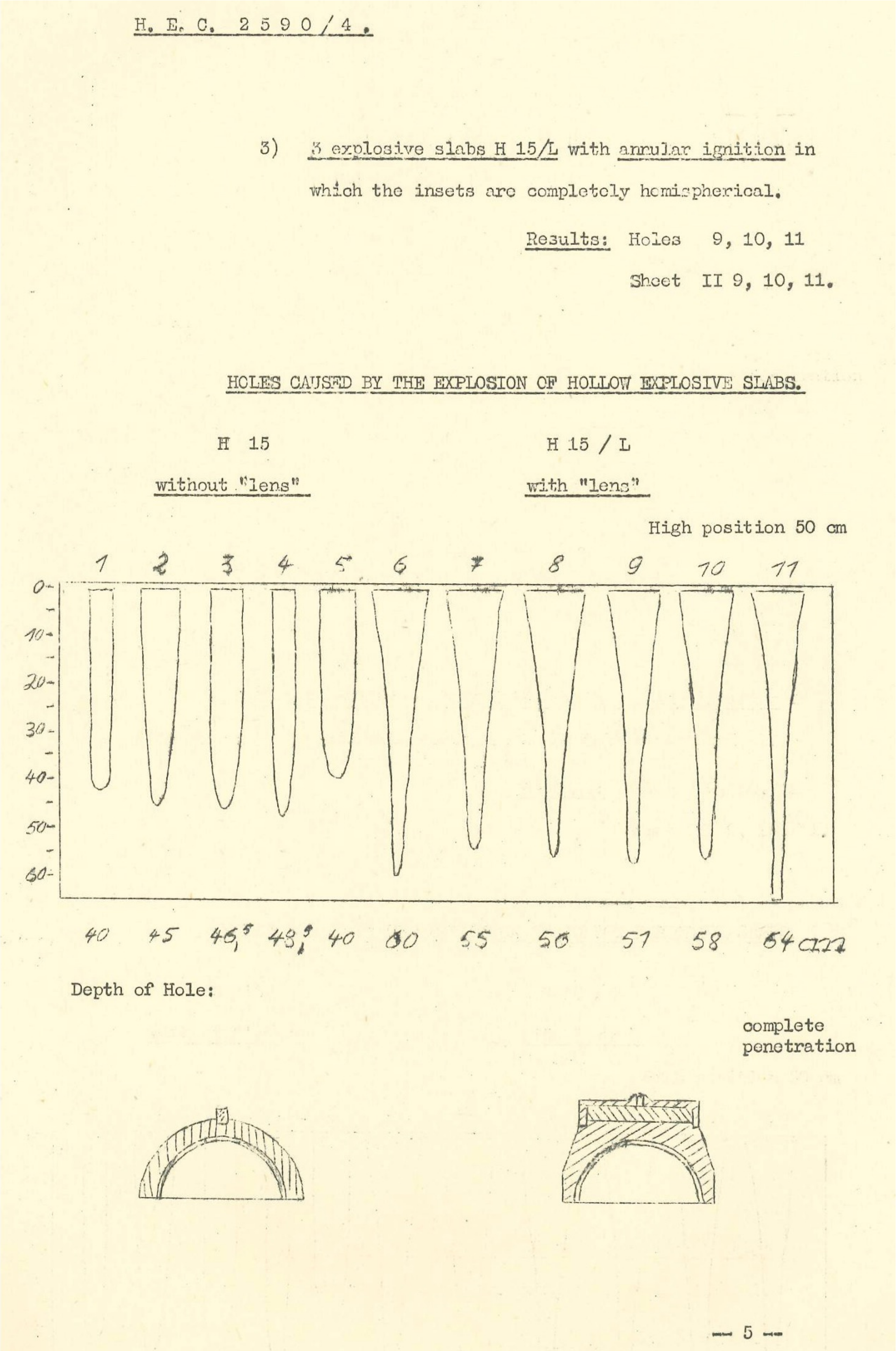
2) The new annular type ignition:

With the assistance of a "lens" made of inexplosive material the detonation wave is forced to ignite the explosive in a circle and to advance in the explosive from this circle in "trumpet form." In this way the detonation wave is better suited to the hollow space forms.

-- 3 --

Figure D.575: Excerpts from a March 1943 report by Erich Schumann and Gerd Hinrichs showing the design and successful experimental demonstration of explosive lenses [HEC 2590, English translation, U.K. Imperial War Museum, Duxford Archive].

HEC 2590 (English translation). Erich Schumann and Gerd Hinrichs. March 1943.
Report on tests of explosive lenses. Imperial War Museum, Duxford Archive.



H. E. C. 2590/4.

3) 3 explosive slabs H 15/L with annular ignition in which the insets are completely hemispherical.

Results: Holes 9, 10, 11
Sheet II 9, 10, 11.

HOLES CAUSED BY THE EXPLOSION OF HOLLOW EXPLOSIVE SLABS.

H 15 without "lens"	H 15 / L with "lens"

High position 50 cm

1	2	3	4	5	6	7	8	9	10	11
40	45	46,5	48,5	40	60	55	56	57	58	64 cm

Depth of Hole:

complete penetration

— 5 —

Figure D.576: Excerpts from a March 1943 report by Erich Schumann and Gerd Hinrichs showing the design and successful experimental demonstration of explosive lenses [HEC 2590, English translation, U.K. Imperial War Museum, Duxford Archive].

HEC 2590 (English translation). Erich Schumann and Gerd Hinrichs. March 1943. Report on tests of explosive lenses. Imperial War Museum, Duxford Archive.

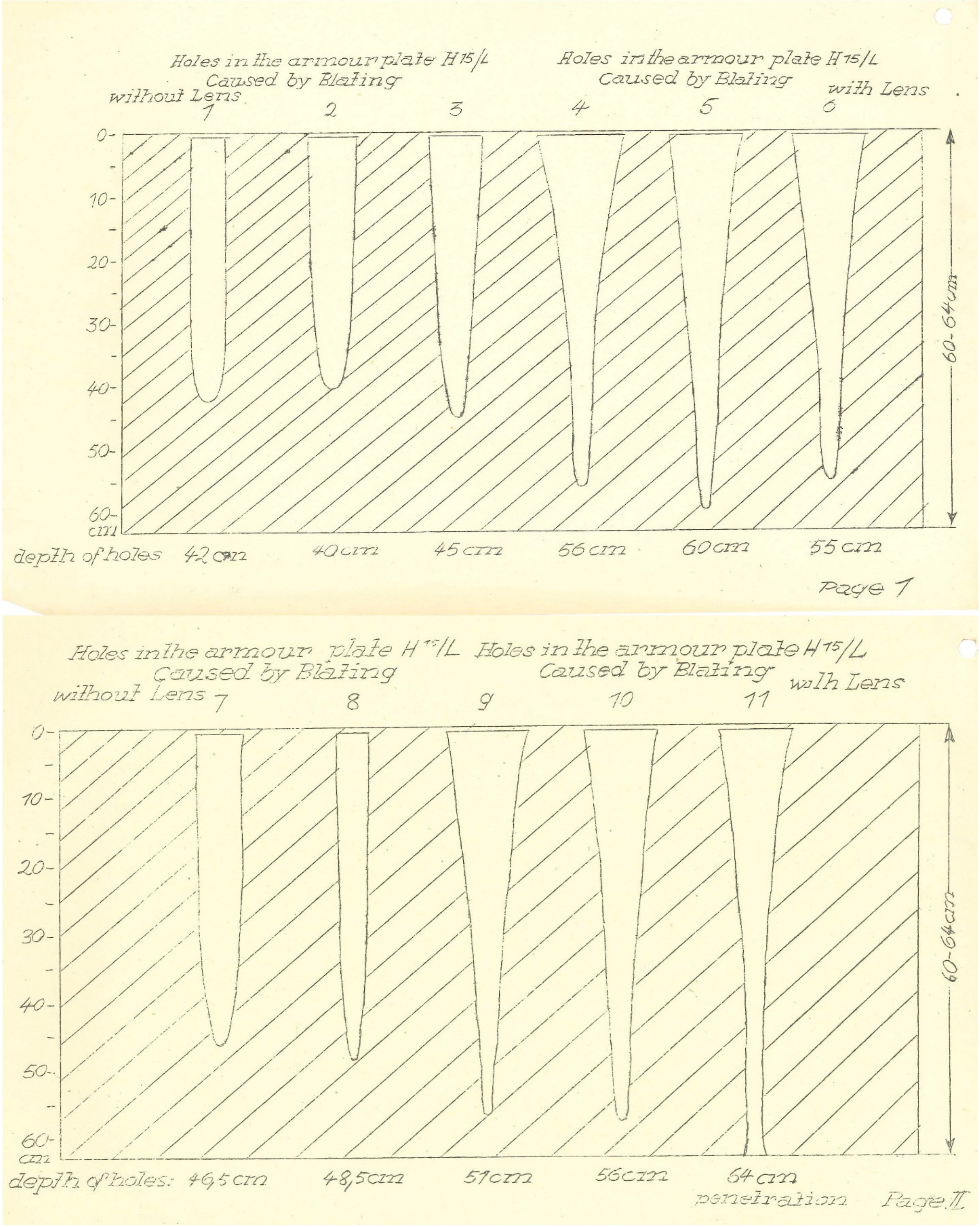


Figure D.577: Excerpts from a March 1943 report by Erich Schumann and Gerd Hinrichs showing the design and successful experimental demonstration of explosive lenses [HEC 2590, English translation, U.K. Imperial War Museum, Duxford Archive].

HEC 2590 (English translation). Erich Schumann and Gerd Hinrichs. March 1943. Report on tests of explosive lenses. Imperial War Museum, Duxford Archive.

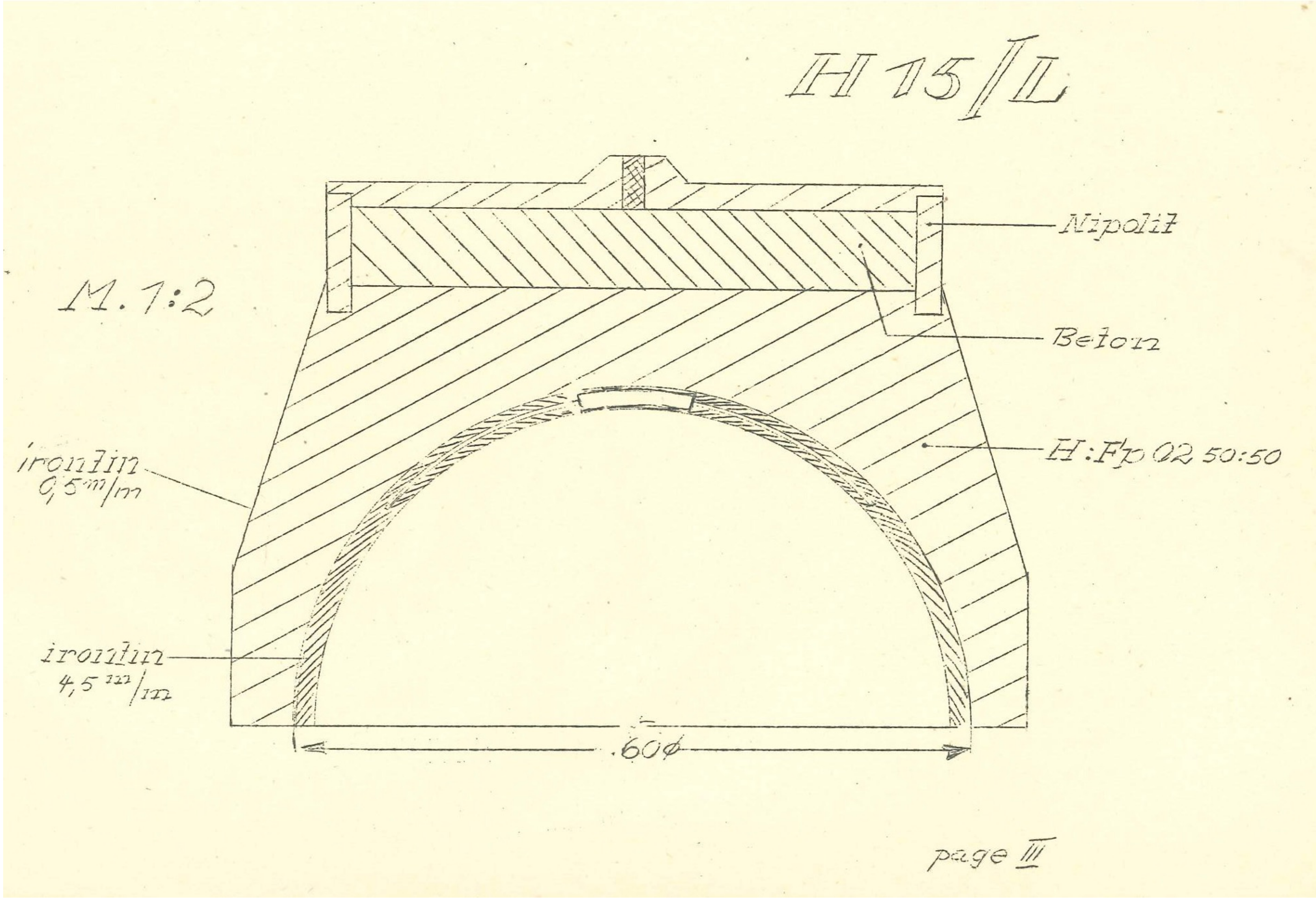


Figure D.578: Excerpts from a March 1943 report by Erich Schumann and Gerd Hinrichs showing the design and successful experimental demonstration of explosive lenses [HEC 2590, English translation, U.K. Imperial War Museum, Duxford Archive].

HEC 2590 (English translation). Erich Schumann and Gerd Hinrichs. March 1943.
Report on tests of explosive lenses. Imperial War Museum, Duxford Archive.

Abb. S 1: Versuchsaufbau des Körpers H 15/I.

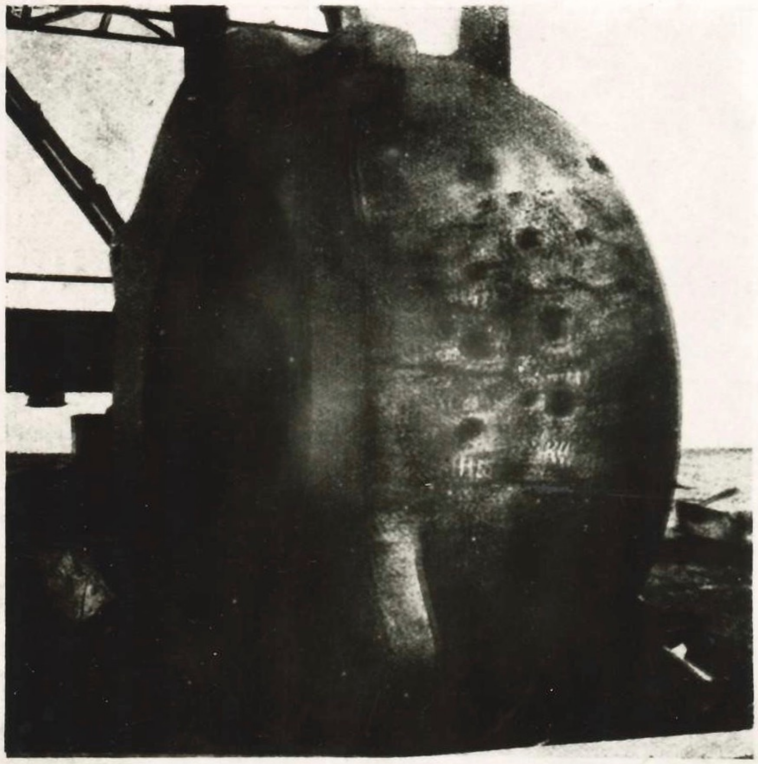
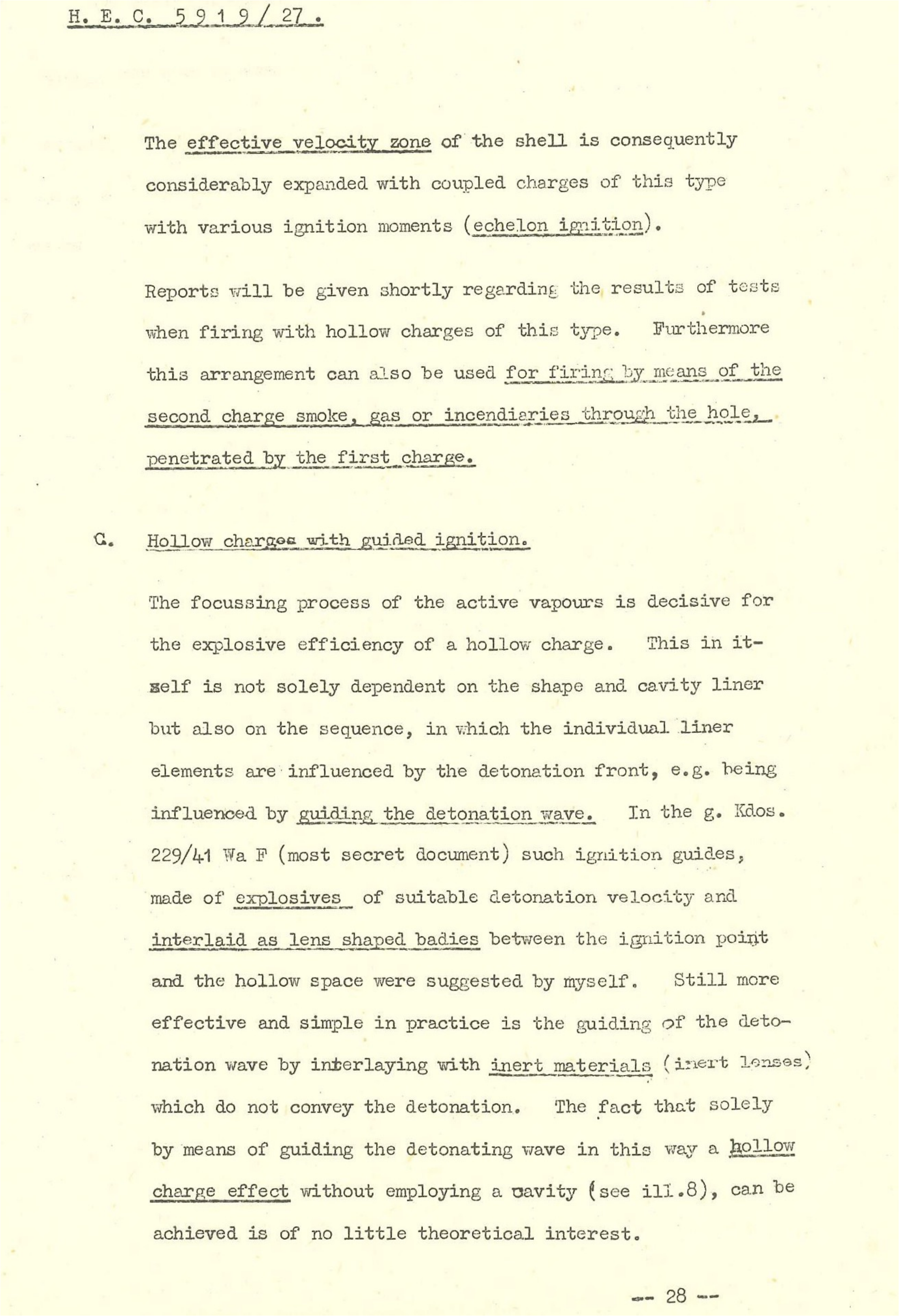


Abb. S 2: Kuppel mit Sprenglöchern der Sprengkörper H 15 u. H 15/I.

Figure D.579: Excerpts from a March 1943 report by Erich Schumann and Gerd Hinrichs showing the design and successful experimental demonstration of explosive lenses [HEC 2590, English translation, U.K. Imperial War Museum, Duxford Archive].



H. E. C. 5919/27.

The effective velocity zone of the shell is consequently considerably expanded with coupled charges of this type with various ignition moments (echelon ignition).

Reports will be given shortly regarding the results of tests when firing with hollow charges of this type. Furthermore this arrangement can also be used for firing by means of the second charge smoke, gas or incendiaries through the hole, penetrated by the first charge.

C. Hollow charges with guided ignition.

The focussing process of the active vapours is decisive for the explosive efficiency of a hollow charge. This in itself is not solely dependent on the shape and cavity liner but also on the sequence, in which the individual liner elements are influenced by the detonation front, e.g. being influenced by guiding the detonation wave. In the g. Kdos. 229/41 Wa F (most secret document) such ignition guides, made of explosives of suitable detonation velocity and interlaid as lens shaped badies between the ignition point and the hollow space were suggested by myself. Still more effective and simple in practice is the guiding of the detonation wave by interlaying with inert materials (inert lenses) which do not convey the detonation. The fact that solely by means of guiding the detonating wave in this way a hollow charge effect without employing a cavity (see ill.8), can be achieved is of no little theoretical interest.

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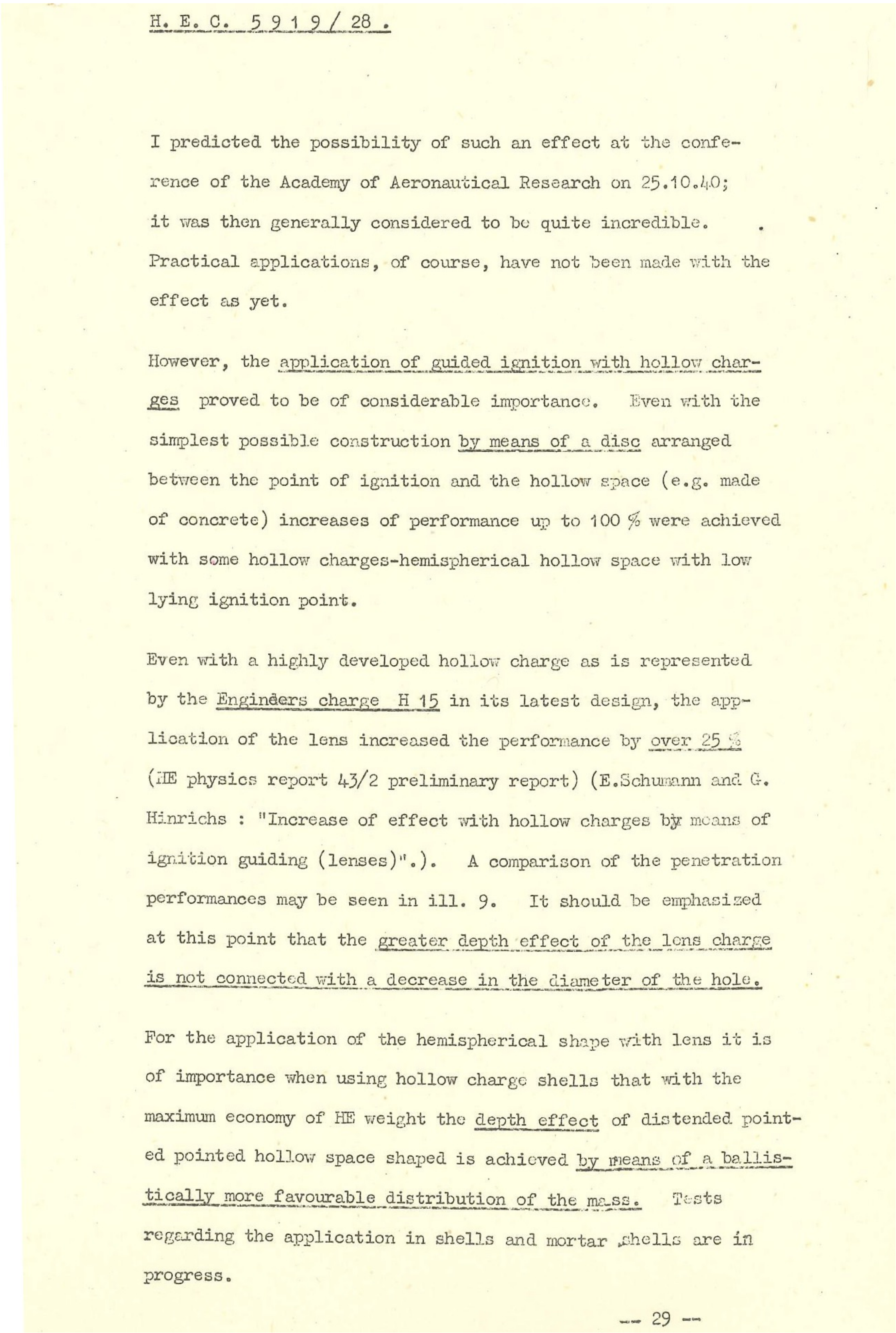
HEC 5919 (English translation). Erich Schumann. 1943.

Cites other reports on explosive lenses. Imperial War Museum, Duxford Archive.

Figure D.580: Excerpts from a 1943 report by Erich Schumann, citing his other reports on explosive lenses going back to 1940 [HEC 5919, English translation, U.K. Imperial War Museum, Duxford Archive].



H. E. C. 5919 / 28 .

I predicted the possibility of such an effect at the conference of the Academy of Aeronautical Research on 25.10.40; it was then generally considered to be quite incredible. Practical applications, of course, have not been made with the effect as yet.

However, the application of guided ignition with hollow charges proved to be of considerable importance. Even with the simplest possible construction by means of a disc arranged between the point of ignition and the hollow space (e.g. made of concrete) increases of performance up to 100 % were achieved with some hollow charges-hemispherical hollow space with low lying ignition point.

Even with a highly developed hollow charge as is represented by the Engineers charge H 15 in its latest design, the application of the lens increased the performance by over 25 % (HE physics report 43/2 preliminary report) (E.Schumann and G. Hinrichs : "Increase of effect with hollow charges by means of ignition guiding (lenses)".). A comparison of the penetration performances may be seen in ill. 9. It should be emphasized at this point that the greater depth effect of the lens charge is not connected with a decrease in the diameter of the hole.

For the application of the hemispherical shape with lens it is of importance when using hollow charge shells that with the maximum economy of HE weight the depth effect of distended pointed pointed hollow space shaped is achieved by means of a ballistically more favourable distribution of the mass. Tests regarding the application in shells and mortar shells are in progress.

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HEC 5919 (English translation). Erich Schumann. 1943.
Cites other reports on explosive lenses. Imperial War Museum, Duxford Archive.

Figure D.581: Excerpts from a 1943 report by Erich Schumann, citing his other reports on explosive lenses going back to 1940 [HEC 5919, English translation, U.K. Imperial War Museum, Duxford Archive].

G-303. Walter Herrmann, Georg Hartwig, Heinz Rackwitz, Walter Trinks, and H. Schaub. 1944. ***Versuche über die Einleitung von Kernreaktionen durch die Wirkung explodierender Stoffe.*** **[*Experiments on Initiation of Nuclear Reactions by Explosives.*]**
Deutsches Museum number FA 002/0721.
https://digital.deutsches-museum.de/item/FA-002-721/

[See document photos on pp. 4222–4224. This report describes one of the long series of Schumann-Trinks implosion experiments. This particular experiment was a simple test using fusion fuel but no fission fuel. The report showed both from experimental measurements and from theoretical calculations that implosion by chemical explosives had far too little energy to produce significant pure fusion reactions. Thus in other documents when members of the Schumann-Trinks group discussed "atomic bombs" that used implosion, they clearly knew that fission fuel was an essential component of such bombs: either fission fuel only, or a combination of fission and fusion fuel. Where are all the other reports on all the other experiments by the Schumann-Trinks group throughout the entire war?]

1) Es wurde des öfteren vorgeschlagen, zur Einleitung von Kern- und Kettenreaktionen die Schwadengeschwindigkeit bei der Explosion von Sprengstoffen zu benutzen. Es sollten dabei die entstehenden Kernprozesse die Wirkung von Explosionsstoffen erhöhen. Obwohl dieser Weg nach einfachen Ueberlegungen ungangbar scheint, wurden, um endlich eine experimentell begründete Aussage darüber geben zu können, auf Anregung von Herrn Prof. Gerlach in der Heeresforschungsstelle Kdf. einige orientierende Versuche durchgeführt.

2) Durchführung der Versuche:
In zylindrische Sprengkörper aus Trinitrotoluol (12 cm Ø, 10 cm Höhe); (5,0 cm Ø, 8 cm Höhe) wurden in der Mitte der Grundfläche kleine Kegel (1,5 cm Ø, 3,0 cm Höhe) aus Deutero-Paraffin eingesetzt. Die im Sprengstoff laufenden Druckwellen sollten die D-Atome des Deutero-Paraffins beschleunigen und durch zusammenstossende D-Atome Neutronen erzeugen. Zum Nachweis dieser D-D-Reaktion wurde unter dem Paraffinkegel ein Silber-Indikator vorgesehen, dessen Aktivität, durch die Neutronen der D-D-Reaktion angeregt, gemessen werden sollte. Die Aktivitätsmessungen wurden mit β-Zählrohr, Verstärker und Zählwerk ausgeführt.

1) It has often been proposed to use the gas velocity during the explosion of explosives to initiate nuclear and chain reactions. The resulting nuclear processes should increase the effect of explosives. Although this approach seems unfeasible on the basis of simple considerations, in order to finally be able to make an experimentally substantiated statement about it, a number of preliminary tests were carried out at the Army Research Center Kummersdorf at the suggestion of Prof. Gerlach.

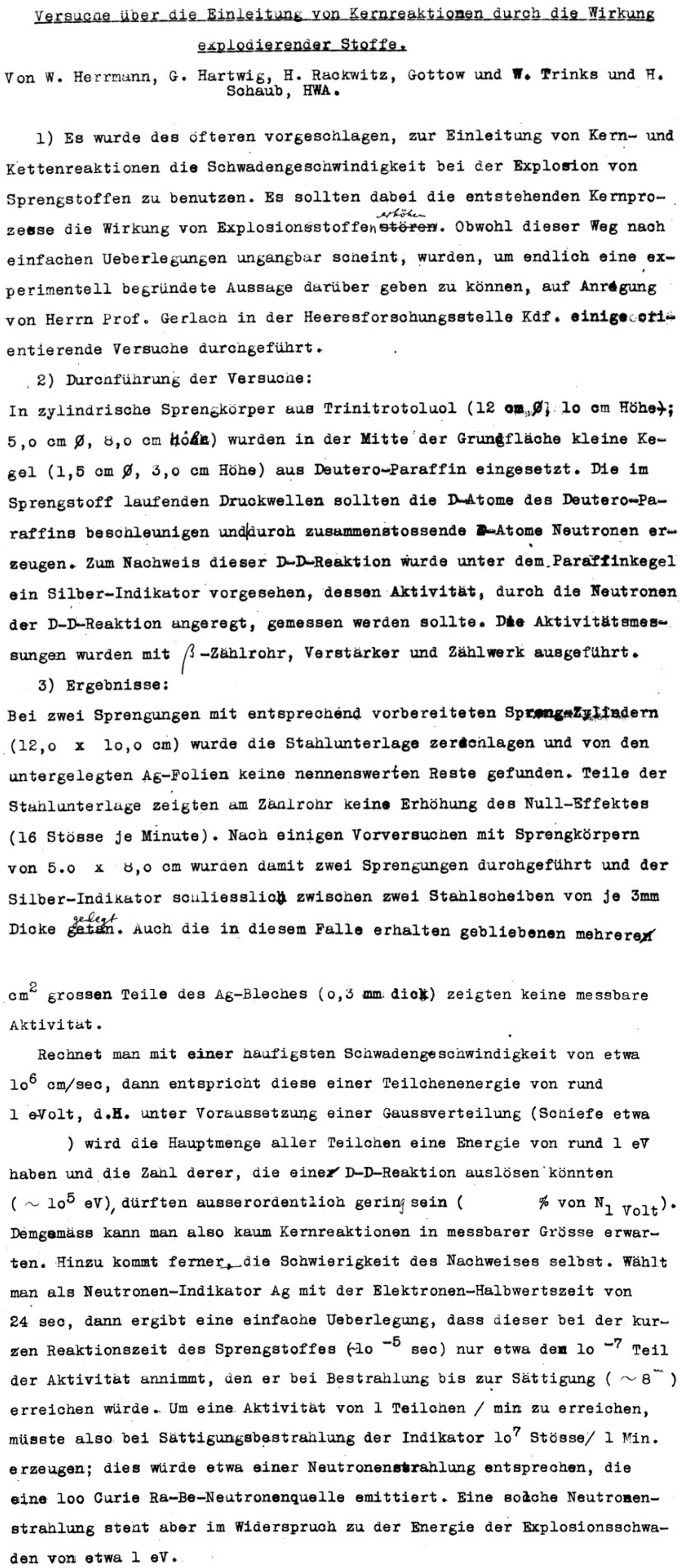
2) Performance of the experiments:
Small cones (1.5 cm Ø, 3.0 cm high) of deutero-paraffin were placed in the center of the base of cylindrical explosives made of trinitrotoluene (12 cm Ø, 10 cm high); (5.0 cm Ø, 8 cm high). The pressure waves in the explosive were intended to accelerate the D atoms of the deutero-paraffin and generate neutrons by colliding D atoms. To detect this D-D reaction, a silver indicator was placed under the paraffin cone, the radioactivity of which was to be measured after stimulation by the neutrons of the D-D reaction. The radioactivity measurements were carried out using a β detection tube, amplifier, and counter.

3) Ergebnisse:
Bei zwei Sprengungen mit entsprechend vorbereiteten Spreng-Zylindern (12,0 x 10,0 cm) wurde die Stahlunterlage zerechlagen und von den untergelegten Ag-Folien keine nennenswerten Reste gefunden. Teile der Stahlunterlage zeigten am Zählrohr keine Erhöhung des Null-Effektes (16 Stösse je Minute). Nach einigen Vorversuchen mit Sprengkörpern von 5,0 x 8,0 cm wurden damit zwei Sprengungen durchgeführt und der Silber-Indikator schliesslich zwischen zwei Stahlscheiben von je 3mm Dicke gelegt. Auch die in diesem Falle erhalten gebliebenen mehrere cm^2 grossen Teile des Ag-Bleches (0,3 mm dick) zeigten keine messbare Aktivität.

Rechnet man mit einer häufigsten Schwadengeschwindigkeit von etwa 10^6 cm/sec, dann entspricht diese einer Teilchenenergie von rund 1 e-Volt, d.H. unter Voraussetzung einer Gaussverteilung (Schiefe etwa ___) wird die Hauptmenge aller Teilchen eine Energie von rund 1 eV haben und die Zahl deren, die eine D-D-Reaktion auslösen könnten ($\sim 10^5$ eV), dürften ausserordentlich gering sein (___% von $N_{1\text{ Volt}}$). Demgemäss kann man also kaum Kernreaktionen in messbarer Grösse erwarten. Hinzu kommt ferner, die Schwierigkeit des Nachweises selbst. Wählt man als Neutronen-Indikator Ag mit der Elektronen-Halbwertszeit von 24 sec, dann ergibt eine einfache Ueberlegung, dass dieser bei der kurzen Reaktionszeit des Sprengstoffes ($\sim 10^{-5}$ sec) nur etwa den 10^{-7} Teil der Aktivität annimmt, den er bei Bestrahlung bis zur Sättigung (~ 8) erreichen würde. Um eine Aktivität von 1 Teilchen/min zu erreichen, müsste also bei Sättigungsbestrahlung der Indikator 10^7 Stösse/1 Min. erzeugen; dies würde etwa einer Neutronenstrahlung entsprechen, die eine 100 Curie Ra-Be-Neutronenquelle emittiert. Eine solche Neutronenstrahlung steht aber im Widerspruch zu der Energie der Explosionsschwaden von etwa 1 eV.

3) Results:
In two blasts with appropriately prepared blasting cylinders (12.0 x 10.0 cm), the steel base was crushed and no significant remains of the Ag foils placed underneath were found. Parts of the steel base showed no increase over the background level (16 counts per minute) on the detection tube. After some preliminary tests with detonators measuring 5.0 x 8.0 cm, two detonations were carried out and the silver indicator was finally placed between two steel disks, each 3 mm thick. Even the parts of the Ag sheet (0.3 mm thick) measuring several cm^2 that remained in this case showed no measurable activity.

If one assumes a most probable gas velocity of about 10^6 cm/sec, then this corresponds to a particle energy of about 1 electron-volt, i.e. assuming a Gaussian distribution (deviation about ___); the bulk of all particles will have an energy of about 1 eV and the number of those that could trigger a D-D reaction ($\sim 10^5$ eV) is likely to be extremely small (___% von $N_{1\text{ Volt}}$). Accordingly, one can hardly expect nuclear reactions of a measurable amount. In addition, there is the difficulty of the detection itself. If silver with a beta half-life of 24 seconds is chosen as the neutron indicator, then a simple consideration shows that with the short reaction time of the explosive ($\sim 10^{-5}$ seconds) it only attains about 10^{-7} parts of the activity that it would achieve if irradiated to saturation (~ 8). In order to achieve an activity of 1 particle/min, the indicator would therefore have to generate 10^7 counts/1 min at saturation irradiation; this would correspond approximately to neutron radiation emitted by a 100 Curie Ra-Be neutron source. However, such neutron radiation is in contradiction to the energy of the explosion gases of about 1 eV.



Versuche über die Einleitung von Kernreaktionen durch die Wirkung explodierender Stoffe.

Von W. Herrmann, G. Hartwig, H. Rackwitz, Gottow und W. Trinks und H. Schaub, HWA.

1) Es wurde des öfteren vorgeschlagen, zur Einleitung von Kern- und Kettenreaktionen die Schwadengeschwindigkeit bei der Explosion von Sprengstoffen zu benutzen. Es sollten dabei die entstehenden Kernprozesse die Wirkung von Explosionsstoffen ~~stören~~ erhöhen. Obwohl dieser Weg nach einfachen Ueberlegungen ungangbar scheint, wurden, um endlich eine experimentell begründete Aussage darüber geben zu können, auf Anregung von Herrn Prof. Gerlach in der Heeresforschungsstelle Kdf. einige orientierende Versuche durchgeführt.

2) Durchführung der Versuche:

In zylindrische Sprengkörper aus Trinitrotoluol (12 cm Ø, lo cm Höhe; 5,o cm Ø, 8,o cm Höhe) wurden in der Mitte der Grundfläche kleine Kegel (1,5 cm Ø, 3,o cm Höhe) aus Deutero-Paraffin eingesetzt. Die im Sprengstoff laufenden Druckwellen sollten die D-Atome des Deutero-Paraffins beschleunigen und durch zusammenstossende D-Atome Neutronen erzeugen. Zum Nachweis dieser D-D-Reaktion wurde unter dem Paraffinkegel ein Silber-Indikator vorgesehen, dessen Aktivität, durch die Neutronen der D-D-Reaktion angeregt, gemessen werden sollte. Die Aktivitätsmessungen wurden mit β-Zählrohr, Verstärker und Zählwerk ausgeführt.

3) Ergebnisse:

Bei zwei Sprengungen mit entsprechend vorbereiteten Sprengzylindern (12,o x lo,o cm) wurde die Stahlunterlage zerschlagen und von den untergelegten Ag-Folien keine nennenswerten Reste gefunden. Teile der Stahlunterlage zeigten am Zählrohr keine Erhöhung des Null-Effektes (16 Stösse je Minute). Nach einigen Vorversuchen mit Sprengkörpern von 5.o x 8,o cm wurden damit zwei Sprengungen durchgeführt und der Silber-Indikator schliesslich zwischen zwei Stahlscheiben von je 3mm Dicke ~~getan~~ gelegt. Auch die in diesem Falle erhalten gebliebenen mehrere cm^2 grossen Teile des Ag-Bleches (o,3 mm dick) zeigten keine messbare Aktivität.

Rechnet man mit einer häufigsten Schwadengeschwindigkeit von etwa lo^6 cm/sec, dann entspricht diese einer Teilchenenergie von rund 1 eVolt, d.h. unter Voraussetzung einer Gaussverteilung (Schiefe etwa) wird die Hauptmenge aller Teilchen eine Energie von rund 1 eV haben und die Zahl derer, die eine D-D-Reaktion auslösen könnten ($\sim$ lo^5 eV), dürften ausserordentlich gering sein (% von $N_{1\ \mathrm{Volt}}$). Demgemäss kann man also kaum Kernreaktionen in messbarer Grösse erwarten. Hinzu kommt ferner die Schwierigkeit des Nachweises selbst. Wählt man als Neutronen-Indikator Ag mit der Elektronen-Halbwertszeit von 24 sec, dann ergibt eine einfache Ueberlegung, dass dieser bei der kurzen Reaktionszeit des Sprengstoffes (lo^{-5} sec) nur etwa dem lo^{-7} Teil der Aktivität annimmt, den er bei Bestrahlung bis zur Sättigung ($\sim$ 8^{-}) erreichen würde. Um eine Aktivität von 1 Teilchen / min zu erreichen, müsste also bei Sättigungsbestrahlung der Indikator lo^7 Stösse/ 1 Min. erzeugen; dies würde etwa einer Neutronenstrahlung entsprechen, die eine loo Curie Ra-Be-Neutronenquelle emittiert. Eine solche Neutronenstrahlung steht aber im Widerspruch zu der Energie der Explosionsschwaden von etwa 1 eV.

Figure D.582: G-303. Walter Herrmann, Georg Hartwig, Heinz Rackwitz, Walter Trinks, and H. Schaub. 1944. *Versuche über die Einleitung von Kernreaktionen durch die Wirkung explodierender Stoffe.* Deutsches Museum number FA 002/0721. https://digital.deutsches-museum.de/item/FA-002-721/

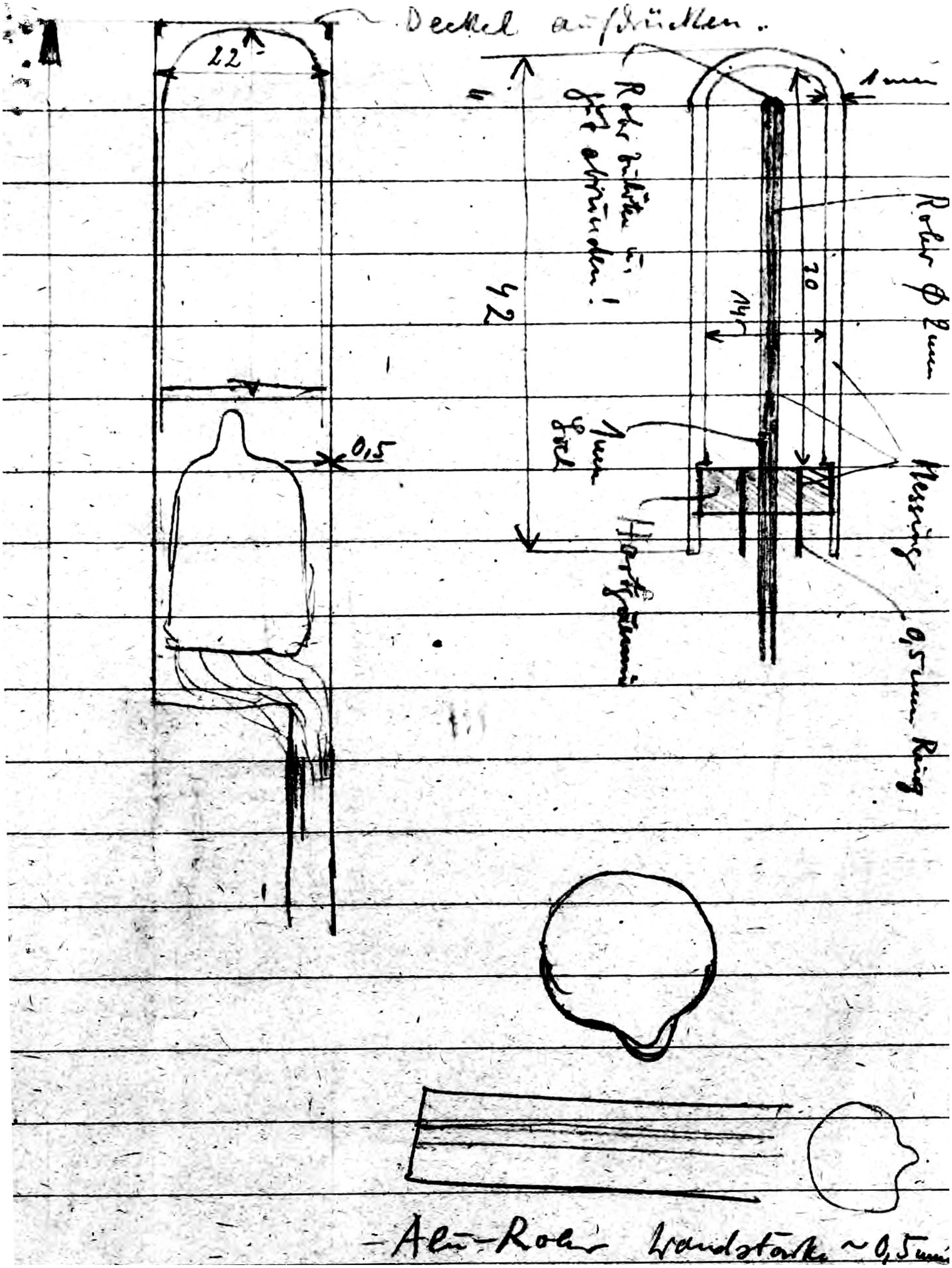
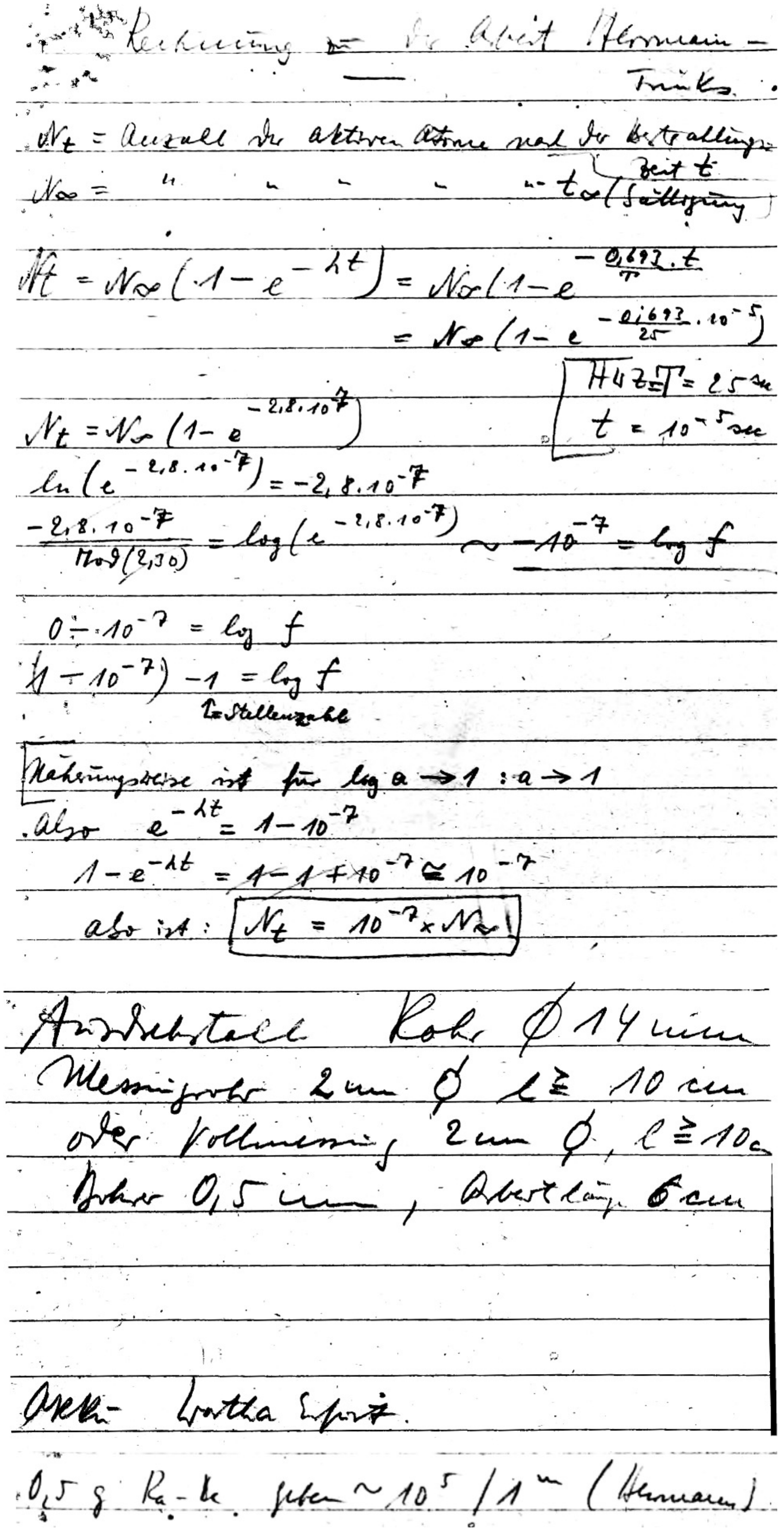


Figure D.583: G-303. Walter Herrmann, Georg Hartwig, Heinz Rackwitz, Walter Trinks, and H. Schaub. 1944. *Versuche über die Einleitung von Kernreaktionen durch die Wirkung explodierender Stoffe.* Deutsches Museum number FA 002/0721. https://digital.deutsches-museum.de/item/FA-002-721/



Rechnung zu der Arbeit Herrmann – Trinks.

N_t = Anzahl der aktiven Atome nach der Bestrahlungszeit t

N_∞ = " " " " " t_∞ (Sättigung)

$$N_t = N_\infty \left(1 - e^{-\lambda t}\right) = N_\infty \left(1 - e^{-\frac{0{,}693}{T} \cdot t}\right)$$

$$= N_\infty \left(1 - e^{-\frac{0{,}693}{25} \cdot 10^{-5}}\right)$$

HWZ = T = 25 sec

$t = 10^{-5}$ sec

$$N_t = N_\infty \left(1 - e^{-2{,}8 \cdot 10^{-7}}\right)$$

$$\ln\left(e^{-2{,}8 \cdot 10^{-7}}\right) = -2{,}8 \cdot 10^{-7}$$

$$\frac{-2{,}8 \cdot 10^{-7}}{\text{Mod}(2{,}30)} = \log\left(e^{-2{,}8 \cdot 10^{-7}}\right) \sim -10^{-7} = \log f$$

$$0 \div 10^{-7} = \log f$$

$$(1 \div 10^{-7}) \underbrace{-1}_{1 = \text{Stellenzahl}} = \log f$$

Näherungsweise ist für $\log a \rightarrow 1 : a \rightarrow 1$

Also $e^{-\lambda t} = 1 - 10^{-7}$

$$1 - e^{-\lambda t} = \cancel{1 - 1} + 10^{-7} \cong 10^{-7}$$

also ist: $\boxed{N_t = 10^{-7} \times N_\infty}$

Aus Edelstahl Rohr ∅ 14 mm

Messingrohr 2 mm ∅ $l \geqq 10$ cm

oder Vollmessing 2 mm ∅, $l \geqq 10$ c

Bohrer 0,5 mm, Arbeitslänge 6 cm

Okti- Wartha Export.

0,5 g Ra-Be geben $\sim 10^5 / 1''$ (Herrmann)

Figure D.584: G-303. Walter Herrmann, Georg Hartwig, Heinz Rackwitz, Walter Trinks, and H. Schaub. 1944. *Versuche über die Einleitung von Kernreaktionen durch die Wirkung explodierender Stoffe.* Deutsches Museum number FA 002/0721. https://digital.deutsches-museum.de/item/FA-002-721/

Erich Schumann. 1949. *Die Wahrheit über die deutschen Arbeiten und Vorschläge zum Atomenergie-Problem (1939–45).* Unpublished manuscript from Schumann estate [courtesy of Rainer Karlsch].

[This manuscript is an unfinished, unpublished attempt by Schumann to describe the parts of the German nuclear program with which he was involved. In its current form, the manuscript is missing many pages, and those that do exist are often simply abbreviated notes for what Schumann intended to write.]

[S. 38] Wenn über die in Deutschland gegen Kriegsende geplanten und vorbereiteten Versuche bisher nichts berichtet worden ist, so hat das seinen Grund darin, das nur wenige Wissenschaftler darüber unterrichtet waren und die Akten im April 1945 vernichtet werden mußten.

[S. 39] Diese Vorschläge, die ich im Herbst 1944 dem Chef des Heereswaffenamts, General d. Art. Leeb, vorlegte, basieren auf gemeinsam mit Trinks angestellten Überlegungen im Anschluss an unsere Arbeiten2) auf dem Gebiet der Sprengstoffphysik.

2) niedergelegt in den Berichten des Reichsforschungsrats (Sprengstoffphysikberichte, herausgegeben vom Bevollmächtigten für Sprengstoffphysik), ferner in den Berichten der Forschungsabteilung des Heereswaffenamts und in etwa 40 Geheimpatentschriften.

[S. 121] Immer wieder, insbesondere in der Presse und von nicht kompetenten Stellen wird behauptet, Hitler habe an die A-Bomb geglaubt, diese sei die unausgesprochene Wunderwaffe in seinen Bluffreden gewesen.

Alle mit der Atomangelegenheit sachlich befassten amtlichen Stellen wissen, dass das nicht der Fall war. Erst Ende 1941 ist Hitler durch den Postminister Dr. Ohnesorge über das Atomenergieproblem unterrichtet worden. [...] Hitler war skeptisch und lehnte ab, noch schärfer als bei seiner Unterrichtung über die Rakete.

[p. 38] If nothing has been reported about the experiments planned and prepared in Germany towards the end of the war, this is due to the fact that only a few scientists were informed and the files had to be destroyed in April 1945.

[p. 39] These proposals, which I submitted to the Chief of the Army Ordnance Office in the fall of 1944, General d. Art. Leeb, presented, are based on considerations shared with Trinks following our work in the field of explosives physics2).

2) set forth in the reports of the Reich Research Council (Explosives Physics Reports, issued by the Explosives Physics Commissioner), in the reports of the Army Ordnance Research Department and in about 40 secret patents.

[p. 121] Again and again, especially in the press and from incompetent sources, it is alleged that Hitler had believed in the A-bomb, which had been the unspoken miracle weapon in his bluffing stories.

All the official bodies concerned with the nuclear issue know that this was not the case. At the end of 1941, Hitler was briefed by the postmaster Ohnesorge about the nuclear energy problem. [...] Hitler was skeptical and rejected it, even more sharply than his briefing on the rocket.

[S. 127] Im übrigen machte sich schon der Einfluss der Waffen-SS geltend, der dahin ging, ein eigenes Waffenamt aufzubauen und es selbstverständlich ablehnte, dass das OKW in irgendeiner Weise hinein zureden vermochte.

[S. 131] Deutschland hat nie reines ^{235}U in nennenswerten Mengen hergestellt; nur Harteck 1943 bis 44 mittels Zentrifuge (Anreicherung). Clusius-Verfahren ging nicht, weil Thermodiffusionskoeffizient negativ war.

[p. 127] Moreover, the influence of the Waffen-SS, which set out to set up its own weapons office and, of course, refused to allow the Army to speak in any way, became apparent.

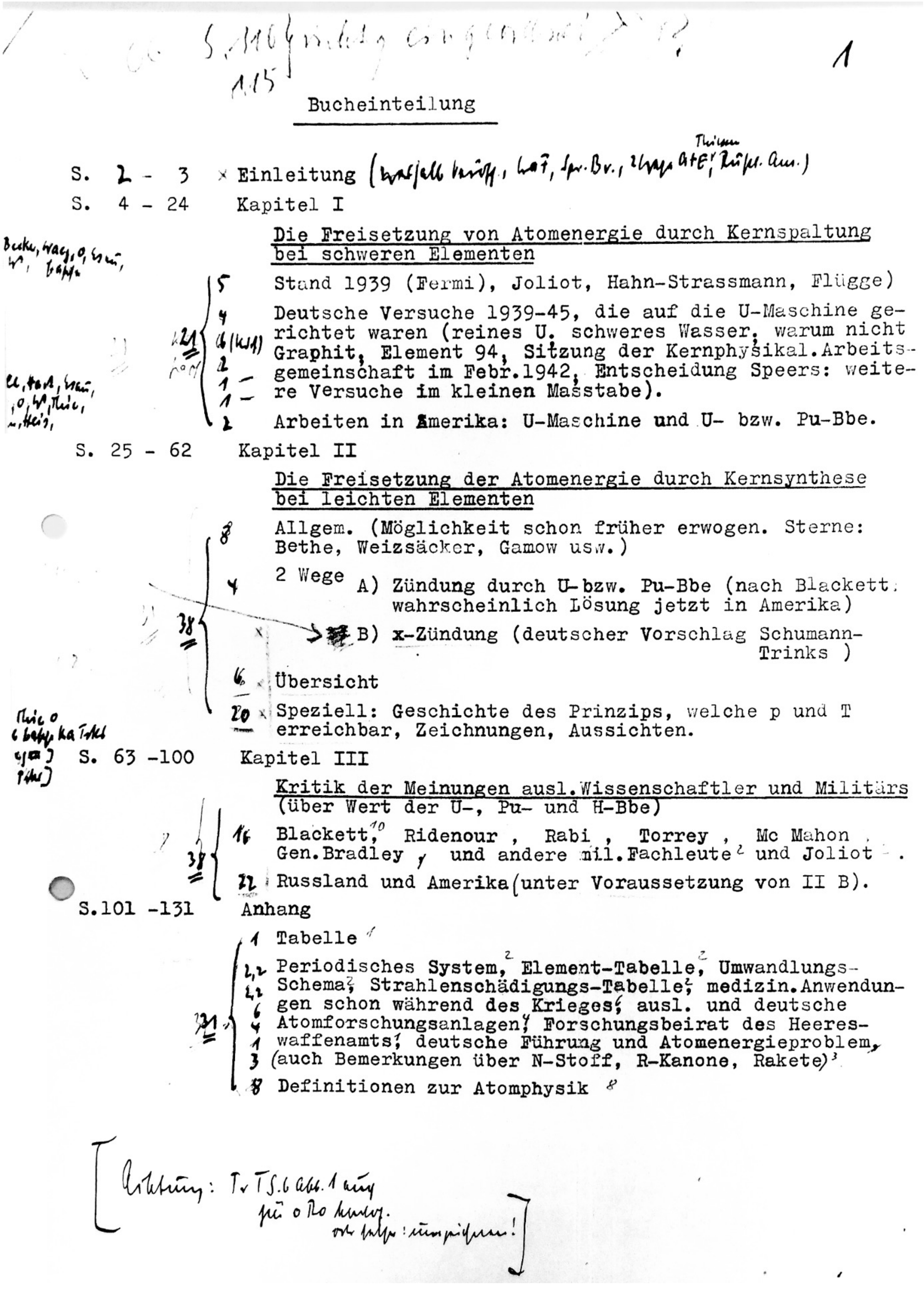
[p. 131] Germany never made pure ^{235}U in appreciable quantities; only Harteck 1943 to 44 by means of centrifuge (enrichment). Clusius method did not work because thermal diffusion coefficient was negative.

[Erich Schumann's implosion systems would have been highly suitable for compressing fission fuel, thus making a complete fission bomb. In this manuscript, Schumann did not describe that; with the highly compartmentalized security of German secret weapons programs, he may not have known much about it. In any event, with postwar Allied interrogations, trials, prison sentences, and executions of Germans who had performed various tasks during the war, Schumann certainly would not have wanted to admit anything that he had known or been involved with.

Schumann stated that he filed "about 40 secret patents" during the war, which presumably covered the material for which he was granted patents in the postwar period. The view that Schumann's postwar papers reflect wartime work is strongly supported by the fact that in August 1945, the U.S. Army Ordnance Technical Intelligence office publicly stated that based on evidence they had collected, Erich Schumann was a "brilliant scientist" who "did much outstanding work" "in the development of atomic bombs"; other U.S. officials then threatened the Ordnance Technical Intelligence office "against making further statements on this subject" (p. 4187). The importance of Schumann's work is supported by Erwin Respondek's 1945 testimony too (p. 4194). The notion that Schumann's postwar papers accurately reflect wartime work is also supported by an April 1947 Russian report that is highly similar to Schumann's work and likely based on some of his wartime papers that were captured by the Russians [Kozyrev 2005].

Schumann confirmed (1) the fact that the SS eclipsed the Army Ordnance in the German nuclear program, (2) the extreme secrecy of the nuclear program during the war, and (3) the destruction of evidence at the end of the war, all consistent with the testimony of Werner Grothmann.

Schumann wrote that he was unaware of enriched uranium sources other than Paul Harteck's centrifuges. Yet Werner Holtz and Werner Schwietzke in his own Army Ordnance Office spent several years developing uranium centrifuges (pp. 3542–3544); the fact that Schumann completely omitted any mention of that fact demonstrates that he withheld important information in this and other writings.]



[illegible] 1.15

1

Bucheinteilung

S. 2 - 3 Einleitung [illegible]

S. 4 - 24 Kapitel I

Die Freisetzung von Atomenergie durch Kernspaltung bei schweren Elementen

5 Stand 1939 (Fermi), Joliot, Hahn-Strassmann, Flügge)

4 Deutsche Versuche 1939-45, die auf die U-Maschine gerichtet waren (reines U. schweres Wasser, warum nicht Graphit, Element 94, Sitzung der Kernphysikal.Arbeitsgemeinschaft im Febr.1942, Entscheidung Speers: weitere Versuche im kleinen Masstabe).

2 Arbeiten in Amerika: U-Maschine und U- bzw. Pu-Bbe.

S. 25 - 62 Kapitel II

Die Freisetzung der Atomenergie durch Kernsynthese bei leichten Elementen

8 Allgem. (Möglichkeit schon früher erwogen. Sterne: Bethe, Weizsäcker, Gamow usw.)

4 2 Wege A) Zündung durch U-bzw. Pu-Bbe (nach Blackett, wahrscheinlich Lösung jetzt in Amerika)

B) x-Zündung (deutscher Vorschlag Schumann-Trinks)

6 Übersicht

20 Speziell: Geschichte des Prinzips, welche p und T erreichbar, Zeichnungen, Aussichten.

S. 63 -100 Kapitel III

Kritik der Meinungen ausl.Wissenschaftler und Militärs (über Wert der U-, Pu- und H-Bbe)

16 Blackett, Ridenour , Rabi , Torrey , Mc Mahon , Gen.Bradley , und andere mil.Fachleute und Joliot .

22 Russland und Amerika (unter Voraussetzung von II B).

S.101 -131 Anhang

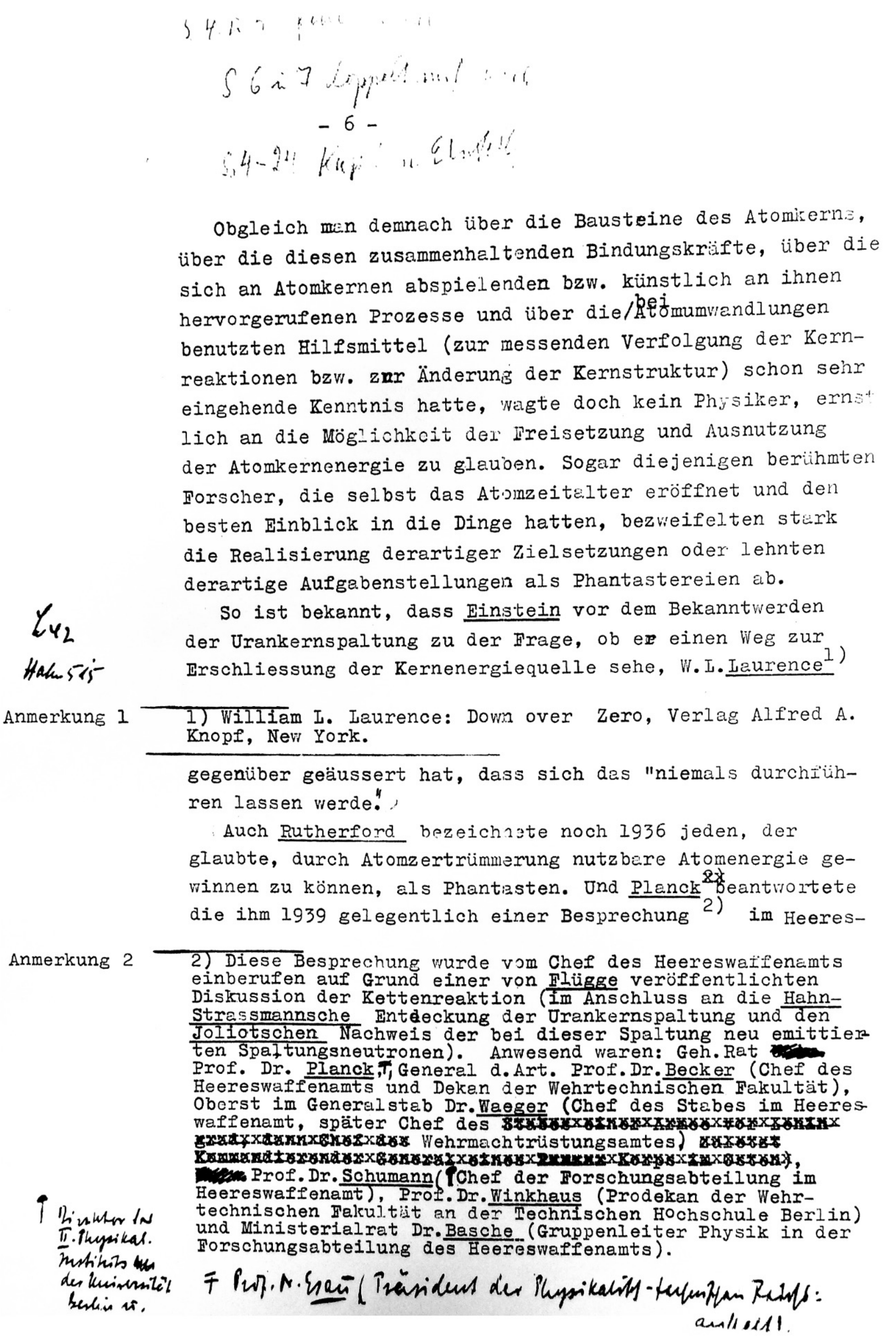
1 Tabelle

Periodisches System, Element-Tabelle, Umwandlungs-Schema, Strahlenschädigungs-Tabelle, medizin.Anwendungen schon während des Krieges, ausl. und deutsche Atomforschungsanlagen, Forschungsbeirat des Heereswaffenamts, deutsche Führung und Atomenergieproblem, (auch Bemerkungen über N-Stoff, R-Kanone, Rakete)

8 Definitionen zur Atomphysik

[illegible]

Figure D.585: The table of contents of an unpublished 1949 manuscript by Erich Schumann, describing some (but only some) of the wartime German nuclear work.



S 4 R 7 [illegible]

S 6 u 7 doppelt [illegible]

- 6 -

S 4-24 Kap. u. [illegible]

Obgleich man demnach über die Bausteine des Atomkerns, über die diesen zusammenhaltenden Bindungskräfte, über die sich an Atomkernen abspielenden bzw. künstlich an ihnen hervorgerufenen Prozesse und über die/bei Atomumwandlungen benutzten Hilfsmittel (zur messenden Verfolgung der Kernreaktionen bzw. zur Änderung der Kernstruktur) schon sehr eingehende Kenntnis hatte, wagte doch kein Physiker, ernstlich an die Möglichkeit der Freisetzung und Ausnutzung der Atomkernenergie zu glauben. Sogar diejenigen berühmten Forscher, die selbst das Atomzeitalter eröffnet und den besten Einblick in die Dinge hatten, bezweifelten stark die Realisierung derartiger Zielsetzungen oder lehnten derartige Aufgabenstellungen als Phantastereien ab.

L 42

Hahn S 15

So ist bekannt, dass Einstein vor dem Bekanntwerden der Urankernspaltung zu der Frage, ob er einen Weg zur Erschliessung der Kernenergiequelle sehe, W.L.Laurence 1) gegenüber geäussert hat, dass sich das "niemals durchführen lassen werde."

Auch Rutherford bezeichnete noch 1936 jeden, der glaubte, durch Atomzertrümmerung nutzbare Atomenergie gewinnen zu können, als Phantasten. Und Planck ~~2)~~ beantwortete die ihm 1939 gelegentlich einer Besprechung 2) im Heeres-

Anmerkung 1

1) William L. Laurence: Down over Zero, Verlag Alfred A. Knopf, New York.

Anmerkung 2

2) Diese Besprechung wurde vom Chef des Heereswaffenamts einberufen auf Grund einer von Flügge veröffentlichten Diskussion der Kettenreaktion (im Anschluss an die Hahn-Strassmannsche Entdeckung der Urankernspaltung und den Joliotschen Nachweis der bei dieser Spaltung neu emittierten Spaltungsneutronen). Anwesend waren: Geh.Rat [redacted] Prof. Dr. Planck, †, General d.Art. Prof.Dr.Becker (Chef des Heereswaffenamts und Dekan der Wehrtechnischen Fakultät), Oberst im Generalstab Dr.Waeger (Chef des Stabes im Heereswaffenamt, später Chef des ~~[illegible]~~ Wehrmachtrüstungsamtes) ~~[illegible]~~, [redacted] Prof.Dr.Schumann (†Chef der Forschungsabteilung im Heereswaffenamt), Prof.Dr.Winkhaus (Prodekan der Wehrtechnischen Fakultät an der Technischen Hochschule Berlin) und Ministerialrat Dr.Basche (Gruppenleiter Physik in der Forschungsabteilung des Heereswaffenamts).

† Direktor des II. Physikal. Instituts der Universität Berlin u.

‡ Prof. Dr. Esau (Präsident der Physikalisch-Technischen Reichsanstalt)

Figure D.586: A page from an unpublished 1949 manuscript by Erich Schumann, describing some (but only some) of the wartime German nuclear work.

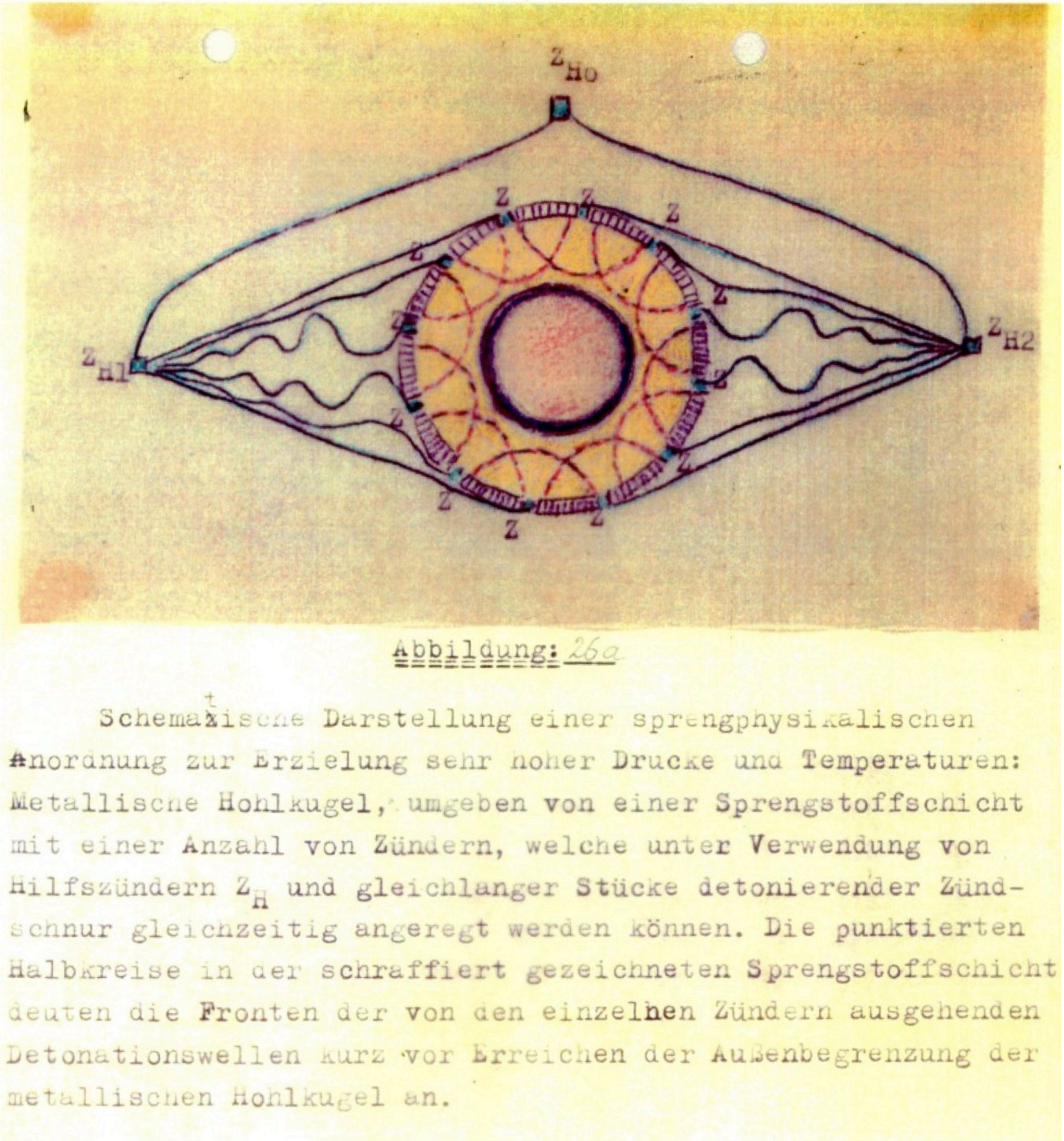


Abbildung: 26a

Schema~~x~~tische Darstellung einer sprengphysikalischen Anordnung zur Erzielung sehr hoher Drucke und Temperaturen: Metallische Hohlkugel, umgeben von einer Sprengstoffschicht mit einer Anzahl von Zündern, welche unter Verwendung von Hilfszündern Z_H und gleichlanger Stücke detonierender Zündschnur gleichzeitig angeregt werden können. Die punktierten Halbkreise in der schraffiert gezeichneten Sprengstoffschicht deuten die Fronten der von den einzelnen Zündern ausgehenden Detonationswellen kurz vor Erreichen der Außenbegrenzung der metallischen Hohlkugel an.

Figure D.587: A page from an unpublished 1949 manuscript by Erich Schumann, describing a spherical implosion bomb design with multiple concentric layers. (See also p. 4240.) Schumann's caption says: "Schematic representation of an explosive physical arrangement for achieving very high pressures and temperatures: Hollow metallic sphere surrounded by a layer of explosives with a number of detonators which can be triggered simultaneously using auxiliary detonators Z_H and pieces of detonating fuse of equal length. The dotted semicircles in the hatched explosive layer indicate the fronts of the detonation waves emanating from the individual detonators shortly before reaching the outer boundary of the hollow metallic sphere." Other pages from Schumann described additional details of the design, including explosive lenses of TNT and RDX within the outer layer, the arrangement of both fission and fusion fuel near the center, and methods of testing the device by mounting it on a tower and using sophisticated high-speed diagnostic instruments to record the explosion.

Letter from Erich Schumann to Ernst Telschow. 2 April 1948 [AMPG, Abt. III, Rep. 83, Nr. 286].

Prof. Dr. Erich Schumann
Göttingen, den 2. April 48
<u>Vertraulich</u>
An Herrn Gen. Dir. Dr. E. Telschow
Max-Planck-Gesellschaft zur
Förderung der Wissenschaften in Göttingen

Im Verlauf von sprengstoff-physikalischen Forschungsarbeiten, insbesondere der die Zündführung bei Hohlsprengkörpern betreffenden Untersuchungen, führten Überlegungen, die ich im Oktober 1943 gemeinsam mit Dr. Walter Trinks anstellte, zu dem Schluss, dass es zufolge der in unseren Berichten [Forschungsabteilung H Wa F, Reichsforschungsrat (Bevollmächtigter für Sprengstoffphysik) und etwa 40 Patentschriften] niedergelegten Erkenntnissen möglich sein müsse, Umwandlungen z. B. von Kohle in Diamant vorzunehmen und ferner <u>Atomenergie auch durch Reaktionen zwischen leichten Elementen freizumachen</u>.

Prinzip: Die außerordentliche Verdichtung der Materie und damit einhergehende ungeheuere Temperatursteigerung, wie sie sich im Entwicklungsgang der Sterne infolge der Gravitation vollzieht, soll im Experiment dadurch erzwungen werden, dass man die hohe Sprengstoffphysikalisch gewonnene kinetische Energie einer großen Masse auf eine wesentlich kleinere Masse überträgt. Siehe nachstehende schematische Darstellung. (Die zu verdichtende Substanz wird im gasförmigen Zustand in einer metallischen Hohlkugel untergebracht, welche außen mit einer Schicht eines brisanten Sprengstoffs belegt ist. Bei geeigneter, gleichmäßig über die ganze Oberfläche der Sprengstoffschicht eingeleiteter Zündung wird für eine gewisse kurze Zeit ein hoher Druck auf die metallische Kugel ausgeübt, unter dessen Einwirkung das Metall in den plastischen Zustand gerät und zum Mittelpunkt hin beschleunigt wird. Dadurch wird die eingeschlossene Gasmasse außerordentlich rasch verdichtet und dabei sehr hoch erhitzt):

Prof. Dr. Erich Schumann
Göttingen, 2 April 48
<u>Confidential</u>
To General Director Dr. E. Telschow
Max Planck Society for the
Advancement of Sciences in Göttingen

In the course of research work in the physics of explosives, in particular the investigations into the detonation of hollow explosives, considerations which I carried out in October 1943 with Dr. Walter Trinks, led to the conclusion that according to the findings laid down in our reports [Research Department H Wa F, Reich Research Council (Commissioner for Explosives Physics) and about 40 patent specifications], it must be possible to carry out transformations, e.g. of coal into diamond, and moreover <u>to release nuclear energy also through reactions between light elements</u>.

Principle: The extraordinary compression of matter and the associated enormous increase in temperature, as it occurs in the evolution of stars as a result of gravity, can be forcibly created in the experiment by transferring the high kinetic energy of a large mass, obtained by explosive physics, to a much smaller mass. See the schematic diagram below. (The substance to be compressed is placed in the gaseous state in a metallic hollow sphere, which is covered on the outside with a layer of explosive material. When a suitable ignition is applied uniformly over the entire surface of the explosive layer, a high pressure is applied to the metal sphere for a short time, which causes the metal to plasticize and accelerate towards the center. This causes the enclosed mass of gas to be compressed extremely rapidly and thereby to heat up very rapidly):

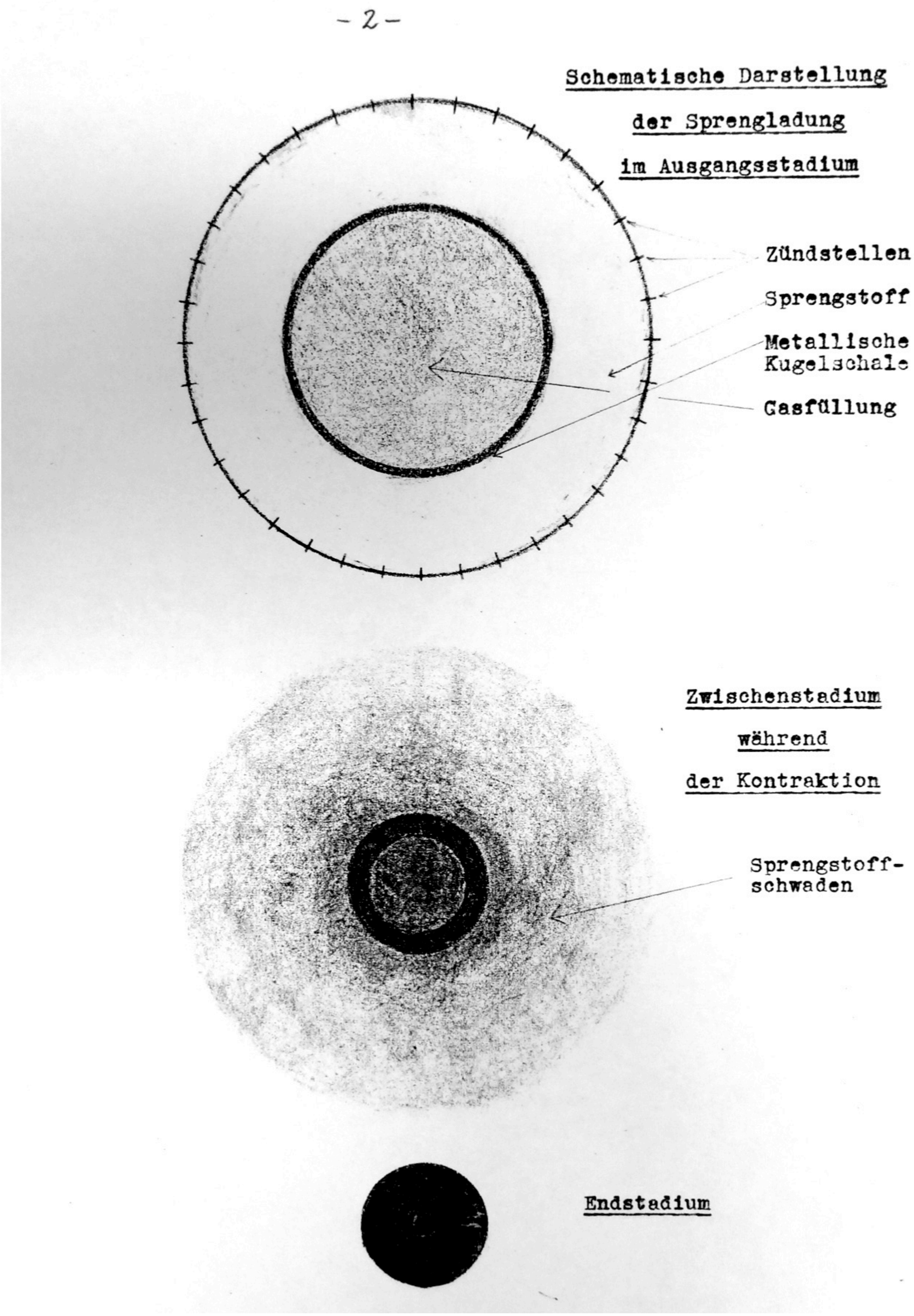


Figure D.588: A 1948 drawing by Erich Schumann, showing a spherical implosion bomb design with multiple concentric layers used to trigger nuclear reactions [AMPG, Abt. III, Rep. 83, Nr. 286].

Es war 1944/45 nicht mehr möglich, die bereits vorbereiteten Versuche durchzuführen, denn vom damaligen Ministerium für Bewaffnung und Munition wurden derartige Versuche nicht unterstützt, ja sogar verboten. Die experimentellen Möglichkeiten und theoretischen Überlegungen wurden aber damals von Dr. Trinks in einer Arbeit, die er als Habilitationsschrift zu benutzen gedachte, niedergelegt. Diese Arbeit wurde weisungsgemäß 1945 mit den übrigen Geheimakten vernichtet und 1947 nach Rücksprache mit Ihnen für die dortige Behörde von Dr. Trinks rekonstruiert.

Besteht beispielsweise die erwähnte Kugelschale aus Eisen, die Füllung aus Wasserstoffgas vom Anfangsdruck 1 Atm., beträgt die Wandstärke der Kugelschale etwa 1/50 ihres Durchmessers und rechnet man weiter mit einer Anfangsgeschwindigkeit der Schalenelemente von etwa 3200 m/sec, welche noch bequem erreichbar erscheint, so ergibt sich—nach Trinks—im Endzustand ein Energiegehalt des verdichteten Wasserstoffgases von etwa 10^{15} erg/g, d.h. mehr als 10 000 mal soviel, wie die brisantesten Sprengstoffe besitzen. Geht man von einem herabgesetzten Anfangsdruck des eingeschlossenen Gases aus, so ist mit noch höheren Energiedichten zu rechnen, also z.B. bei 0,1 Atm. etwa mit 10^{16} erg/g, das ist das 100 000-fache des Wertes für die brisantesten Sprengstoffe.

Durch extrem anwachsende Strahlungsverluste beim Überschreiten der Temperaturgrenze des nichtentarteten Elektronengases, sowie durch sprunghaft erhöhte Kompressibilität bei Überschreiten der Druckgrenze des nichtentarteten Elektronengases werden die theore- tisch möglichen Zündwerte (Temperaturen von 10–100 Millionen Grad und Drucke von 100 Milliarden bis 100 Billionen Atm) allerdings nur annährend erreicht werden können. Diese Schwierigkeiten beginnen jedoch erst von etwa 4 Millionen Grad bei einem Druck von 250 Millionen Atm. An merklich zu werden, während unter ihrer Inrechnungsetzung ein weiterer Anstieg auf etwa 10 Millionen Grad bei einem Druck von etwa 10 Milliarden Atm., das ist nahezu der Zustand im Sonnenmittelpunkt, erwartet werden kann.

In 1944/45 it was no longer possible to carry out the experiments already prepared, because the then Ministry of Armaments and Ammunition did not support such experiments and even prohibited them. The experimental possibilities and theoretical considerations were, however, laid down by Dr. Trinks at that time in a paper which he intended to use as his habilitation thesis. This work was destroyed together with the other secret files in 1945, as ordered, and in 1947, after consultation with you, it was reconstructed by Dr. Trinks for the local authorities.

If, for example, the spherical shell mentioned above consists of iron, the filling of hydrogen gas of the initial pressure of 1 Atm., the wall thickness of the spherical shell is about 1/50 of its diameter and if one continues to calculate with an initial speed of the shell elements of about 3200 m/sec, which still seems to be comfortably attainable, this results—after Trinks—in the final state an energy content of the compressed hydrogen gas of about 10^{15} erg/g, i.e. more than 10,000 times as much as the most explosive explosives possess. If one assumes a reduced initial pressure of the enclosed gas, even higher energy densities can be expected, e.g. at 0.1 atm. about 10^{16} erg/g, i.e. 100,000 times the value for the most explosive explosives.

However, due to extremely increasing radiation losses when the temperature limit of the non-degenerate electron gas is exceeded, as well as due to a sudden increase in compressibility when the pressure limit of the non-degenerate electron gas is exceeded, the theoretically possible ignition values (temperatures of 10–100 million degrees and pressures of 100 billion to 100 trillion Atm) can only be approximately reached. However, these difficulties only start from about 4 million degrees at a pressure of 250 million Atm. It is possible to notice them, whereas if they are taken into account, a further increase to about 10 million degrees at a pressure of about 10 billion Atm., which is almost the state in the center of the sun, can be expected.

Dann sind aber zumindest die beiden Deuteronen-Reaktionen

$$^{2}\mathrm{D} + {}^{2}\mathrm{D} \;=\; {}^{3}\mathrm{He} + {}^{1}\mathrm{n}$$

$$^{2}\mathrm{D} + {}^{2}\mathrm{D} \;=\; {}^{3}\mathrm{Tr} + {}^{1}\mathrm{H}\,,$$

deren Einsetzen im Entwicklungsgang der Sterne bereits bei 200 000^{o} beginnt[x], genügend wahrscheinlich[xx], so dass sie auch während der etwas kurzen Zeiten, die bei dem geplanten Hohlkugelverfahren zur Verfügung stehen (etwa 0,001 sec), in so ausreichendem Umfang stattfinden, dass erhebliche Energiebeträge gewonnen werden können.

Wird z.B. 1/2 Kubikmeter (ca 9 g) schweren Wasserstoffgases vom Druck 0,1 Atm. vollständig nach dem obigen Reaktionsgleichungen umgesetzt, so wird ein Energiebetrag von rund 10^{19} erg entsprechend etwa 275 to Trinitrotoluol, frei. Noch erheblich höhere Beträge können unter Heranziehung anderer leichter Elemente, z. B. Lithium oder Bor, gewonnen werden.

Erich Schumann

But then at least the two deuteron reactions

whose onset in the evolutionary process of stars already starts at 200,000^{o} [x], sufficiently probable[xx], so that even during the somewhat short times available in the planned hollow-sphere process (about 0.001 sec), they take place in such a sufficient amount that considerable amounts of energy can be gained.

If e.g. 1/2 cubic meters (approx. 9 g) of heavy hydrogen gas of pressure 0.1 Atm. are completely converted according to the above reaction equations, an energy amount of about 10^{19} erg corresponding to about 275 tons of TNT is released. Even considerably higher amounts can be obtained by using other light elements, e.g. lithium or boron.

Erich Schumann

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[x] Vgl. Bethe u. Marshak, Rep. on Progr. in Phys. 6, 1–15, 1939.

[xx] Nachgewiesen in dem Hauptbericht Abschn. V, S. 36 unter Benutzung der von Gamow und Teller (Phys. Rev. (2) 53, 608, 1938) verbesserten theoretischen Beziehungen von Atkinson und Houtermans, der Rechnungen von Bethe (Phys. Rev. (2) 55, 434, 1939), sowie der experimentellen Werte des Wirkungsquerschnittes der Deuteronenreaktionen von Ladenburg u. Kanner (Phys. Rev. (2) 52, 911, 1937) und der Messungen von Burhop (Proc. Phil. Soc. 32, 643, 1936).

[x] See Bethe and Marshak, Rep. on Progr. in Phys. 6, 1–15, 1939.

[xx] Proven in the main report, section V, p. 36, using the theoretical relations of Atkinson and Houtermans improved by Gamow and Teller (Phys. Rev. (2) 53, 608, 1938), the calculations of Bethe (Phys. Rev. (2) 55, 434, 1939), as well as the experimental values of the cross section of the deuteron reactions of Ladenburg and Kanner (Phys. Rev. (2) 52, 911, 1937) and the measurements of Burhop (Proc. Phil. Soc. 32, 643, 1936).

[This 1948 letter briefly described a spherical implosion bomb design with multiple concentric layers used to trigger nuclear reactions. While the letter did not delve into still-classified details such as uranium and explosive lenses, clearly it was closely tied both to Schumann's wartime work and to his postwar patents (which are presented on the following pages).]

Erich Schumann and Walter Trinks. Patent DE977825. Vorrichtung, um ein Material zur Einleitung von mechanischen, thermischen oder nuklearen Prozessen auf extrem hohe Drücke und Temperaturen zu bringen. [Device for the introduction of a material for the introduction of mechanical, thermal or nuclear processes to extremely high pressures and temperatures.] Filed 13 August 1952.

[...] In solchen Fällen kann man sich eines Verfahrens bedienen, das darauf beruht, die kinetische Energie einer größeren Masse nahezu vollständig auf eine möglichst kleine Masse in einem sehr kleinen Raumgebiet zu übertragen. Man erreicht durch den Übergang von großen zu kleinen Massen größte Energiedichten, ganz analog wie man einen hohen Druck beim Übergang von großen zu kleinen Flächen erhält oder große Lasten mit einer kleinen Kraft durch Anwendung langer Wege hebt.

Dieses Prinzip der Übertragung der kinetischen Energie großer Massen auf kleinere findet z.B. Anwendung beim sogenannten Wasserhammer oder hydraulischen Widder; eine größere in Strömung befindliche Wassermenge wird plötzlich gebremst; der dabei auftretende Staudruck hebt einen Bruchteil der gestauten Wassermenge auf eine bestimmte Höhe empor und verleiht demselben so einen höheren Betrag an potentieller Energie pro Volumeneinheit, als das ursprünglich fließende Wasser an kinetischer Energie besaß.

Gemäß der Erfindung wird für die Erzeugung extrem hoher Drücke und Temperaturen eine Vorrichtung vorgeschlagen, die eine geschlossene Kammer für das auf die Drücke und Temperaturen zu bringende Material besitzt, bei der eine jenem Material gegenüberliegende, selbst nicht aus Sprengstoff bestehende Wand der Kammer mit einem Sprengstoff belegt ist, wobei diese Wand und ihre Sprengstoffbelegung so ausgebildet sind, daß die Wand durch den bei der Detonation des Sprengstoffes auftretenden Druck auf das genannte Material hin bewegt und in eine zu dem genannten Material hin konkave Form plastisch verformt wird.

[...] In such cases, a method can be used which is based on transferring the kinetic energy of a larger mass almost completely to a mass as small as possible in a very small spatial region. From the transition from large to small masses one attains the greatest energy density, just as a high pressure is obtained in the transition from large to small surfaces, or large loads are lifted with a small force by the application of long paths.

This principle of transferring the kinetic energy of large masses to smaller ones is, for example, applied in the so-called water hammer or hydraulic ram; a larger stream of water is suddenly braked; the pressure occurring in the process lifts a fraction of the accumulated water to a certain height and thus gives it a higher amount of potential energy per unit volume than the kinetic energy of the initially flowing water.

According to the invention, an apparatus is proposed for the production of extremely high pressures and temperatures, which has a closed chamber for the material to be subjected to pressures and temperatures, in which a wall of the chamber, which does not consist of explosives itself, is lined with an explosive, this wall and its explosive covering being designed in such a way that the wall is moved towards the said material by the pressure occurring during the detonation of the explosive and is plastically deformed into a concave shape towards the said material.

Diese Vorrichtung beruht zum Teil auf dem Prinzip der sogenannten Hohlsprengladung. Der maßgebende Teil solcher Hohlsprengladungen besteht aus einem metallischen Hohlkörper von vorzugsweise kegel-, glocken- oder flaschenförmiger Gestalt, welcher außen mit einem Sicherheitssprengstoff, z.B. Hexogen oder Trinitrotoluol, umgeben ist. Bei der Detonation des letzteren gehen die einzelnen Wandelemente des genannten Hohlkörpers unter dem Einfluß des Druckes von etwa 100 000 Atm in den plastischen Zustand über und erhalten eine nach innen gerichtete Geschwindigkeit von mehreren Kilometern pro sec. Beim Zusammentreffen der beschleunigten Wandelemente auf der Hohlraumachse wird ihre Bewegung gebremst, wobei auf einen geschmolzenen Anteil ihrer Masse ein hoher Druck ausgeübt wird. Durch diesen Druck werden die flüssig gewordenen Teilchen in Form eines feinen Strahles mit großer Geschwindigkeit aus dem sich zusammenziehenden Hohlraum herausgepreßt. Bei geeigneter Hohlraumform erreicht man in solchen Hohlsprengladungen Strahlgeschwindigkeiten bis zur doppelten Detonationsgeschwindigkeit, also beispielsweise bei Hexogen 2 × 8 km/sec = 16 km/sec. Dieser Geschwindigkeit entspricht ein Druck im Quellgebiet des Strahles von etwa 10^7 kg/cm^2. [...]

An dem folgenden speziellen Beispiel soll dies näher erläutert werden. Die zu verdichtende Substanz sei in gasförmigem Zustand in einer metallischen Hohlkugel untergebracht, welche außen mit einer Schicht eines brisanten Sprengstoffes belegt ist. Bei geeigneter, gleichmäßig über die ganze Oberfläche eingeleiteter Zündung der Sprengstoffschicht wird für kurze Zeit ein sehr hoher Druck auf die Kugelschale ausgeübt, unter dessen Einwirkung das Metall wie bei den Hohlsprengkörpem in den plastischen Zustand gerät und zum Kugelmittelpunkt hin beschleunigt wird. Dadurch wird die eingeschlossene Gasmasse außerordentlich rasch verdichtet und dabei sehr hoch erhitzt.

This device is based, in part, on the principle of the so-called shaped-charge blasting. The decisive part of such hollow-spring bladders consists of a metallic hollow body of preferably conical, bell-shaped or bottle-shaped shape which is externally provided with a safety explosive, for example hexogen or trinitrotoluene. During the detonation of the latter, the individual wall elements of said hollow body are converted into the plastic state under the influence of the pressure of about 100,000 atmospheres, and receive an inward velocity of several kilometers per second. When the accelerated wall elements meet on the cavity axis, their movement is braked, a high pressure being exerted on a molten portion of their mass. By this pressure the particles, which have become fluid, are pressed out of the constricting cavity in the form of a fine jet at high speed. With a suitable cavity shape, jet velocities of up to twice the detonation velocity are achieved in such hollow-jet blowers, for example, in the case of hexogen 2 × 8 km/sec = 16 km/sec. This pressure corresponds to a pressure in the source region of the jet of about 10^7 kg/cm^2. [...]

This will be explained in more detail in the following specific example. The substance to be compacted is placed in a gaseous state in a metallic hollow sphere, which is externally coated with a layer of a high explosive. In the case of a suitable ignition of the explosive layer uniformly introduced over the entire surface, a very high pressure is exerted on the ball shell for a short time, under the effect of which the metal becomes, as in the case of the hollow bubble bodies, into the plastic state and is accelerated towards the ball center point. As a result, the enclosed gas mass is extremely rapidly compressed and thereby heated very high.

Die dabei auftretenden Beschleunigungen sind ungeheuer groß. Während der Kontraktion der Hohlkugel nimmt ihre Wandstärke dauernd zu. Nähert sich dabei die Innenfläche dem Kugelmittelpunkt, so erhalten die an der Innenfläche gelegenen Materialteilchen sehr hohe Geschwindigkeiten. Man erkennt dies sofort, wenn man sich vergegenwärtigt, welchen Raum das von der Außenfläche—auch bei einem nur kleinen zurückgelegten Weg derselben—überstrichene Volumen einnimmt, wenn es als Kugel um den Mittelpunkt angeordnet wird.

The accelerations occurring in this case are enormous. During the contraction of the hollow spheres their wall thickness increases continuously. As the inner surface approaches the center of the sphere, the material particles located on the inner surface are given very high velocities. This is immediately apparent when we consider the space being spanned—even for a small distance travelled—when it is arranged as a sphere around the center.

Geht man beispielsweise von einer Hohlkugel vom Innendurchmesser $2R = 100$ cm und der Wandstärke 2 cm aus, so füllt das Schalenmaterial eine Kugel vom Durchmesser

If, for example, a hollow sphere with an internal diameter of $2R = 100$ cm and wall thickness 2 cm is compacted, the shell material fills a sphere of diameter

$$2R_0 \;=\; 2\sqrt[3]{52^3 - 50^3} \;=\; 2\sqrt[3]{15608} \;\approx\; 50\,\text{cm}, \tag{D.1}$$

wenn die Hohlkugel völlig zusammengeschrumpft ist, und legt während des letzten Teiles der Kontraktion die Außenfläche einen Weg von nur ⅒ mm zurück, so beträgt in der gleichen Zeit der entsprechende Weg der Innenfläche 2,66 cm, das ist 266mal soviel.

when the hollow sphere is completely shrunk, and during the last part of the contraction the outer surface is a path of only ⅒ mm, the corresponding distance of the inner surface is 2.66 cm, which is 266 times as much.

In Fig. 1a bis 1d ist die Kontraktion einer Hohlkugel im Schnitt schematisch dargestellt. Die starke Schrumpfung des Innenraumes, besonders gegen Ende des Vorganges im Vergleich mit der verhältnismäßig geringen Abnahme des Außendurchmessers, macht das Auftreten enormer Beschleunigungen verständlich. [...]

In Figs. 1a to 1d, the contraction of a hollow sphere is shown schematically in section. The severe shrinkage of the interior, especially towards the end of the process compared with the relatively small decrease in the outside diameter, makes the occurrence of enormous accelerations understandable. [...]

Bei der Beschleunigung mittels detonierender Sprengstoffe sind Anfangsgeschwindigkeiten von $\bar{v} = 3000$ bis 4000 m/sec. noch bequem erreichbar. [...]

During acceleration by means of detonating explosives, initial velocities from $\bar{v} = 3000$ to 4000 m/sec are yet easily accessible. [...]

Fig. 1

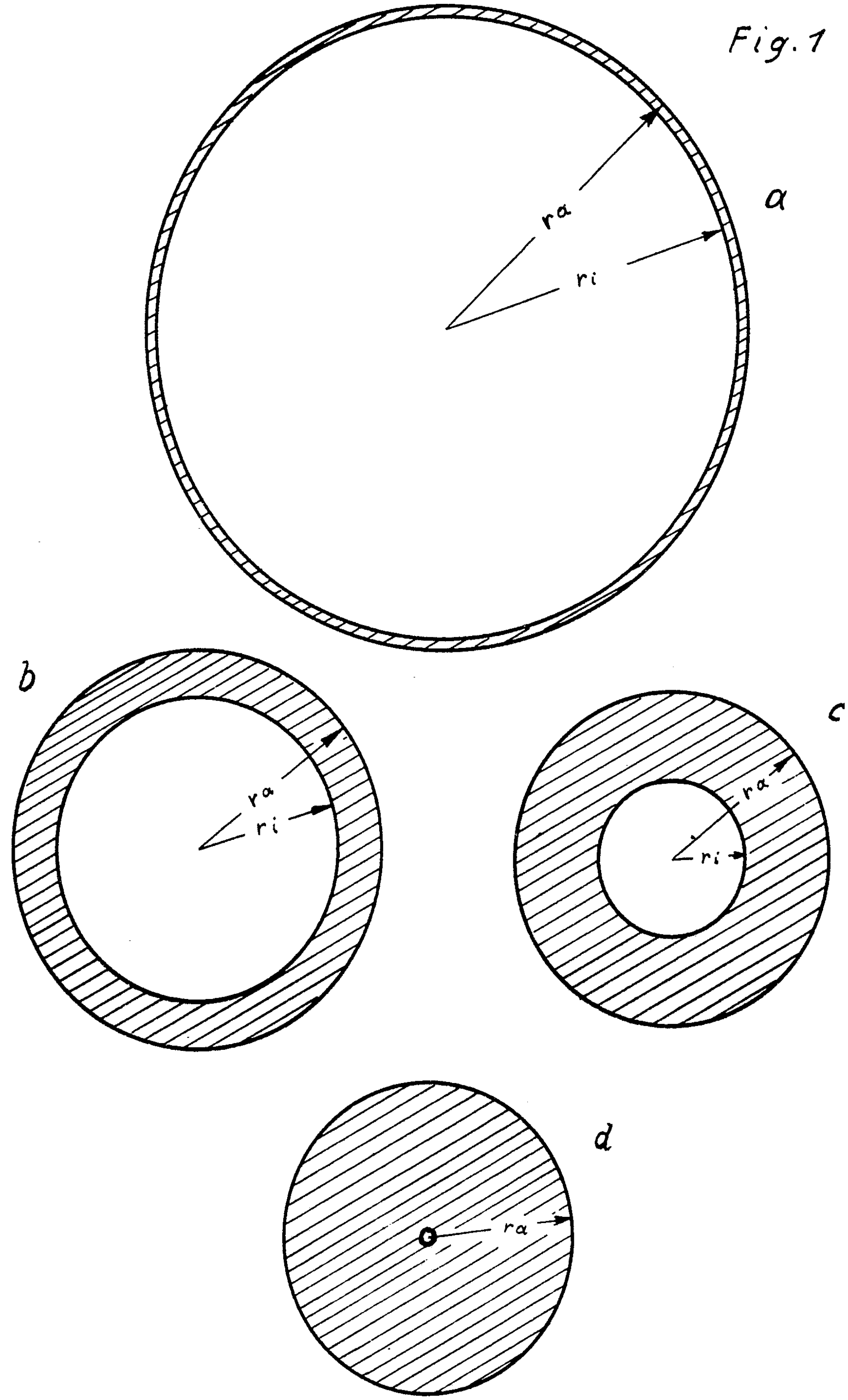

Figure D.589: Figure from Schumann-Trinks patent application showing the implosion of a spherical shell to form a solid sphere of matter.

Zur technischen Durchführung des vorgeschlagenen Verfahrens ist folgendes zu bemerken:

Bei der visuellen Beobachtung eines Sprengvorganges, beispielsweise der Detonation einer Bombe, gewinnt man leicht den Eindruck, als ob dieser Vorgang sich recht ungeordnet vollzöge und daß man sich bei den ungeheuren Belastungen des Materials immer mit gewissen nicht steuerbaren Zufälligkeiten abfinden müsse.

Die modernen Untersuchungsmethoden mit mechanischen Hochleistungszeitdehnern, Funken-, Kerrzellen- und Röntgenblitzkinematographen haben jedoch ergeben, daß Detonationsvorgänge mit derselben Exaktheit ablaufen wie andere physikalische Vorgänge und daß ihr Ablauf und der eintretende Endzustand genau reproduzierbar sind, wenn nur stets von den gleichen Anfangszuständen ausgegangen wird.

Man darf daher bei der Vorbereitung einer Sprengung nicht glauben, es komme nicht so genau darauf an, sondern es ist sehr wichtig, aber auch zugleich lohnend, äußerste Sorgfalt dabei aufzuwenden. Es ist häufig vorgekommen, daß erwartete Effekte erst verspätet nachgewiesen werden konnten, weil man sie nach einem nicht genügend sorgfältig vorbereiteten und deshalb mißglückten Vorversuch voreilig abgetan hat.

Für die Vorbereitung von Anordnungen zur Durchführung des beschriebenen Verfahrens gilt das eben Gesagte ganz besonders, und es ist nicht zuletzt aus diesem Grunde in den angeführten Beispielen von einer Hohlkugel mit dem verhältnismäßig großen Durchmesser von 1 m gesprochen worden, weil dann Ungenauigkeiten leichter zu vermeiden sind.

For the technical implementation of the proposed method, the following should be noted:

When visually observing a blasting process, for example the detonation of a bomb, one easily gains the impression that this process is quite disordered, and that with respect to the enormous loads, one must always accept certain uncontrollable, random incidents.

However, the modern methods of investigation with high-performance mechanical time-lengtheners, spark-, Kerr-cells, and X-ray flash kinematographs have shown that detonation processes proceed with the same exactness as other physical processes and that their sequence and the final state are exactly reproducible when only the same initial states are always assumed.

It is therefore not permissible, when preparing a blasting, to believe that it is not so important, but it is very important, but at the same time worthwhile, to devote extreme care to it. It has often happened that the expected effects could not be demonstrated until later, because they were prematurely dismissed after a preliminary experiment which had not been carefully prepared and therefore failed.

For the preparation of arrangements for carrying out the described method, the above is particularly true, and for this reason, in the examples given, a hollow sphere with the comparatively large diameter of 1 meter has been discussed, since inaccuracies are then easier to avoid.

Besonders ist es die möglichst strenge Einhaltung der Gleichzeitigkeit der Zündung, die in allen vorliegenden Fällen von besonderer Bedeutung ist und die sich bei größeren Körpern leichter erzielen läßt als bei kleineren. Es ist verhältnismäßig schwierig, einen Sprengkörper an allen Punkten einer beliebig geformten Oberfläche gleichzeitig zu zünden. Statt einer flächenhaften Zündung empfiehlt es sich deshalb, eine solche in möglichst vielen Einzelpunkten vorzunehmen.

Einen verhältnismäßig hohen Grad der Gleichzeitigkeit erreicht man dabei mit Hilfe der sogenannten detonierenden Zündschnur (kabelähnlich umsponnene Nitropentaerythrit-oder Fulminat-Seele), indem man Hilfszündpunkte Z_H anwendet, von denen man zu den eigentlichen Zündpunkten Z_1, Z_2, Z_3,... gleich lange Stücke dieser Zündschnur mit konstanter Detonationsgeschwindigkeit (etwa 7500 m/sec) führt.

In Fig. 7 ist eine spreng-physikalische Anordnung zur Erzielung sehr hoher Drücke und Temperaturen dargestellt. Die metallische Hohlkugel B ist von einer Sprengstoffschicht Sp umgeben mit einer Anzahl von Zündern Z, die unter Verwendung von Hilfszündern Z_H und gleich langer Stücke detonierender Zündschnüre gleichzeitig gezündet werden können. Die punktierten Halbkreise in der schraffiert gezeichneten Sprengstoffschicht deuten die Fronten der von den einzelnen Zündern ausgehenden Detonationswellen kurz vor Erreichen der Außenbegrenzung der metallischen Hohlkugel B an.

It is particularly important to observe as closely as possible the simultaneity of the ignition, which is of particular importance in all cases, and which is easier to obtain in larger bodies than in smaller ones. It is relatively difficult to simultaneously ignite an explosive at all points of any arbitrarily shaped surface. Instead of a large-area ignition, it is therefore recommended to carry out such an operation in as many individual points as possible.

To reach a relatively high degree of simultaneity place with the help of so-called detonating fuse (braided nitropentaerythrite or fulminate-soul) by introducing secondary ignition points Z_H, from which one of the actual ignition points Z_1, Z_2, Z_3,... pieces of equal length this detonating cord leads (about 7500 m/sec) at a constant velocity of detonation.

Fig. 7 shows an explosive physical arrangement for achieving very high pressures and temperatures. The metallic hollow sphere B is surrounded by an explosive layer Sp with a number of detonators Z which can be ignited simultaneously using auxiliary detonators Z_H and equally long pieces of detonating cords. The punctured semicircles in the shaded explosive layer indicate the fronts of the detonation waves emanating from the individual detonators shortly before the outer limit of the metallic hollow sphere B is reached.

Fig. 7

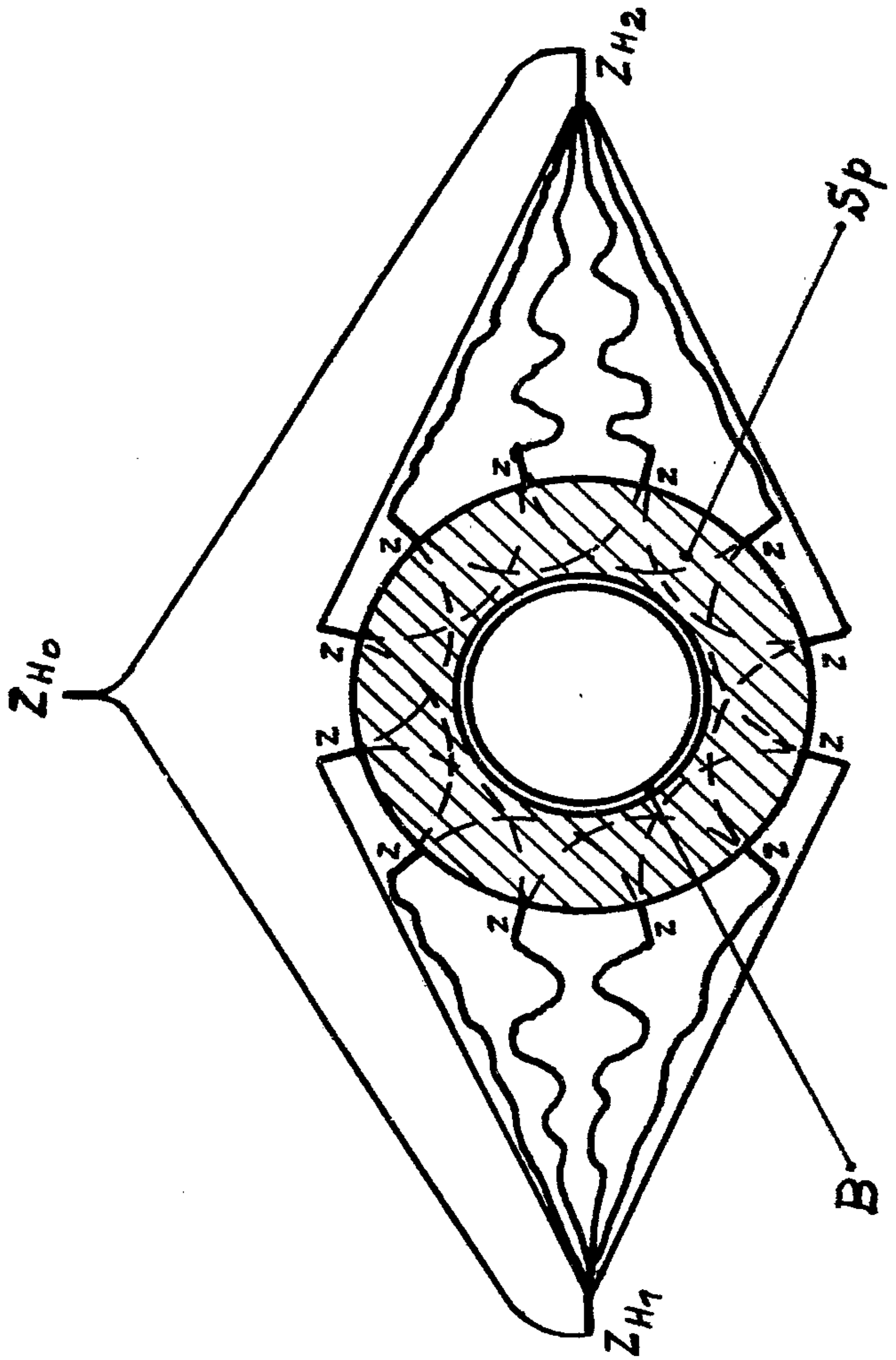

Figure D.590: Figure from Schumann-Trinks patent application showing a spherical implosion bomb design with multiple concentric layers used to trigger nuclear reactions. (See also p. 4229.)

Bei Verwendung elektrischer Zünder ist darauf zu achten, daß diese eine sehr geringe und konstante Verzugszeit aufweisen. Einer Zeitdifferenz von einer millionstel Sekunde entspricht bereits ein Weg der Detonationsfront von rund 1 cm, jedoch ebenfalls ein solches Stück der detonierenden Zündschnur, so daß bei deren Verwendung gute Genauigkeiten zustande kommen. Fehler durch etwa vorhandene Fehlstellen oder Unregelmäßigkeiten in der Schnur können dadurch vermieden werden, daß für jede Übertragungsstrecke mehrfache Schnüre verwendet werden.

Eine Glättung der gewünschten kugelförmigen, zum Mittelpunkt hinlaufenden Detonationsfront ist in Anlehnung an die Optik durch die Verwendung von “Sprengstofflinsen” möglich. Ähnlich wie dort die Lichtstrahlen kann man hier ein divergentes Bündel von Detonationsstrahlen in ein konvergentes umwandeln, indem man in dem Sprengkörper mit der Detonationsgeschwindigkeit D entweder konvexe oder konkave Linsen aus einem Sprengstoff mit größerer Detonationsgeschwindigkeit als D zwischen den Zünder und die zu beschleunigende Hohlkugeloberflache einschiebt. So kann man beispielsweise konvexe Linsen aus Trinitrotoluol bei einem Hauptsprengkörper aus Hexogen oder konkave Linsen aus Hexogen oder Nitropentaerythrit bei einem Hauptsprengkörper aus Trinitrotoluol verwenden.

Sprengstoffe mit noch kleineren Detonationsgeschwindigkeiten, beispielsweise Bergwerkssprengstoffe, sind für derartige Anwendungen nicht geeignet.

Obgleich sie einen größeren “Brechungsindex” ergeben würden, wird man doch wegen ihrer zu geringen Homogenität von ihrem Gebrauch für den vorliegenden Zweck absehen.

When using electric igniters, care must be taken that these have a very low and constant delay time. A time difference of one millionth of a second corresponds already to a distance of about 1 cm of the detonation front, but also to such a portion of the detonating fuse, so that good accuracies are obtained when they are used. Flaws caused by any imperfections or irregularities in the cord can be avoided by using multiple cords for each transfer path.

A smoothing of the desired spherical detonation front leading to the center is possible according to principles similar to those in optics through the use of “explosive lenses.” Similar to light beams, a divergent bundle of detonation beams can be transformed into a convergent one by inserting either the convex or concave lenses of an explosive with a greater detonation velocity than D between the detonators and the hollow spherical surface to be accelerated. For example, convex lenses made of trinitrotoluene can be used within a main body made of hexogen, or concave lenses made of hexogen or nitropentaerythrite within a main body made of trinitrotoluene.

Explosives with even lower detonation velocities, for example mining explosives, are not suitable for such applications.

Although they would give a larger “index of refraction,” their inadequate homogeneity will be considered to be of no use for the present purpose.

Die Form der Trennflächen zwischen den Sprengstoffen mit den verschiedenen Detonationsgeschwindigkeiten (D_1 und D_2) ergibt sich sehr einfach aus der folgenden Bedingung für die Wege s der Detonationsstrahlen

The shape of the interfaces between the explosives with the different detonation velocities (D_1 and D_2) is obtained very simply from the following condition for the paths s of the detonation rays

$$\frac{s_1}{D_1} + \frac{s_2}{D_2} = \text{const} = \frac{s_{10}}{D_1} + \frac{s_{20}}{D_2} \tag{D.2}$$

für eine einfache Trennfläche

for a simple separation surface

oder

or

$$\frac{s_1}{D_1} + \frac{s_2}{D_2} + \frac{s_1'}{D_1} = \text{const} = \frac{s_{10}}{D_1} + \frac{s_{20}}{D_2} + \frac{s_{10}'}{D_1} \tag{D.3}$$

für eine doppelte Trennfläche bei “Linsen”, wobei sich die Indizes 1 und 2 auf die beiden Sprengstoffe und der Index 0 auf den kürzesten Detonationsweg beziehen.

for a double separation surface for “lenses,” the indices 1 and 2 refer to the two explosives and the index 0 to the shortest detonation path.

In der Fig. 8 ist eine solche Umkehr der Krümmung der Detonationsflächen bei der Verwendung von Trinitrotoluol mit $D_1 = 6500$ m/sec und eines Zwischenkörpers aus Nitropentaerythrit mit $D_2 = 7800$ m/sec dargestellt. Die Figur zeigt, wie durch Einschaltung derartiger Sprengstoff-Linsen die gestrichelt dargestellten Detonationsflächen im Lauf ihres Fortschreitens der Krümmung der zu beschleunigenden Masse M angepaßt werden.

Fig. 8 shows such a reversal of the curvature of the detonation surfaces during the use of trinitrotoluene with $D_1 = 6500$ m/sec and an intermediate body of nitropentaerythritol with $D_2 = 7800$ m/sec. The figure shows how, by the activation of such explosive lenses, the detonation surfaces represented by dashed lines are adapted in the course of their progress to the curvature of the mass M to be accelerated.

Zur Erzielung einer möglichst großen Energiedichte ist es vorteilhaft, einen Sprengstoff mit möglichst hoher Detonationsgeschwindigkeit, z.B. Hexogen, für die Beschleunigung der Hohlkugelwand zu verwenden. Zweckmäßig preßt man dann die Sprengstoffumhüllung des Druckgefäßes als einzelne Teilstücke. Auf diese Weise läßt sich eine bessere Homogenität der Sprengstoffhülle und damit ein gleichmäßigerer Ablauf der Detonation erzielen als mit gegossenen Mischungen, welche häufig Lunker und andere Inhomogenitäten enthalten.

In order to achieve the greatest possible energy density, it is advantageous to use an explosive with the highest possible detonation speed, for example, hexogen [RDX], for the acceleration of the hollow ball wall. Expediently, the explosive lining of the pressure vessel is then pressed as individual parts. In this way, a better homogeneity of the explosive shell and thus a more uniform discharge of the detonation can be achieved than with cast mixtures, which often contain voids and other inhomogeneities.

Fig. 8

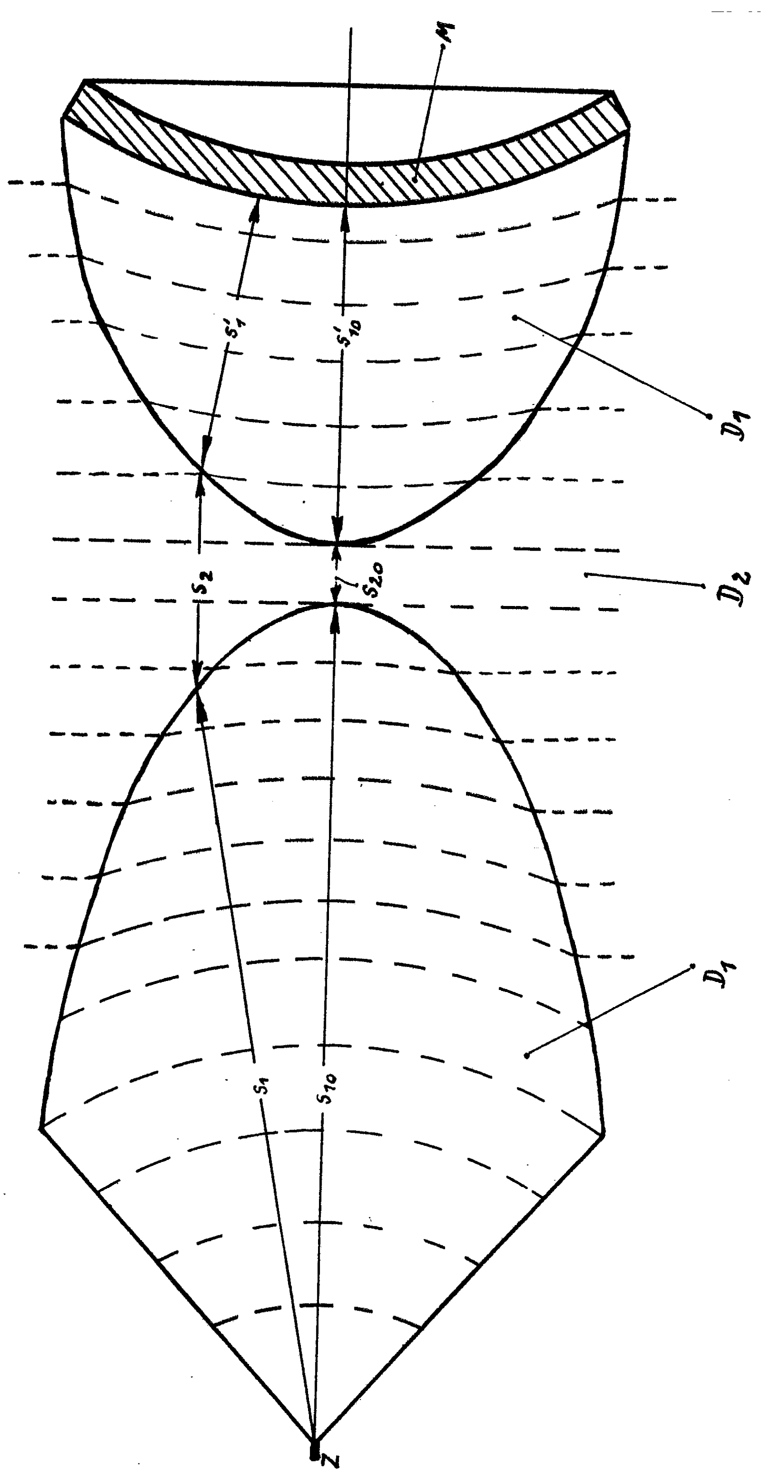

Figure D.591: Figure from Schumann-Trinks patent application showing an explosive lens containing shaped segments of two different explosive materials with different explosion velocities.

Im Hinblick auf einen möglichst gleichmäßigen Ablauf der Detonation, insbesondere auch auf ein möglichst regelmäßiges Anlaufen derselben in der Umgebung der Zündstellen sowie auf eine gute Aus- nutzung des Sprengstoffes ist es ferner vorteilhaft, die Sprengstoffschicht außen mit einer Verdämmung zu versehen und den ganzen Körper beispielsweise in Beton oder Erdbereich einzubetten. Beispielsweise ist es zweckmäßig, die nach außen frei werdende Sprengstoffenergie zugleich anderweitig auszunutzen, indem man derartige Versuche in Bergwerken oder Steinbrüchen durchführt.

Zur besseren Beobachtung der Vorgänge während und kurz nach der Detonation sowie zur leichteren Auffindung der verbleibenden Rückstände, welche die wertvollen Endprodukte enthalten, wird es sich jedoch auch häufig empfehlen, den Sprengkörper unverdämmt einige Meter über einer möglichst ebenen und glatten Fläche des Erdbodens frei aufzuhängen.

Im übrigen ist eine Zerlegung der Hohlkugel in viele Einzelteile nicht zu erwarten, da sie zusammenschrumpft und ihre Wandstärke dann 20- bis 30-mal so groß wie der Innenraum weit ist. Nachteilig ist bei den erwähnten Ausführungsbeispielen, daß sich bei den größeren der geplanten Körper recht erhebliche Gewichte ergeben, so daß auch aus diesem Grunde gegossene Sprengkörper kaum in Frage kommen, weil diese zu unhandlich werden würden. Eine eiserne Hohlkugel vom Durchmesser 1 m und der Wandstärke von nur 1 cm wiegt z.B. etwa 250 kg. Dazu kommt bei 20 cm starker Belegung ein Sprengstoffgewicht von etwa 1500 kg. Zusammen mit der Außenverdämmung ergibt sich so ein Gesamtgewicht von rund 2 t. [...]

With a view to the as uniform as possible of the detonation, in particular also to a regular start-up of the same in the vicinity of the ignition points, as well as to a good utilization of the explosive, it is also advantageous to provide the explosive layer with an external tamper and to place the whole arrangement in concrete or in earth, too. For example, it is practical to simultaneously exploit the outwards-released explosive energy by performing such experiments in mines or quarries.

For the better observation of the processes during and shortly after the detonation as well as for the easier detection of the remaining residues, which contain the valuable end products, it is also frequently recommended to freely hang the explosive device a few meters above a flat and smooth surface of the ground.

Moreover, it is not to be expected that the hollow spheres will be decomposed into many parts, since they shrink together and their wall thickness is then 20 to 30 times as large as the interior space. It is disadvantageous in the case of the mentioned exemplary embodiments that the larger of the planned bodies produce quite considerable weights so that explosive bodies cast for this reason are scarcely to be considered because they would become too bulky. An iron hollow sphere of diameter 1 m and wall thickness of only 1 cm weighs for example about 250 kg. In addition, an explosive weight of about 1500 kg is obtained when the coating is 20 cm thick. Together with the outer insulation, this results in a total weight of around 2 tons. [...]

[Compare Erich Schumann's designs for a two-ton spherical implosion bomb with other descriptions of the German fission bomb design (p. 4157), especially Ivan Ilyichev's 23 March 1945 report (p. 4485).]

Neben der eben beschriebenen Abänderung der prinzipiell sehr einfachen, jedoch in der praktischen Durchführung etwas komplizierten rein kugelförmigen dynamischen Druckzelle gibt es noch eine ganze Reihe anderer Möglichkeiten, die Grundidee der Übertragung der kinetischen Energie größerer, sprengphysikalisch beschleunigter Massen auf wesentlich kleinere Massen und der Erzeugung hoher Drücke und Temperaturen auf diesem Wege zu verwirklichen.

Hierzu werden noch einige Ausführungsbeispiele angegeben. Zunächst soll auf eine Anordnung mit zylindrischer Druckkammer eingegangen werden. Diese hat eine Reihe von Vorzügen, insbesondere auch deshalb, weil sich dabei besonders einfache Wege zur Einleitung der Zündung ergeben. Als Beispiel hierfür ist in der Fig. 11 schematisch eine solche Anordnung im Aufriß dargestellt. Die Druckkammer B besteht aus einem Zylinder, auf dessen Grundflächen Halbkugeln aufgesetzt sind. Der Sprengstoff Sp umgibt die Zylinderwand in Form eines Doppelkegels, längs dessen Grundlinie die Zündung gleichzeitig erfolgt. Dazu ist der Sprengstoff Sp umhüllt mit einem Mantel aus inertem Material J, beispielsweise Zement, welcher selbst wiederum außen mit einer dünnen Sprengstoffschicht Sp verkleidet ist. Wird dann letztere gleichzeitig in den beiden Spitzen des entstandenen Doppelkegels gezündet, so läuft die Detonation zugleich in zwei Ästen die beiden Kegelmäntel entlang, ohne dabei zunächst den inneren Sprengkörper zu beeinflussen, weil jener durch die inerten Zwischenschichten geschützt ist.

In addition to the modification of the purely spherical dynamic pressure cell which has been described above, but which is somewhat complicated in practice, there are also a whole series of other possibilities for the transfer of the kinetic energy of larger, physically accelerated masses to substantially smaller masses and the generation of high pressures and temperatures in this way.

For this purpose, a few exemplary embodiments are given. First, an arrangement with a cylindrical pressure chamber will be described. This has a number of advantages, in particular also because there are particularly simple ways of initiating the ignition. An example of such an arrangement is shown schematically in Fig. 11. The pressure chamber B consists of a cylinder, on the bases of which are placed hemispheres. The explosive Sp surrounds the cylinder wall in the form of a double cone, along which the ignition takes place at the same time. For this purpose, the explosive Sp is covered with a jacket of inert material J, for example cement, which itself is once again covered with a thin explosive layer Sp. If the latter is then ignited simultaneously in the two peaks of the resulting double cone, the detonation runs simultaneously into two branches along the two conical coats, without first affecting the inner explosive, because the latter is protected by the inert intermediate layers.

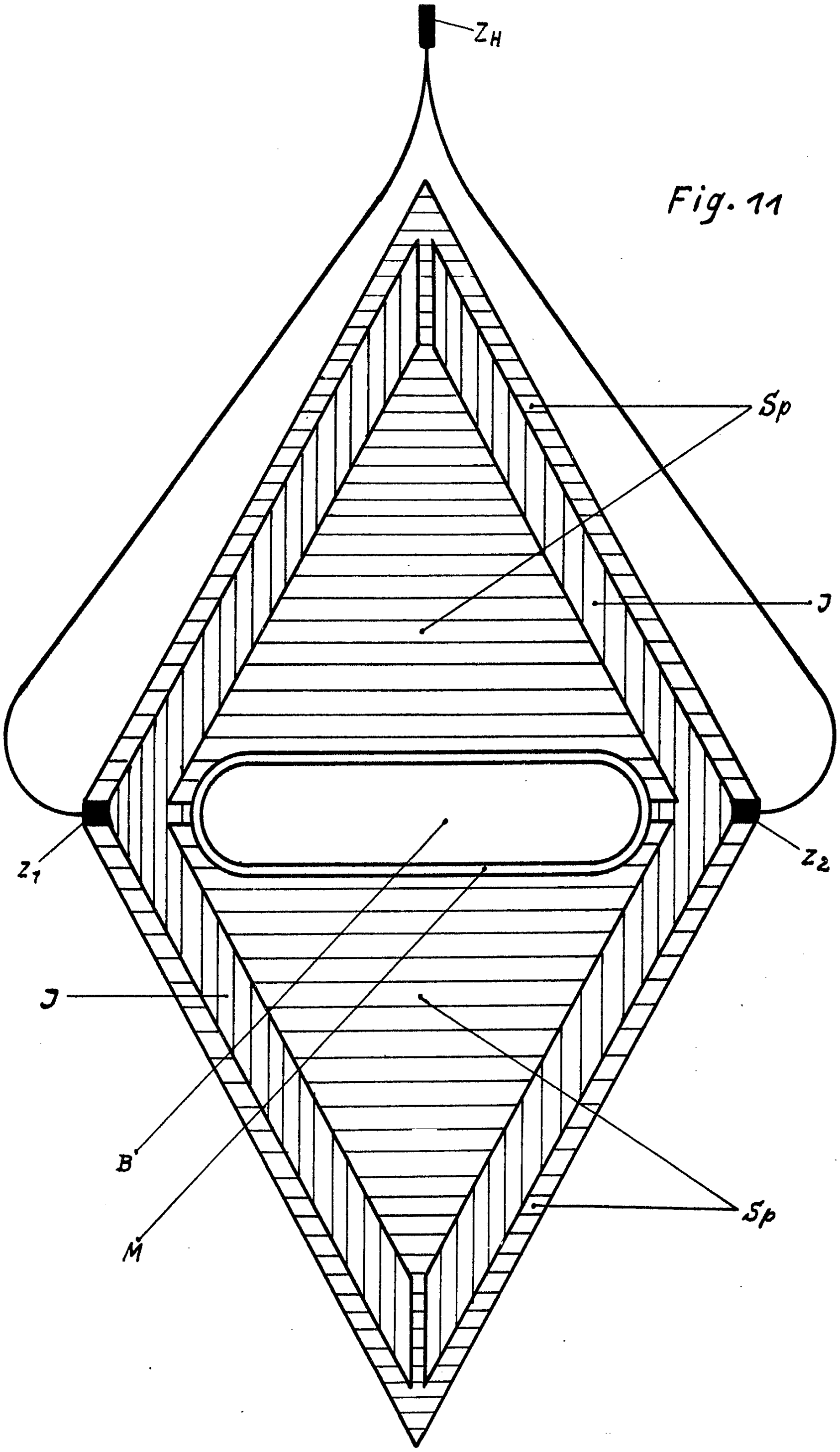

Figure D.592: Figure from Schumann-Trinks patent application showing a biconic implosion bomb.

Bei dem Zusammentreffen der beiden Zündäste wird dann erst der innere Sprengstoffdoppelkegel längs seiner Grundlinie, an welcher die inerte Umhüllung unterbrochen ist, intensiv gezündet. Durch die Wahl der symmetrischen Zündungsäste von den beiden Spitzen des Doppelkegels aus wird eine größere Gleichmäßigkeit mit einer besonders kräftigen Einleitung der Zündung des Hauptkörpers verbunden. Bei dieser Zündung werden nun die Elemente der mittleren Zone des metallischen Hohlzylinders gleichzeitig von der Detonation erfaßt und zur Achse hin beschleunigt. Dort werden nun entweder durch die rasche Kompression einer Gas-oder Dampffüllung oder aber, bei evakuiertem Hohlraum, beim Zusammentreffen der Wandelemente auf der Hohlraumachse hohe Drücke und Temperaturen erzeugt.

Eine im Prinzip ähnliche Anordnung mit zylindrischer Druckkammer B ist in der Fig. 12 dargestellt. Der Unterschied gegenüber der im vorhergehenden beschriebenen besteht erstens darin, daß hier die Druckkammer B an ihren Grundflächen durch starke verdämmende Metallplatten Me abgeschlossen ist, und zweitens die Wellenfront bei der Detonation durch linsenähnliche Sprengstoffanordnungen, beispielsweise aus Trinitrotoluol und Hexogen, weitgehend einer Zylinderfläche angeglichen wird. Die Zündführung Z_f verläuft innerhalb einer Packung aus inertem Material J.

When the two ignition branches meet, the inner explosive double cone is then intensively ignited along its basic line, at which the inert enclosure is interrupted. By selecting the symmetrical ignition branches from the two tips of the double cone, greater uniformity is combined with a particularly powerful introduction of the ignition of the main body. At this time, the elements of the central zone of the metallic hollow cylinder are simultaneously caught by the detonation and accelerated towards the axis. In this case, high pressures and temperatures are generated either by the rapid compression of a gas or steam filling or, in the case of an evacuated cavity, when the wall elements meet on the cavity axis.

A basically similar arrangement with a cylindrical pressure chamber B is shown in Fig. 12. The difference compared to the one described above consists, first, in that the pressure chamber B is terminated at its base surfaces by strong, damming metal plates Me, and second the wavefront is largely matched to a cylinder surface by detonation by means of lens-like explosive arrangements, for example from trinitrotoluene and hexogen. The ignition guide Z_f runs within a pack of inert material J.

Fig. 12

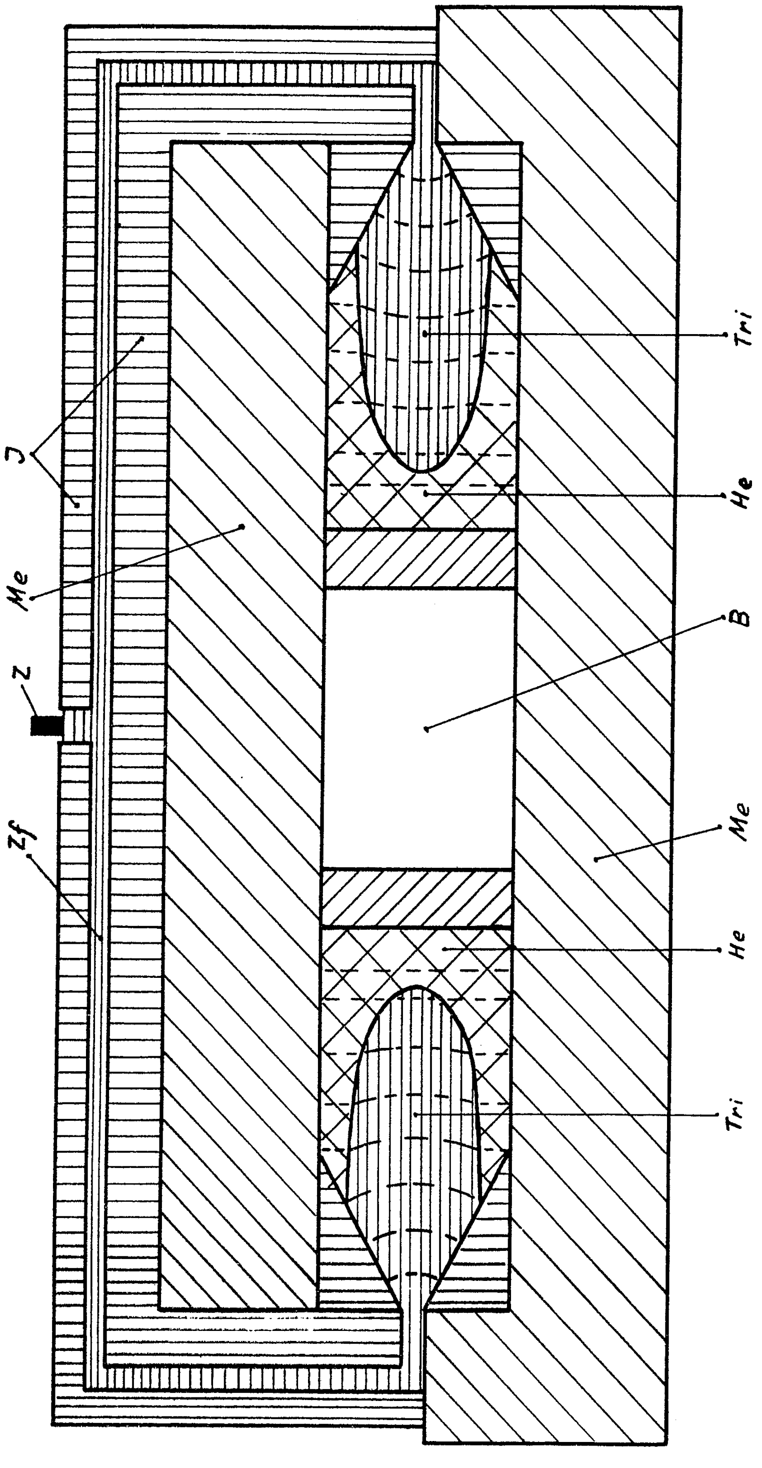

Figure D.593: Figure from Schumann-Trinks patent application showing a cylindrical implosion bomb.

Walter Trinks. German patent DE977862. Vorrichtung nach Patent 977825 zur Behandlung von Material mit hohen Drücken und Temperaturen. Filed 13 August 1952.

Die Verformung und Beschleunigung der Hilfsmasse erfordert eine beträchtliche Energiemenge, die für die Druckerzeugung innerhalb der Kammer verlorengeht. Es besteht daher das Bedürfnis, diese Hilfsmasse aus einem relativ leichten und plastischen Material herzustellen, und es bewährte sich besonders Aluminium.

Auch die Kammerwände kann man ganz oder teilweise aus Aluminium herstellen. [...]

PATENTANSPRUCH:

Vorrichtung nach Patent 977 825 zur Behandlung von Material mit hohen Drücken und Temperaturen, dadurch gekennzeichnet, daß die durch die Detonation zu beschleunigende Masse (und gegebenenfalls die Kammerwand) aus Aluminium besteht.

The deformation and acceleration of the auxiliary mass requires a considerable amount of energy which is lost for the generation of the printer within the chamber. There is therefore a need to manufacture these auxiliary materials from a relatively light and plastic material, and aluminum has proved particularly suitable.

The chamber walls can also be made entirely or partly from aluminum. [...]

PATENT CLAIM:

Apparatus according to patent 977,825 for the treatment of material with high pressures and temperatures, characterized in that the mass to be accelerated by the detonation (and, if appropriate, the chamber wall) consists of aluminum.

Walter Trinks. German patent DE977839. Vorrichtung nach Patent 977825 zur Erzielung hoher Drücke und Temperaturen zwecks Einleitung mechanischer, thermischer oder nuklearer Prozesse mittels einer gleichmaessig mit Sprengstoff belegten, die Reaktionskammer umschliessenden Hohlkugel. Filed 13 August 1952.

PATENTANSPRUCH:

Vorrichtung nach Patent 977 825 zur Behandlung von Material mit hohen Drücken und Temperaturen, dadurch gekennzeichnet, daß mehrere Kugeln mit von innen nach außen zunehmender Wandstärke und Sprengstoffbelegung ineinander angeordnet sind.

PATENT CLAIM:

A device according to patent 977,825 for the treatment of material with high pressures and temperatures, characterized in that a set of spherical shells are arranged concentrically with wall thickness and explosive material increasing from the inside outwards.

Erich Schumann and Walter Trinks. Patent DE977863. Vorrichtung zur Behandlung von Material mit hohen Drücken und Temperaturen. Filed 13 August 1952.

Das Hauptpatent betrifft eine Vorrichtung, um Material zur Einleitung von mechanischen, thermischen oder nuklearen Prozessen auf extrem hohe Drücke und Temperaturen zu bringen. Dabei sieht man eine geschlossene Kammer für das auf die Drücke und Temperaturen zu bringende Material vor und belegt eine jenem Material gegenüberliegende, selbst nicht aus Sprengstoff bestehende Wand der Kammer mit einem Sprengstoff. Die Wand und ihre Sprengstoffbelegung werden so ausgebildet, daß die Wand durch den bei einer Detonation des Sprengstoffes auftretenden Druck auf das genannte Material hin bewegt und in eine zu dem genannten Material hin konkave Form plastisch verformt wird.

Für die Freimachung von Atomenergie auf der Uranbasis ist es von großem Nachteil, daß, abgesehen von dem verhältnismäßig seltenen Vorkommen der Uranerze, ein ganz ungeheurer Aufwand erforderlich ist, um das spaltbare, nur mit ganz geringem Prozentsatz im Uran enthaltene Isotop abzutrennen oder um das ihm gleichwertige Plutonium zu gewinnen.

Bei diesem Sachverhalt ist es von großer Bedeutung, daß außer den Spaltungen der wenig stabilen schweren Kerne, z.B. des Uran 235 oder des Plutoniums, noch andere Kernprozesse existieren, bei denen ebenfalls große Energiebeträge frei werden, wobei jedoch die Ausgangsprodukte dieser Prozesse viel häufiger vorkommen und mit verhältnismäßig geringem Aufwand, z.B. aus Wasser, rein dargestellt werden können.

Es handelt sich hier im Gegensatz zu den Spaltprozessen der schweren Kerne, welche am Ende des periodischen Systems der Elemente stehen, um Reaktionen zwischen den Kernen der leichtesten Elemente, z.B. leichter und schwerer Wasserstoff, Lithium, Beryllium und Bor. [...]

The main patent relates to a device for bringing material to extremely high pressures and temperatures to initiate mechanical, thermal or nuclear processes. In this case, a closed chamber is provided for the material to be subjected to the pressures and temperatures, and a wall of the chamber, which is opposite to the material, is exposed to an explosive. The wall and its explosive coating are formed in such a way that the wall is moved towards the said material by the pressure occurring upon detonation of the explosive and is plastically deformed into a concave shape towards the said material.

For the liberation of atomic energy on the basis of uranium, it is a great disadvantage that, apart from the relatively rare occurrence of the uranium ores, a tremendous effort is required to produce the fissionable, separable small percentage of the isotope contained in the uranium or to obtain the equivalent plutonium.

In this state of affairs it is of great importance that, besides the fission of the less stable heavy nuclei, for example uranium 235 or plutonium, other nuclear processes also exist in which large amounts of energy are also released, but the starting products of these processes are much more common and are produced with relatively little effort, for example from water.

Here, in contrast to the fission processes of the heavy nuclei, which are at the end of the periodic table of the elements, in order to establish reactions between the nuclei of the lightest elements, for example light and heavy hydrogen, lithium, beryllium and boron. [...]

Temperaturen und Drucke der erforderlichen Höhe lassen sich experimentell und kurzzeitig mit sprengphysikalischen Mitteln erreichen und zur Einleitung und Durchführung von Atomkernreaktionen verwenden, wenn man die in dem Patent 977 825 beschriebenen Vorrichtungen zur Erzeugung höchster Drücke und Temperaturen nutzbar macht.

[...] Eine andere Form der Druckkammer besteht gemäß Fig. 4 in einer mit der zu behandelnden Substanz angefüllten, in brisanten Sprengstoff *Sp* eingebetteten Hohlkegel *B*, beispielsweise aus Eisen, Kupfer, Zink, Aluminium, Blei, Wolfram, Graphit od. dgl., deren Wandung gleichzeitig als zu beschleunigende Hilfsmasse dient. Die Schrumpfung des Innenraumes bei gleichzeitiger Zündung der auf der Oberfläche der Sprengstoffumhüllung angeordneten Zünder *Z* macht das Auftreten enormer Beschleunigungen verständlich.

Zur Glättung der Detonationsfront und zur Anpassung derselben an die Außenoberfläche der Kugel in der Umgebung der einzelnen Zündstellen können auch hier Linsen aus Sprengstoffen mit verschiedenen Detonationsgeschwindigkeiten angeordnet sein.

Zur Verlängerung der Einwirkungszeit können zwei oder mehrere der Hohlkugeln ineinandergeschachtelt sein, wobei Wandstärke und Sprengstoffbelegung der jeweils folgenden äußeren Hohlkugel stärker dimensioniert sind als diejenigen der jeweils vorhergehenden inneren Hohlkugel. [...]

Wird z.B. ½ Kubikmeter schweren Wasserstoffgases vom Anfangsdruck 0,1 at, das sind rund 9 g, nach den Reaktionsgleichungen

Temperatures and pressures of the required magnitude can be obtained experimentally and for short times by explosive-physical means and can be used to initiate and carry out atomic nuclear reactions if the devices described in patent 977,825 are used to generate the highest pressures and temperatures.

[...] According to Fig. 4, another form of the pressure chamber consists of a hollow cone *B*, which is filled with the substance to be treated and is embedded in explosive explosive *Sp*, for example of iron, copper, zinc, aluminum, lead, tungsten, graphite or the like, at the same time serves as an auxiliary mass to be accelerated. The shrinkage of the interior while simultaneously igniting the detonator *Z* located on the surface of the explosive envelope makes it possible to achieve enormous accelerations.

For smoothing the detonation front and adapting it to the outer surface of the ball in the vicinity of the individual ignition points, here, too, lenses of explosives with different detonation velocities can be arranged.

To prolong the exposure time, two or more of the hollow spheres can be nested within each other. Both the wall thickness and the thickness of the explosive liner of the next outer hollow sphere must be shaped larger than those of the preceding inner hollow spheres. [...]

For example, ½ cubic meter of deuterium gas with the initial pressure 0.1 atmosphere, which is about 9 g, according to the reaction equations becomes

$$ {}^{2}_{1}\mathrm{D} + {}^{2}_{1}\mathrm{D} = {}^{3}_{2}\mathrm{He} + {}^{1}_{0}\mathrm{n} + 3.3\,\mathrm{MeV} \tag{D.4} $$

und

and

$$ {}^{2}_{1}\mathrm{D} + {}^{2}_{1}\mathrm{D} = {}^{3}_{1}\mathrm{H} + {}^{1}_{1}\mathrm{H} + 4.0\,\mathrm{MeV} \tag{D.5} $$

[...] Ferner ist zu beachten, daß bei den dann erreichten hohen Temperaturen auch andere Kernprozesse genügend wahrscheinlich werden, so daß sie mit zur Energieerzeugung herangezogen werden können.

[...] It should also be noted that, in the case of the then high temperatures, other nuclear processes become sufficiently probable so that they can be used for the generation of energy.

Bei Anwesenheit von Protonen wird z.B. auch die sehr energiereiche Reaktion

In the presence of protons, for example, also the very energetic reaction

$$ {}^{3}_{1}\mathrm{Tr} + {}^{1}_{1}\mathrm{H} = {}^{4}_{1}\mathrm{He} + 20\ \mathrm{MeV} \tag{D.6} $$

stattfinden, welche nach den Deuteronenprozessen die wahrscheinlichste Kernreaktion ist, oder bei Anwesenheit von Lithium die Reaktionen

takes place, which is the most probable nuclear reaction after the deuteron processes, or the reactions in the presence of lithium

$$ {}^{7}_{3}\mathrm{Li} + {}^{1}_{1}\mathrm{H} = 2\,{}^{4}_{2}\mathrm{He} + 17\ \mathrm{MeV} \tag{D.7} $$

und

and

$$ {}^{6}_{3}\mathrm{Li} + {}^{2}_{1}\mathrm{D} = 2\,{}^{4}_{2}\mathrm{He} + 22.5\ \mathrm{MeV} \tag{D.8} $$

sowie

just as

$$ {}^{7}_{3}\mathrm{Li} + {}^{2}_{1}\mathrm{D} = 2\,{}^{4}_{2}\mathrm{He} + {}^{1}_{0}\mathrm{n} + 15\ \mathrm{MeV} \tag{D.9} $$

welch letztere wiederum Neutronen befreit.

which in turn liberates neutrons.

Die Deuteronenprozesse spielen dann vergleichsweise die Rolle des leicht entzündlichen Zündholzes, das die schwerer entzündlichen Brennstoffe anzündet.

The deuteron processes then play comparatively the role of the highly flammable match that ignites the heavy flammable fuel.

Diesem Umstand kann man gemäß der Erfindung dadurch nutzbringend Rechnung tragen, daß man zugleich mit der Füllung der anzuwendenden Druckzellen mit Wasserstoff, insbesondere schwerem Wasserstoff, andere leichte Elemente, z.B. Lithium, Beryllium, Bor oder auch leichten Wasserstoff als Elemente oder in Form von chemischen Verbindungen an der Innenwand der Druckzellen oder auch in der Wand der Druckzellen, durch dünne Schichten vom Innenraum getrennt, zur Anwendung bringt. So empfiehlt sich beispielsweise die Verwendung von schwerem Lithiumhydrid (LiD).

According to the invention, this circumstance can be taken advantage of by virtue of the fact that, at the same time as the filling of the pressure cells to be applied with hydrogen, in particular heavy hydrogen, other light elements, for example, lithium, beryllium, boron or also light hydrogen as elements or in the form of chemical compounds on the inner wall of the pressure cells or also in the wall of the pressure cells, separated from the inner space by thin layers. For example, the use of heavy lithium hydride (LiD) is recommended.

Insgesamt wird so die Befreiung eines Energiebetrages möglich, der die zur Einleitung dieser Kernreaktionen aufzuwendende chemische Energie des Sprengstoffes (ungefähr 10^{16} erg) sehr beträchtlieh überschreitet.

Auch die bei der einen der D-Kernreaktionen frei werdenden Neutronen können zur weiteren Befreiung von Energie herangezogen werden. Die Reaktion

In general, the liberation of an energy supply is possible, which greatly exceeds the chemical energy of the explosive (about 10^{16} erg) to be expended for the initiation of these nuclear reactions.

The neutrons released in one of the D nuclear reactions can also be used to further release energy. The reaction

$$ {}^{6}_{3}\mathrm{Li} \; + \; {}^{1}_{0}\mathrm{n} \quad = \quad {}^{3}_{1}\mathrm{Tr} \; + \; {}^{4}_{2}\mathrm{He} \tag{D.10} $$

würde z.B. auf Grund der Massenbilanz die Energie von 4,7 MeV befreien, oder die entsprechende Reaktion mit Bor

would, for example, free the energy of 4.7 MeV on account of the mass balance, or the corresponding reaction with boron

$$ {}^{10}_{5}\mathrm{B} \; + \; {}^{1}_{0}\mathrm{n} \quad = \quad {}^{7}_{3}\mathrm{Li} \; + \; {}^{4}_{2}\mathrm{He} \tag{D.11} $$

würde ungefähr 3 MeV freisetzen.

Ferner kann man die bei der Deuteronenreaktion frei werdenden Neutronen dazu benutzen, die Spaltung des U^{235} in dem natürlichen Uran, also dem gewöhnlichen Isotopengemisch, vorzunehmen.

Wenn die Innenwand der das Deuterium enthaltenden Druckzelle mit einer genügend starken Graphitschicht ausgekleidet wird, auf die eine Schicht Uran folgt, werden die frei werdenden Neutronen mit sehr hohem Energiegehalt auf thermische Neutronen abgebremst, ehe sie die Uranschicht erreichen. Dort werden sie dann nicht vom U^{238} eingefangen, sondern können an dem U^{235} die Spaltung hervorrufen. Man müßte dann nur, wie in allen Fällen, in denen die frei werdenden Neutronen herangezogen werden sollen, durch eine geeignete Außenhülle der anzuwendenden Druckzellen ein Entweichen nach außen verhindern, ähnlich wie dies bei den Atombomben durch den sogenannten “Tamper” geschieht.

would release about 3 MeV.

Furthermore, the neutrons liberated in the deuteron reaction can be used to carry out the fission of U^{235} in natural uranium, that is, the ordinary isotope mixture.

When the inner wall of the pressure cell containing the deuterium is lined with a sufficiently strong graphite layer followed by a layer of uranium, the liberating neutrons with a very high energy content are decelerated to thermal neutrons before they reach the uranium layer. There they are not caught by the U^{238}, but can cause the fission of the U^{235}. As in all cases in which the neutrons which are liberated are released, it is only necessary to prevent the escape from the outside by means of a suitable outer shell of the pressure cells to be applied, similar to that of the atom bombs by the so-called “tamper.”

Man kann auch die frei werdenden Neutronen aus den D-Kernreaktionen zunächst zu einer unmittelbaren Temperatursteigerung im Zentrum der Druckzelle benutzen, indem man dort eine winzige Menge Cadmium anbringt, welches die Neutronen unter Erhitzung absorbiert.

Wesentlich wichtiger als die Befreiung von Atomenergie zu militärischen Zwecken ist die Herstellung und Verwendung von Neutronen für friedliche Aufgaben.

Auf die Bedeutung und die große Intensität der bei der Umsetzung von Deuterium entstehenden Neutronenstrahlung wurde bereits weiter vorn hingewiesen. Hier sei nur noch hinzugefügt, daß selbst, wenn mit Hilfe des beschriebenen Verfahrens nur eine Temperatur von 2 Millionen Grad erreichbar wäre, aus nur 2 g schwerem Wasserstoff während 1 zehntausendstel sec nach den Resultaten von Bethe sowie Gamow und Teller ungefähr $3 \cdot 10^{21}$ Neutronen frei gemacht werden, was etwa 10^{18} Curie bzw. einer Radium-Berylliumquelle von rund 1 Milliarde kg entspricht. Eine starke Hochspannungsanlage würde 350 Jahre benötigen, um diese Neutronenmenge zu erzeugen.

Derartige Neutronenintensitäten sind bisher nur in den “Uran-piles” beobachtet worden. Ihre Erzeugung erfordert dort jedoch einen unvergleichlich größeren Aufwand, als er bei dem vorgeschlagenen Verfahren erforderlich ist.

PATENTANSPRÜCHE:

1. Vorrichtung nach Patent 977 825 zur Behandlung von Material mit hohen Drücken und Temperaturen, dadurch gekennzeichnet, daß die Wandung der Wasserstoff, insbesondere schweren Wasserstoff, enthaltenden Druckzelle leichte Elemente, wie Lithium, Beryllium, Bor oder leichten Wasserstoff als Element oder in gebundener Form aufweist.

It is also possible to use the free neutrons from the deuterium nuclear reactions for a direct increase in temperature at the center of the pressure cell by applying a minute quantity of cadmium which absorbs the neutrons while heating.

Essentially more important than the liberation of nuclear energy for military purposes is the production and use of neutrons for peaceful tasks.

The importance and the great intensity of the neutron radiation generated during the reaction of deuterium has already been pointed out before. In this case, it should be added that even if, by means of the method described, only a temperature of 2 million degrees is attainable, from only 2 g of heavy hydrogen is formed during one ten-thousandth of a second, according to the results of Bethe, and Gamow and Teller, approximately $3 \cdot 10^{21}$ neutrons, which is about 10^{18} Curie, or corresponding to a radium-beryllium source of around one billion kg. A strong high-voltage system would take 350 years to produce this neutron quantity.

Such neutron intensities have hitherto been observed only in “uranium piles.” However, their production requires an incomparably greater effort there than is required in the proposed method.

PATENT CLAIMS:

1. Apparatus according to patent 977,825 for the treatment of material with high pressures and temperatures, characterized in that the wall of the pressure cell containing hydrogen, in particular heavy hydrogen, has light elements, such as lithium, beryllium, boron or light hydrogen as element or in bound form.

2. Vorrichtung nach Anspruch 1, dadurchgekennzeichnet, daß die leichten Elemente die Innenwand der Zelle bedecken.	2. Device according to Claim 1, characterized in that the light elements cover the inner wall of the cell.
3. Vorrichtung nach Anspruch 2, dadurch gekennzeichnet, daß die leichten Elemente durch eine dünne Schicht abgedeckt sind.	3. Device according to Claim 2, characterized in that the light elements are covered by a thin layer.
4. Vorrichtung nach Anspruch 1 oder folgenden, dadurch gekennzeichnet, daß die Wand wenigstens teilweise aus Uran, insbesondere natürlichem Uran, besteht.	4. Device according to Claim 1 or the following, characterized in that the wall is at least partly of uranium, in particular of natural uranium.
5. Vorrichtung nach Anspruch 4, dadurch gekennzeichnet, daß das Uran durch Graphit abgedeckt ist.	5. Device according to Claim 4, characterized in that the uranium is covered by graphite.

Top Secret Cable from Warsaw to Secretary of State. 7 March 1946 [NARA RG 77, Entry UD-22A, Box 160, Folder 205.2 Cables Incoming, Top Secret]

From: Warsaw

To: Secretary of State

Nr: 300 7 March 1946

Nr 300. Signed Lane.

Information has been given this Embassy by a capable young engineer working in the zinc industry, that one of the best if not the only material for atomic bomb containers is cadmium. According to the informant the cadmium output of Poland in 1945 amounted to 49.15 tons, and in January of 1946 to 10.9 tons. In 1945 there was exported to Russia the total Polish cadmium output.

End

ACTION: General Groves

INFO: General Spaatz, General Hull, General Vandenberg

[See document photo on p. 4256.

A “capable young engineer” in Poland stated that atomic bomb case designs use a layer of cadmium, apparently based on his personal experience in the wartime German program. That detail is highly consistent with the bomb descriptions given by Schumann and Trinks (above) and also by Ilyichev (p. 4485).]

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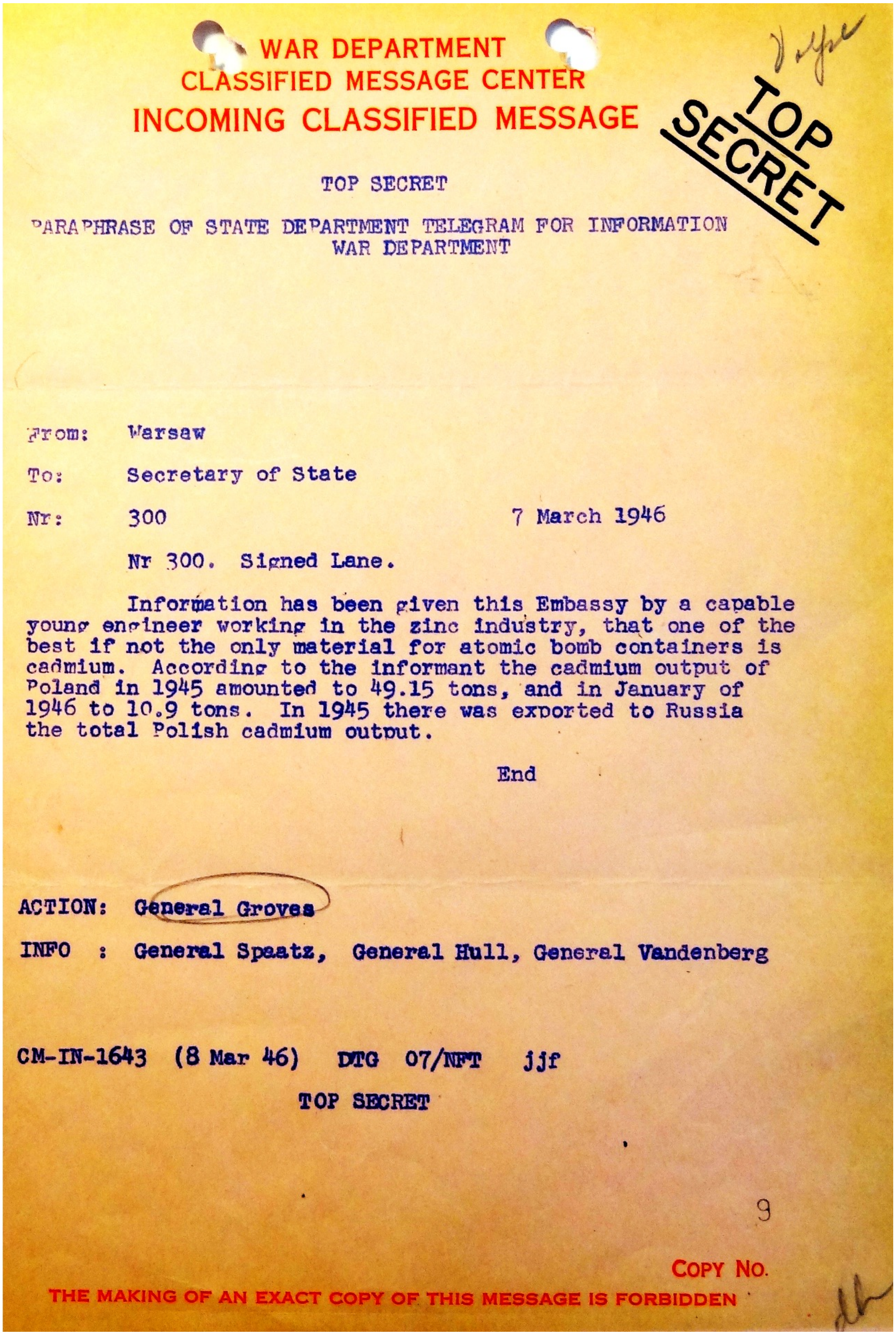


WAR DEPARTMENT
CLASSIFIED MESSAGE CENTER
INCOMING CLASSIFIED MESSAGE

TOP SECRET

TOP SECRET

PARAPHRASE OF STATE DEPARTMENT TELEGRAM FOR INFORMATION
WAR DEPARTMENT

From: Warsaw

To: Secretary of State

Nr: 300 7 March 1946

Nr 300. Signed Lane.

Information has been given this Embassy by a capable young engineer working in the zinc industry, that one of the best if not the only material for atomic bomb containers is cadmium. According to the informant the cadmium output of Poland in 1945 amounted to 49.15 tons, and in January of 1946 to 10.9 tons. In 1945 there was exported to Russia the total Polish cadmium output.

End

ACTION: General Groves

INFO : General Spaatz, General Hull, General Vandenberg

CM-IN-1643 (8 Mar 46) DTG 07/NFT jjf

TOP SECRET

9

COPY NO.

THE MAKING OF AN EXACT COPY OF THIS MESSAGE IS FORBIDDEN

NARA RG 77, Entry UD-22A, Box 160,
Folder 205.2 Cables Incoming, Top Secret

Figure D.594: Top Secret Cable from Warsaw to Secretary of State. 7 March 1946 [NARA RG 77, Entry UD-22A, Box 160, Folder 205.2 Cables Incoming, Top Secret].

Walter Trinks. Undated but probably summer 1945. [NARA RG 319, Entry A1-134B, Box ??, Folder XE098301 Trinks, Walter]

Dr. Walter Trinks
Int. No. 8-3448-M-AA
7th Coy.

TO THE AMERICAN COMMAND OF THE INTERNMENT CAMP? CIC-STAFF.

When I was imprisoned at Bad Aibling an American officer in an address asked German scientists and specialists to present themselves. Having presented myself I was told to give further written information on my altuition [education] and my career. Having been transferred to this camp I could not do so. I am a Physicist and have been employed with the OKH [Oberkommando des Heeres] until the end of the war in the research dept. of the office for arms [Heereswaffenamt] as referee for the physics of explosions and blasting. The tasks of that dept. included:

1st Research of physical phenomena at the explosion

2nd Augmentation of and defense against the effect of blasting materials through physical methods

3rd Research of difficulties and troubles.

4th The replacement of valuable raw materials.

During the war the principal labor was dedicated to the principle of hollow charges and its use in armour breaking amunition as F-I-7,5 cm grenade, HL(ABC), 10 cm G.Hl, rifle grenade, Panzerfaust and Panzerschreck, Panzerhandgrenade, Redcap, Magnetic H 3 and H 15.

At the end of the war I was occupied with experiments for producing extreme high pressures and temperatures, extreme velocities (up to 15 km/sec) and heavy swingings of the air [shock waves]. The practical use of these researches comprises:

1st for the war: the defense against V-weapons super- and atomic bombs by destroying them before they reach their target and the initiation of atomic bombs.

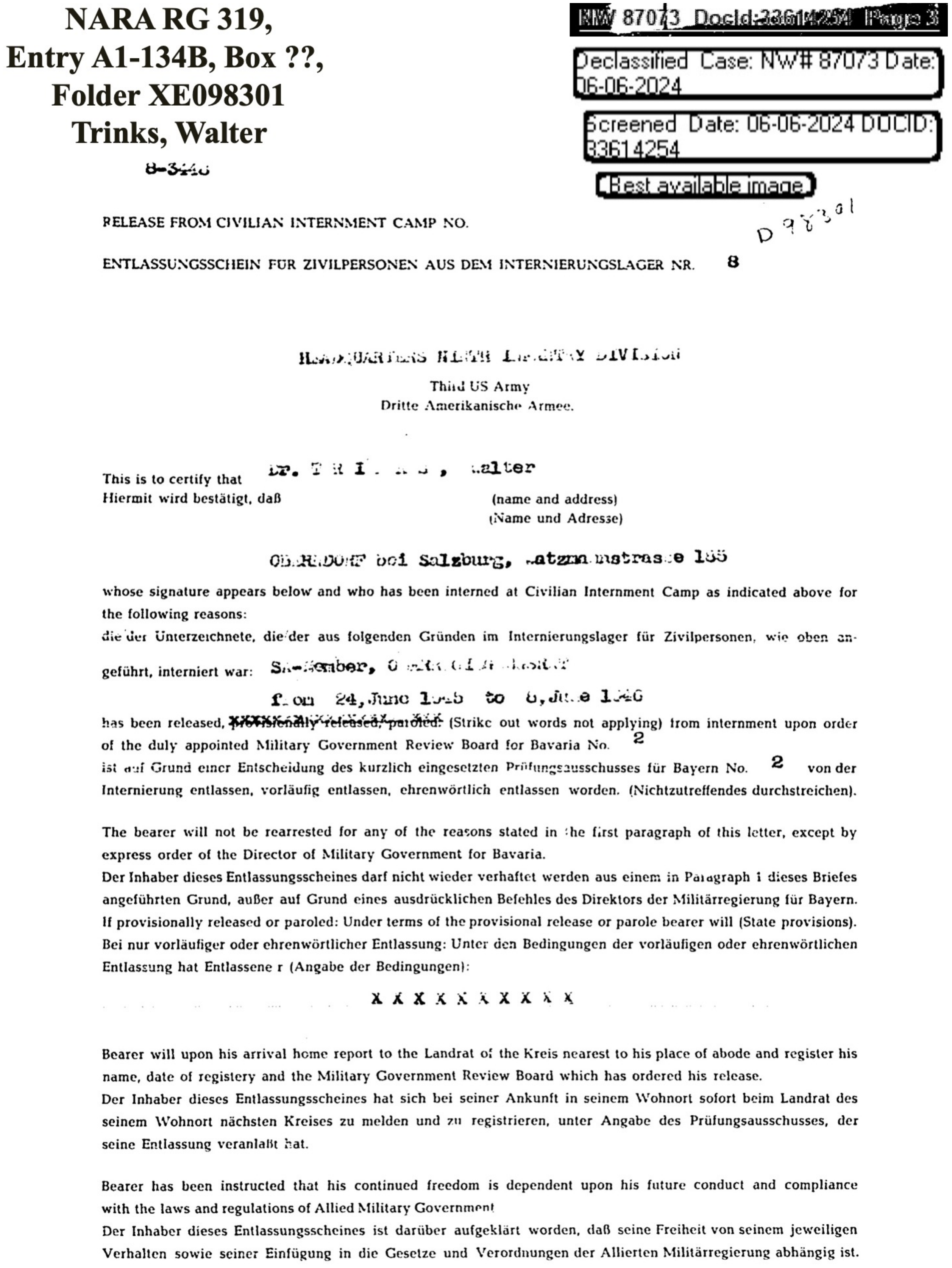
2nd for peacetime: the producing of artificial diamonds and the enriching of minerals and materials.

3rd for purely scientific research of special molecules and atoms under extreme pressures and temperatures.

I esteem these researches to be important and promising and therefore ask to be allowed to prosecute them at the service of the U.S.A.

[See document photos on pp. 4258–4259. Due to the number of English spelling and capitalization mistakes, this document appears to have been written in English by Trinks himself, not translated by a native English speaker. For ease of understanding, I have corrected most of the document's English mistakes in the above transcription.

Trinks was imprisoned by the U.S. Army from June 1945 to June 1946, and he informed them that "At the end of the war I was occupied with experiments for... the initiation of atomic bombs." Where are the detailed reports on his interrogations and everything he told U.S. officials about his wartime work? What exactly did he work on after the war, and for whom?]



NARA RG 319,
Entry A1-134B, Box ??,
Folder XE098301
Trinks, Walter

8-3446

NW 87073 DocId:33614254 Page 3

Declassified Case: NW# 87073 Date: 06-06-2024

Screened Date: 06-06-2024 DOCID: 33614254

Best available image

D 98301

RELEASE FROM CIVILIAN INTERNMENT CAMP NO.

ENTLASSUNGSSCHEIN FÜR ZIVILPERSONEN AUS DEM INTERNIERUNGSLAGER NR. 8

HEADQUARTERS NINTH INFANTRY DIVISION
Third US Army
Dritte Amerikanische Armee.

This is to certify that Dr. TRINKS, Walter
Hiermit wird bestätigt, daß (name and address)
(Name und Adresse)

OBERNDORF bei Salzburg, Watzmannstrasse 155

whose signature appears below and who has been interned at Civilian Internment Camp as indicated above for the following reasons:
die/der Unterzeichnete, die/der aus folgenden Gründen im Internierungslager für Zivilpersonen, wie oben angeführt, interniert war: SA-Member, O[illegible]

from 24, June 1945 to 6, June 1946

has been released, ~~provisionally released, paroled.~~ (Strike out words not applying) from internment upon order of the duly appointed Military Government Review Board for Bavaria No. 2
ist auf Grund einer Entscheidung des kurzlich eingesetzten Prüfungsausschusses für Bayern No. 2 von der Internierung entlassen, vorläufig entlassen, ehrenwörtlich entlassen worden. (Nichtzutreffendes durchstreichen).

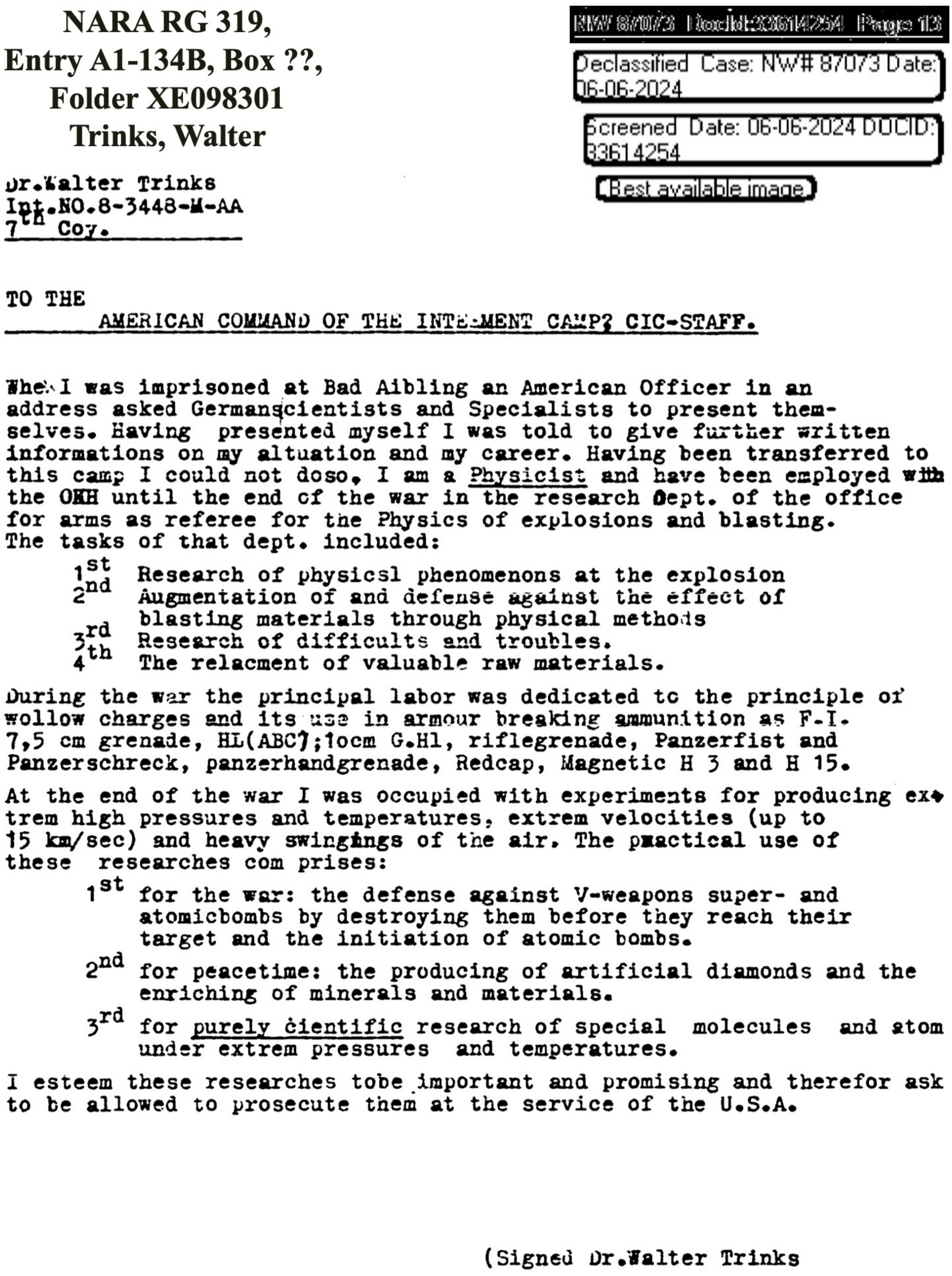
The bearer will not be rearrested for any of the reasons stated in the first paragraph of this letter, except by express order of the Director of Military Government for Bavaria.
Der Inhaber dieses Entlassungsscheines darf nicht wieder verhaftet werden aus einem in Paragraph 1 dieses Briefes angeführten Grund, außer auf Grund eines ausdrücklichen Befehles des Direktors der Militärregierung für Bayern.
If provisionally released or paroled: Under terms of the provisional release or parole bearer will (State provisions).
Bei nur vorläufiger oder ehrenwörtlicher Entlassung: Unter den Bedingungen der vorläufigen oder ehrenwörtlichen Entlassung hat Entlassene r (Angabe der Bedingungen):

X X X X X X X X X X

Bearer will upon his arrival home report to the Landrat of the Kreis nearest to his place of abode and register his name, date of registery and the Military Government Review Board which has ordered his release.
Der Inhaber dieses Entlassungsscheines hat sich bei seiner Ankunft in seinem Wohnort sofort beim Landrat des seinem Wohnort nächsten Kreises zu melden und zu registrieren, unter Angabe des Prüfungsausschusses, der seine Entlassung veranlaßt hat.

Bearer has been instructed that his continued freedom is dependent upon his future conduct and compliance with the laws and regulations of Allied Military Government
Der Inhaber dieses Entlassungsscheines ist darüber aufgeklärt worden, daß seine Freiheit von seinem jeweiligen Verhalten sowie seiner Einfügung in die Gesetze und Verordnungen der Allierten Militärregierung abhängig ist.

Figure D.595: Walter Trinks was imprisoned by the U.S. Army from June 1945 to June 1946. Where are the detailed reports on his interrogations and everything he told U.S. officials about his wartime work? [NARA RG 319, Entry A1-134B, Box ??, Folder XE098301 Trinks, Walter]



NARA RG 319, Entry A1-134B, Box ??, Folder XE098301 Trinks, Walter

Dr.Walter Trinks
Int.NO.8-3448-M-AA
7th Coy.

TO THE
AMERICAN COMMAND OF THE INTE-MENT CAMP? CIC-STAFF.

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3rd for purely cientific research of special molecules and atom under extrem pressures and temperatures.

I esteem these researches tobe important and promising and therefor ask to be allowed to prosecute them at the service of the U.S.A.

(Signed Dr.Walter Trinks

Figure D.596: During his imprisonment by the U.S. Army, Walter Trinks informed U.S. officials that “At the end of the war I was occupied with experiments for... the initiation of atomic bombs.” Where are the detailed reports on his interrogations and everything he revealed about his wartime work? What exactly did he work on after the war, and for whom? [NARA RG 319, Entry A1-134B, Box ??, Folder XE098301 Trinks, Walter].

Kurt Diebner. UK Patent 841,387. Thermonuclear Reactions. Filed 30 November 1956.

I, Kurt Diebner, of Eppendorfer Stieg 8, Hamburg 39, Germany, of German nationality do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:–

This invention relates to a method for the ignition of the thermonuclear fuels deuterium and tritium.

Amongst known attempts for the generation of very high temperatures, two in particular promise to be successful, of which each one currently permits when using a suitable arrangement, the attainment of temperatures of the order of 10^5 °K to 10^6 °K and over. One of these methods is the generation of converging shock waves through suitable ignition of an explosive in the form of a hollow body at its outer shell. The other method consists in generating highly ionised gases by concentrated discharges and making use of the pinch- effect in a restricted space. One possible method of execution recorded in the literature is given by an electric arc burning between two carbon electrodes, between which a condenser battery of high capacity and with a high voltage charge is briefly short-circuited.

The present invention consists in a method for the ignition of the thermonuclear fuels deuterium and tritium, to initiate thermonuclear reactions, wherein converging compression shock waves are produced in a hollow body by solid or liquid explosives, the generation of high temperatures in the centre of convergence of the shock waves being combined with an increase of temperature generated by concentrated electrical discharges in the fusionable nuclear fuels so that the temperature raising effects are superimposed and temperatures necessary for fusion processes are produced at the centre of the converging shock wave.

The invention further consists in a method for the ignition of thermonuclear fuels to promote thermonuclear reactions therein, which consists in detonating an explosive charge in the form of a hollow body surrounding the thermonuclear fuel, thereby generating a converging shock wave in the interior thereof, and creating a concentrated electrical discharge in the thermonuclear fuel at the centre of convergence of the shock wave in order to attain a temperature sufficient for the ignition of the thermonuclear fuel.

In the accompanying drawings:–

Figure 1 is a diagrammatic view of apparatus for carrying out the method according to the present invention, and

Figure 2 shows a wiring diagram for the apparatus of figure 1.

In carrying the invention into effect according to one convenient mode by way of example, reference 1 (figure 1) denotes an explosive body of spherical shell shape provided with two openings in the shape of a truncated cone, in which a spherically shaped high pressure container 5 is embedded for the uptake of the deuterium 2, perhaps in gaseous form under very high pressure. The spherically shaped high pressure container can however also be dispensed with, and the deuterium can be incorporated directly under pressure into the explosive material. The explosive body 1 can be surrounded by a further spherical shell 6, which tamps the explosive body towards the outside. Two insulated electrodes, for example lithium (lithium 6), between which an electric arc 4 can burn, are introduced into the high pressure container 5. For this purpose the electrode material should have a low nuclear charge number and be as thin as possible in order to maintain at a low level the larger proton reflection with its related higher nuclear charge number. Lithium 6 is furthermore particularly suitable because with it tritium is formed in the thermonuclear combustion process.

Fig. 1

Fig. 2

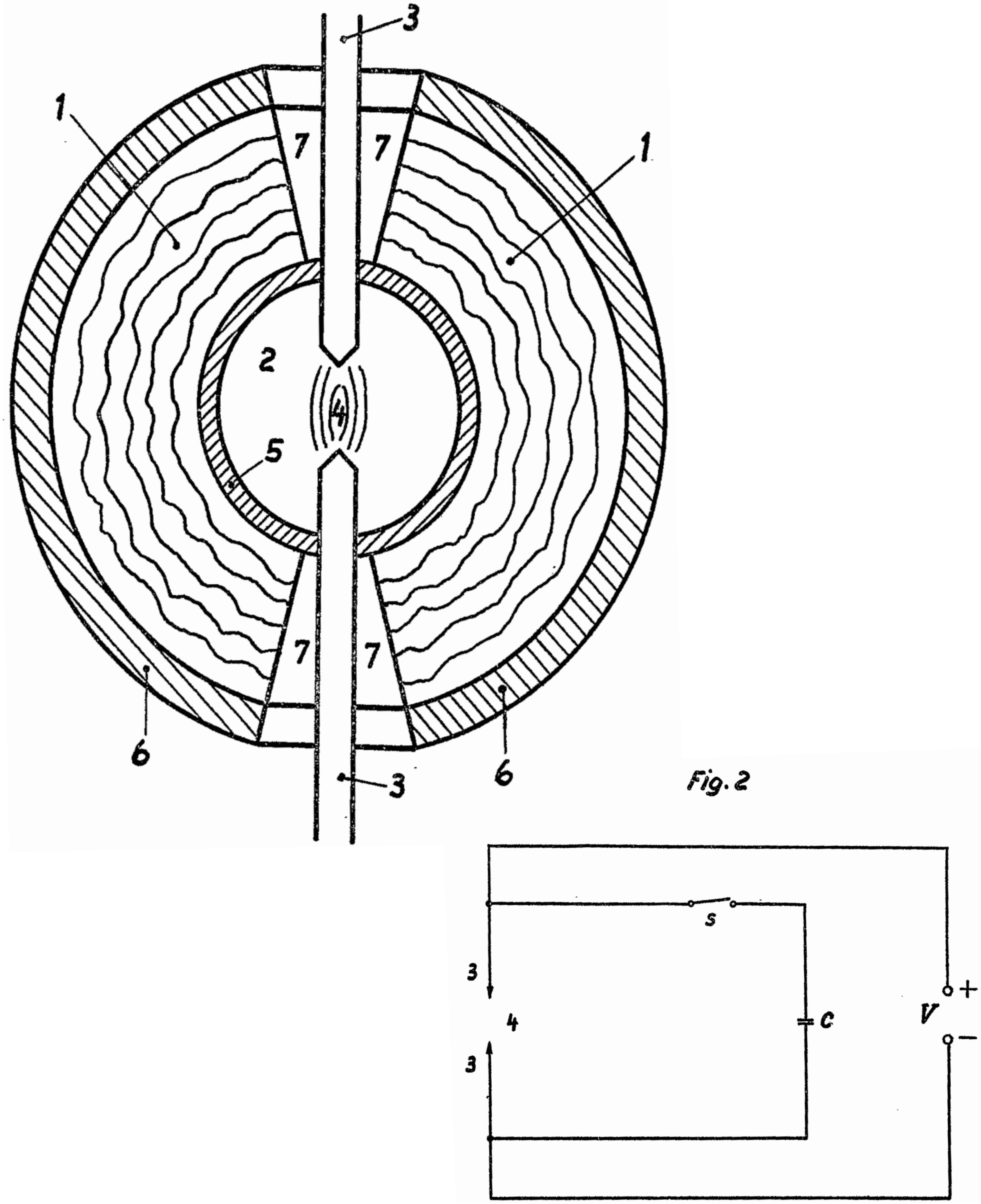


Figure D.597: Figures from Kurt Diebner's U.K. Patent 841,387.

An example is shown in Figure 2 of an electric connection for the electric arc and the connected condenser, in which C represents a condenser. S is a suitable switch which can connect the condenser to the electric arc. V is the source of tension for the electric arc 4. The release of the thermonuclear reaction in the deuterium gas 2 is now to proceed as follows:

The explosive material is so ignited at the boundary surface between 6 and 1, that a converging shock wave results, which after exceeding the boundary surface 5, runs towards the centre of the electric arc 4, and there contributes to an increase of the temperature of the already burning electric arc. The electric arc burns thereby in a gas of high pressure, so that under these circumstances it can already operate on its own at temperatures of the order of 10,000 degrees and more.

The height of the temperature to be reached in the moment when the shock wave reaches the centre of convergence 4, depends amongst other things on the geometry of the arrangement, and on the explosive material used (trinitrotoluol or hexogen or others). It also depends on whether a high pressure container 5 is used, and the material from which it is composed, as well as finally on the temperature, power and shape of the electric arc.

When the shock wave has reached the centre of convergence, further suitable measures are provided according to Figure 1, which permit further considerable heating of the gas (plasma) which is under the highest pressure and which has thereby become highly conductive. Because of this in the example provided, a further additional heating of the deuterium by the electric spark follows, directly before the compression shock reaches in its last phase the centre of convergence. Through this combination of the various methods in an appropriate sequence it is possible to attain the highest temperatures during the arrival of the shock wave in the centre of convergence. A further condition is that the electrodes are still active at the moment of the setting in of the discharge. Since it is an electrical process which is being dealt with, when the condenser C which has been charged with high voltage is suddenly discharged, and since on the other hand the deuterium gas in the electric arc 4 is already extensively pre-ionised, it is possible to add at least partially, to the convergence centre, the energy accumulated in the condenser. Furthermore, at the moment of connecting the condenser, because of the magnetic effects in the discharge path, an adiabatic contraction of the highly ionised plasma in the sense of the pinch-effect takes place, which has the effect of raising the temperature. In the given circumstances it is merely a question of the amount of energy accumulated in the condenser and which is available for the continuation of the working process, and the temperature in the convergence centre 4 can be increased additionally to such an extent, that the added energy is great enough to allow the thermonuclear ignition of the deuterium gas to take place.

Besides the given example, temperature effects can be superposed or supplemented, additional consideration being taken of an adiabatic compression and suitable temporal sequence with combination of gas discharges, spark discharges, a mechanically or chemically generated adiabatic compression, detonation wave or some of them, which are suitable for producing the temperatures necessary for the ignition of the gaseous, liquid, and if need be solid thermonuclear fuels. It is also possible for example, to fill the space 7 with liquid deuterium, tritium or D_2O, in the manner that the deuterium 2 serves as initiator for further larger quantities of thermonuclear fuel. Installations with half spherical-hollow bodies can also be constructed, which can also cause the ignition of the thermonuclear fuel, in the convergence centre,—such a fuel corresponding to the deuterium 2—and/or to use the latter for the initial ignition of further quantities of the same or of other thermonuclear fuels. Any other form of hollow body which permits the production of a suitable converging compression shock under suitable ignition is also admissible according to the purposes for which the ignited thermonuclear fuel is to be used, whereby it is particularly to be noted, that these installations can also be used to produce thermonuclear reactions which do not lead or need not lead to ignition.

It is also conceivable, for example, for deuterium enclosed in a volume, to be preheated by adiabatic compression, electrical discharges or any other means, and then to be ignited by a linear and/or if necessary converging compression shock, or else to achieve this with adiabatically pre-heated thermonuclear fuel, using concentrated electrical discharges. Such installations as mentioned in the last example are suitable when their intermittent activity is controlled for the production of mechanical energy. The process explained in Figure 1 can also be carried out in a large pressure container and thus be suitable for maintaining in this large boiler, pressures and/or temperatures required for energy withdrawal or energy generation for certain purposes. This can take place during the intermittent or continuous running of several such processes, respectively repeated any number of times, whereby temperatures and/or pressures can be added to any desired purpose, such as heat engines, the drive of turbines, and others.

What I claim is:–

l. A method for the ignition of the thermonuclear fuels deuterium and tritium, to initiate thermonuclear reactions, wherein converging compression shock waves are produced in a hollow body by solid or liquid explosives, the generation of high temperatures in the centre of convergence of the shock waves being combined with an increase of temperature generated by concentrated electrical discharges in the fusionable nuclear fuels so that the temperature-raising effects are superimposed and temperatures necessary for fusion processes are produced at the centre of the converging shock waves.

2. A method for the ignition of thermonuclear fuels to promote thermonuclear reactions therein, which consists in detonating an explosive charge in the form of a hollow body surrounding the thermonuclear fuel, thereby generating a converging shock wave in the interior thereof, and creating a concentrated electrical discharge in the thermonuclear fuel at the centre of convergence of the shock wave in order to attain a temperature sufficient for the ignition of the thermonuclear fuel.

3. A method as claimed in claim 1 or 2, wherein the processes of the converging percussion wave and of the concentrated electrical discharges are temporarily connected in sequence in such a manner that, the electrical discharge is first effected at the instant when the percussion wave just reaches the convergence centre.

4. A method as claimed in claim 1, 2, or 3, wherein in order to increase the effect of the converging percussion wave a tamping of the explosive is used on its outer side.

5. A method as claimed in any of claims 1 to 4, distinguished in that, the thermonuclear nuclear fuels to be ignited, whether gaseous or liquid, are under high pressure.

6. A method as claimed in any of claims 1 to 5, distinguished in that, the electrical discharges take place in a space which is considerably pre-heated by adiabatic compression which is generated chemically.

7. A method as claimed in any of claims 1 to 6, wherein the nuclear fuel to be ignited is surrounded by a pressure container, the components of which will further increase the action of the converging shock wave.

8. A method as claimed in any of claims 1 to 7, wherein by initiating thermonuclear reactions in

a small volume, the initial condition is created for initiating fusion reactions in a larger volume of thermonuclear fuel.

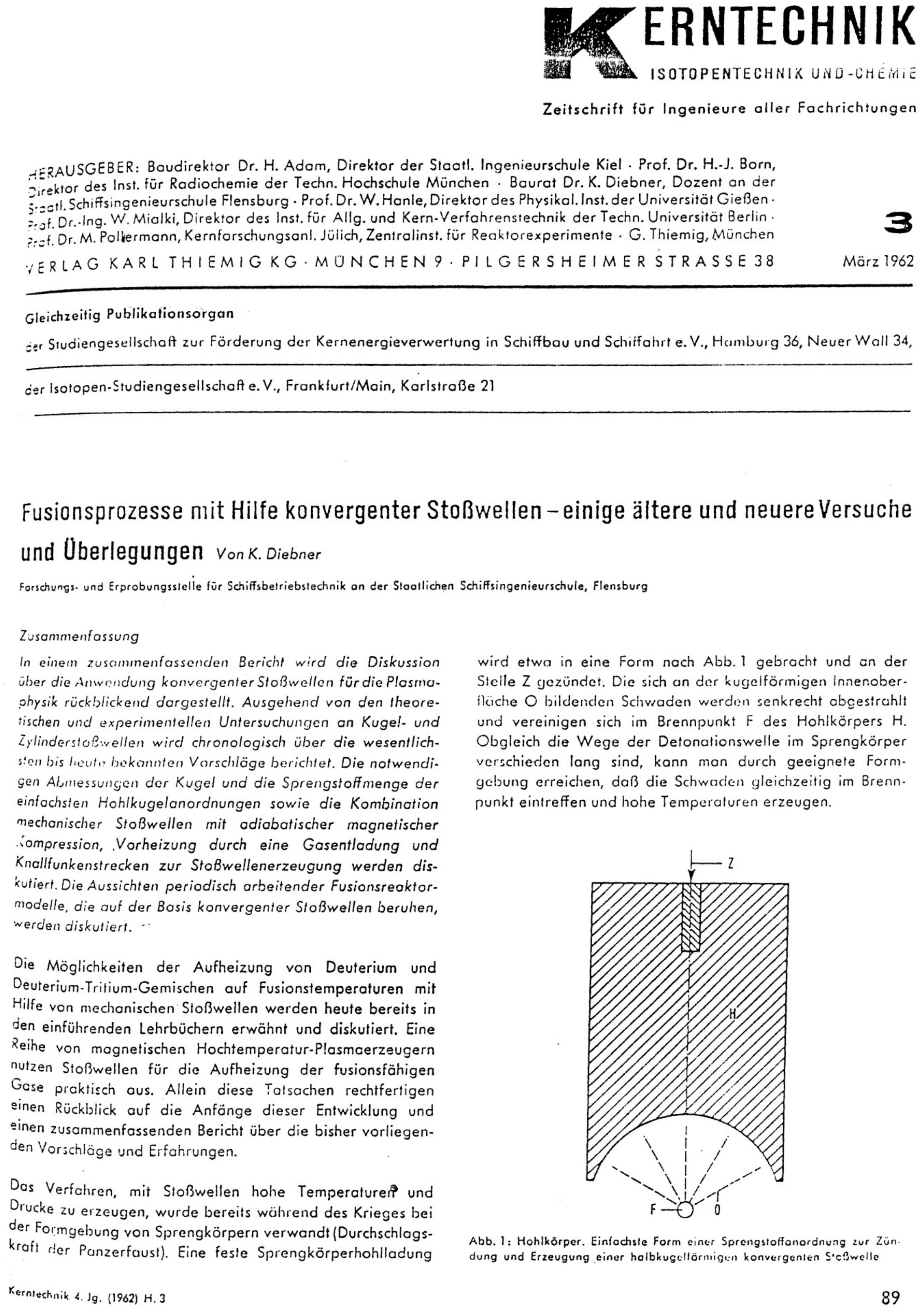
9. A method as claimed in any of claims 1 to 8, wherein the thermonuclear reactions take place in a suitable container for the maintenance of required pressures and/or required temperatures, and that thus the fusion energy can be utilized.

10. A method as claimed in claim 9, wherein the process is repeated periodically or not periodically, and it serves for driving turbines, heat engines and/or other power combinations.

11. A method for the ignition of thermonuclear fuels substantially as described with reference to the accompanying drawings.

Kurt Diebner. 1962. Fusionsprozesse mit Hilfe konvergenter Stosswellen—einige ältere und neuere Versuche und überlegungen. *Kerntechnik* 4:3:89–93.

[See pp. 4265–4267.]



KERNTECHNIK
ISOTOPENTECHNIK UND -CHEMIE

Zeitschrift für Ingenieure aller Fachrichtungen

HERAUSGEBER: Baudirektor Dr. H. Adam, Direktor der Staatl. Ingenieurschule Kiel · Prof. Dr. H.-J. Born, Direktor des Inst. für Radiochemie der Techn. Hochschule München · Baurat Dr. K. Diebner, Dozent an der Staatl. Schiffsingenieurschule Flensburg · Prof. Dr. W. Hanle, Direktor des Physikal. Inst. der Universität Gießen · Prof. Dr.-Ing. W. Mialki, Direktor des Inst. für Allg. und Kern-Verfahrenstechnik der Techn. Universität Berlin · Prof. Dr. M. Pollermann, Kernforschungsanl. Jülich, Zentralinst. für Reaktorexperimente · G. Thiemig, München

3

VERLAG KARL THIEMIG KG · MÜNCHEN 9 · PILGERSHEIMER STRASSE 38

März 1962

Gleichzeitig Publikationsorgan

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der Isotopen-Studiengesellschaft e. V., Frankfurt/Main, Karlstraße 21

Fusionsprozesse mit Hilfe konvergenter Stoßwellen – einige ältere und neuere Versuche und Überlegungen

Von K. Diebner

Forschungs- und Erprobungsstelle für Schiffsbetriebstechnik an der Staatlichen Schiffsingenieurschule, Flensburg

Zusammenfassung

In einem zusammenfassenden Bericht wird die Diskussion über die Anwendung konvergenter Stoßwellen für die Plasmaphysik rückblickend dargestellt. Ausgehend von den theoretischen und experimentellen Untersuchungen an Kugel- und Zylinderstoßwellen wird chronologisch über die wesentlichsten bis heute bekannten Vorschläge berichtet. Die notwendigen Abmessungen der Kugel und die Sprengstoffmenge der einfachsten Hohlkugelanordnungen sowie die Kombination mechanischer Stoßwellen mit adiabatischer magnetischer Kompression, Vorheizung durch eine Gasentladung und Knallfunkenstrecken zur Stoßwellenerzeugung werden diskutiert. Die Aussichten periodisch arbeitender Fusionsreaktormodelle, die auf der Basis konvergenter Stoßwellen beruhen, werden diskutiert.

Die Möglichkeiten der Aufheizung von Deuterium und Deuterium-Tritium-Gemischen auf Fusionstemperaturen mit Hilfe von mechanischen Stoßwellen werden heute bereits in den einführenden Lehrbüchern erwähnt und diskutiert. Eine Reihe von magnetischen Hochtemperatur-Plasmaerzeugern nutzen Stoßwellen für die Aufheizung der fusionsfähigen Gase praktisch aus. Allein diese Tatsachen rechtfertigen einen Rückblick auf die Anfänge dieser Entwicklung und einen zusammenfassenden Bericht über die bisher vorliegenden Vorschläge und Erfahrungen.

Das Verfahren, mit Stoßwellen hohe Temperaturen und Drucke zu erzeugen, wurde bereits während des Krieges bei der Formgebung von Sprengkörpern verwandt (Durchschlagskraft der Panzerfaust). Eine feste Sprengkörperhohlladung wird etwa in eine Form nach Abb. 1 gebracht und an der Stelle Z gezündet. Die sich an der kugelförmigen Innenoberfläche O bildenden Schwaden werden senkrecht abgestrahlt und vereinigen sich im Brennpunkt F des Hohlkörpers H. Obgleich die Wege der Detonationswelle im Sprengkörper verschieden lang sind, kann man durch geeignete Formgebung erreichen, daß die Schwaden gleichzeitig im Brennpunkt eintreffen und hohe Temperaturen erzeugen.

Abb. 1: Hohlkörper. Einfachste Form einer Sprengstoffanordnung zur Zündung und Erzeugung einer halbkugelförmigen konvergenten Stoßwelle

Kerntechnik 4. Jg. (1962) H. 3

89

Figure D.598: Kurt Diebner's paper describing (among other designs) a spherical implosion fission bomb with a deuterium-tritium fusion boost in the center [Diebner 1962].

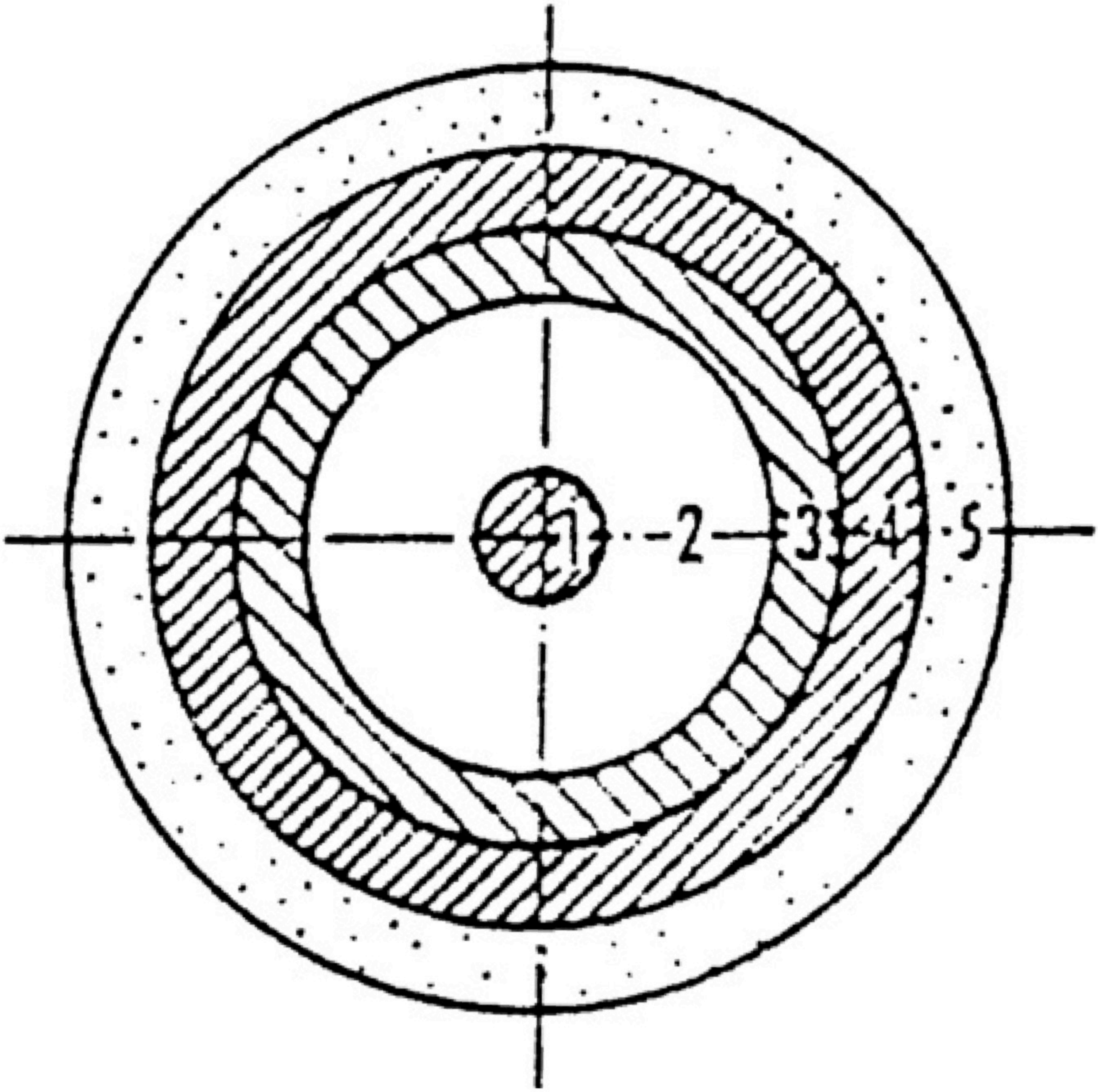
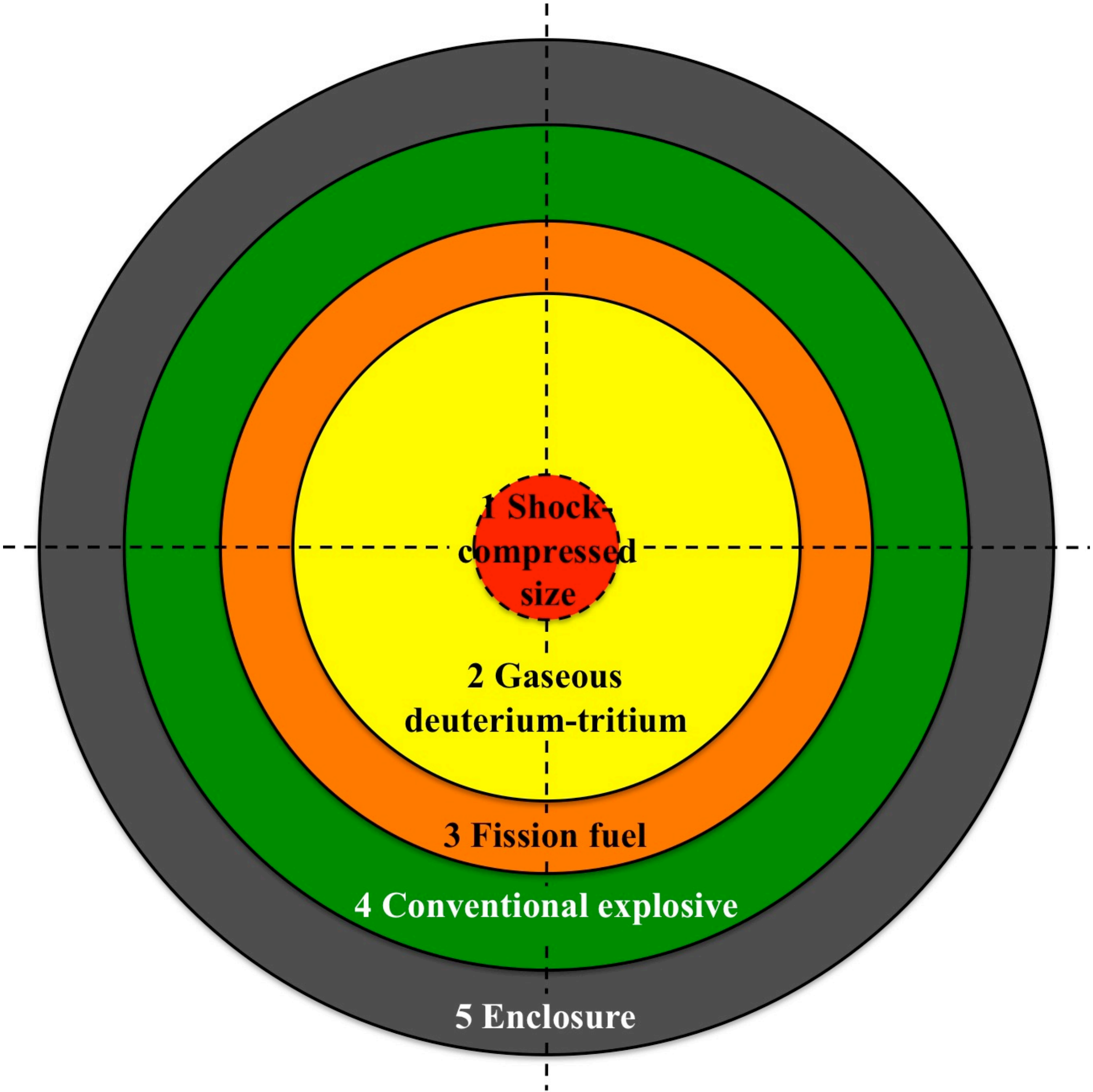


Abb. 5: Kugelschalenanordnung von Kernspaltstoff (3) und gewöhnlichem Sprengstoff (4), die in einer Verdämmung (5) eingeschlossen sind. Im Hohlraum (2) der Schichtfolge befindet sich gasförmiges Deuterium bzw. ein Deuterium-Tritium-Gemisch. Das Reaktionsvolumen der Stoßwelle ist wieder (1). Die Schale (3) ist so dimensioniert, daß der Kernspaltstoff erst dann eine kritische Anordnung darstellt, wenn durch Detonation der Schale (4) eine Stoßwelle die Hohlkugel in der Nähe des Konvergenzzentrums zu einem kompakten Gebilde zusammenschiebt

Figure D.599: Kurt Diebner's schematic illustration of a spherical implosion fission bomb design with a deuterium-tritium fusion boost in the center [Diebner 1962].



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A spherical shell arrangement of fission fuel (3) and conventional explosive (4) which is enclosed in a casing (5). In the central cavity (2) of the sequence of layers, there is gaseous deuterium or a deuterium-tritium mixture. The reaction volume of the shock wave is (1). The shell (3) is dimensioned in such a way that the fission fuel is only a critical assembly when, by detonation of the layer (4), a shock wave compresses the hollow sphere into a compact structure around the convergence center.

Figure D.600: Redrawn and translated version of Kurt Diebner's schematic illustration of a spherical implosion fission bomb design with a deuterium-tritium fusion boost in the center.

Vincent Nouzille and Olivier Huwart. 1999. Comment la France a recruté des savants de Hitler. *L'Express* no. 2498 (20 May), p. 122. https://www.lexpress.fr/informations/comment-la-france-a-recrute-des-savants-de-hitler_633743.html

La France recrute d'autres savants au passé controversé. En mars 1945, le Pr Hubert Schardin, l'un des patrons du centre de recherches de la Luftwaffe à Berlin-Gatow, formait des stagiaires en vue de créer une ultime "arme miracle" pour Hitler! Replié à Biberach, dans le Wurtemberg, il est fait prisonnier par le commandant Lutz, de la 1re division blindée de l'armée française. Le 7 mai 1945, Lutz indique à Schardin qu'il aura "toute liberté d'action". Le lendemain, jour de la capitulation allemande, le savant note dans son agenda: "Le travail a repris"... Avec une trentaine d'autres ingénieurs, il s'installe près de la frontière franco-allemande et devient codirecteur du Laboratoire de recherches balistiques et aérodynamiques de Saint-Louis (Haut-Rhin), créé spécialement par le ministère de l'Armement.

Parmi la centaine de recrues allemandes qui rejoignent progressivement ce laboratoire militaire se trouve le Dr Rudi Schall, un physicien berlinois de renom, venu d'un autre centre de recherches militaires. Agé aujourd'hui de 85 ans, retiré près du lac de Constance, il confie à L'Express: "C'est vrai que j'étais membre du parti nazi, comme beaucoup de mes collègues qui y étaient plus ou moins obligés, sans être forcément actifs. En 1945, les Américains nous ont embarqués, mais ils nous traitaient comme des moins-que-rien. Les Britanniques, eux, m'ont proposé de m'embaucher, mais sans que ma femme puisse me rejoindre. Alors que les Français ont été très chaleureux. La dénazification des postes était en cours en Allemagne. Mais on nous a dit que cela ne nous concernait pas. Je suis arrivé début 1946 à Saint-Louis." Rudi Schall succédera à Schardin comme codirecteur de ce laboratoire, devenu en 1959 le symbole de la nouvelle coopération militaire franco-allemande!

France is recruiting other scientists with a controversial past. In March 1945, Professor Hubert Schardin, one of the bosses of the Luftwaffe Research Centre in Berlin-Gatow, prepared assistants to create a final "miracle weapon" for Hitler! Folded back to Biberach, Württemberg, he was taken prisoner by Commander Lutz, of the 1st Armoured Division of the French Army. On May 7, 1945, Lutz told Schardin that he would have "complete freedom of action." The next day, the day of the German surrender, the scientist noted in his diary: "Work has resumed"... With about thirty other engineers, he settled near the Franco-German border and became co-director of the Laboratoire de recherches balistiques et aérodynamiques de Saint-Louis (Haut-Rhin), created especially by the Ministry of Armament.

Among the hundred German recruits who are gradually joining this military laboratory is Dr. Rudi Schall, a renowned Berlin physicist from another military research centre. Now 85 years old, retired near Lake Constance, he told L'Express: "It is true that I was a member of the Nazi party, like many of my colleagues who were more or less obliged to do so, without necessarily being active. In 1945, the Americans took us in, but they treated us like less than nothing. The British offered to hire me, but my wife could not join me. While the French were very warm and friendly. The denazification of posts was under way in Germany. But we were told that this did not concern us. I arrived in early 1946 in Saint-Louis." Rudi Schall succeeded Schardin as co-director of this laboratory, which became the symbol of the new Franco-German military cooperation in 1959!

Certaines embauches sont encore plus troublantes. Selon l'historien allemand Ulrich Albrecht, le comte Helmut Zborowski, ingénieur chez BMW, est emprisonné en 1945 à cause de son appartenance aux Waffen SS. Ce lourd passé n'empêche pas la France, en 1947, de convier Zborowski à rejoindre la Société européenne de propulsion par réaction (SEPR). Ce scientifique controversé créera, en 1950 à Paris, le Bureau technique Zborowski. Subventionné sur fonds publics par la Snecma, l'ex-SS concevra un drôle d'engin à décollage vertical, le Coléoptère, véritable gadget technique, dont les essais en vol se révéleront dangereux...

Le gouvernement tient également à conserver quelques chimistes allemands. Arrêtés par les Américains, Walter Reppe—qualifié de "nazi bon teint"—et Karl Wurster—présumé "criminel de guerre"—seront blanchis et rejoindront leurs postes à l'usine de Ludwigshafen, avec la bienveillance des Français. Tous les Alliés pratiquent le même cynisme. Le cas d'Otto Ambros, un des directeurs d'IG Farben, est exemplaire. Ambros a participé à la décision d'utiliser le zyklon B dans les chambres à gaz. Il a également supervisé une usine de caoutchouc synthétique à Auschwitz-Buna-Monowitz, dans laquelle de nombreux déportés ont été maltraités. Interrogé par des militaires français en août 1945, il rédige un rapport ultrasensible sur la production allemande de nouveaux gaz de combat (tabun, sarin, soman). De quoi intéresser les promoteurs d'armes chimiques françaises! Puis, selon l'historienne Marie-France Ludmann-Obier, ce scientifique, considéré comme "criminel de guerre", est invité par le ministère de la Guerre à Paris pour faire des conférences! Après des mois de pressions américaines, les Français finissent par livrer Ambros à des GI. Un tribunal de Nuremberg le condamne en 1948 à huit ans de prison pour esclavage. Libéré en 1951, il fera carrière comme conseiller d'un grand groupe chimique aux Etats-Unis...

Some hires are even more troubling. According to the German historian Ulrich Albrecht, Count Helmut Zborowski, an engineer at BMW, was imprisoned in 1945 because of his membership of the Waffen SS. This heavy history did not prevent France, in 1947, from inviting Zborowski to join the European Society for Jet Propulsion (SEPR). This controversial scientist created the Zborowski Technical Office in Paris in 1950. Subsidized on public funds by Snecma, the ex-SS will design a strange vertical take-off device, the Beetle, a real technical gadget, whose flight tests will prove dangerous...

The government also wants to keep some German chemists. Arrested by the Americans, Walter Reppe—described as a "well-rounded Nazi"—and Karl Wurster—allegedly a "war criminal"—were cleared and returned to their posts at the Ludwigshafen factory, with the goodwill of the French. All Allies practice the same cynicism. The case of Otto Ambros, one of the directors of IG Farben, is exemplary. Ambros was involved in the decision to use zyklon B in the gas chambers. He also supervised a synthetic rubber factory in Auschwitz-Buna-Monowitz, where many deportees were mistreated. When questioned by French soldiers in August 1945, he wrote a highly sensitive report on the German production of new poison gases (tabun, sarin, soman). This is of interest to French chemical weapons promoters! Then, according to historian Marie-France Ludmann-Obier, this scientist, considered a "war criminal," was invited by the Ministry of War in Paris to give lectures! After months of American pressure, the French finally delivered Ambros to GIs. A Nuremberg tribunal sentenced him in 1948 to eight years in prison for slavery. Released in 1951, he made a career as an advisor to a large chemical group in the United States...

[Ambros, Schardin, Schall, and Zborowski appear to have played important roles in the German nuclear weapons program, and likely used that knowledge to help the postwar French nuclear weapons program. Almost certainly there are extensive French files on their wartime and postwar work, but those files remain unavailable.]

Ingeborg Brandt, who worked in the Hans Lindemayer group in Anklam and then Friedland. Letter to Karl Spietz. 20 October 1995. Heimatmuseum Friedland, Akte Nr. 157. [Karlsch 2005, pp. 169, 230]

Vor unserer Halle war so eine Art Terrasse. Man nannte dies Prüfstand. Dort stand so eine Kugel [...] Ich selbst schätze sie auf einen Durchmesser von 1,80 Meter.

There was a kind of terrace in front of our hall. This was called the test stand. There was such a ball [...] I estimate it to be 1.80 meters in diameter.

Irene König, who worked in Anklam and then Friedland. 16 July 2004 interview by Heiko Petermann. [Karlsch 2005, pp. 169–170]

Da wurden zwei Aluminiumkugeln ineinander gesetzt, eine große und eine kleine, und die dampften. Zuerst dachte ich, die kochen darin Wasser. Aber ich habe mich natürlich nicht getraut zu fragen, das war ja alles so geheim. Wir wurden dann nach dem Bombenangriff nach Friedland verlagert. Lindemayer ging nach Nordhausen, und Johann Grüner übernahm die Leitung der Gruppe. In Friedland wurden die Kugeln in einem großen Kessel mit hoher Geschwindigkeit gedreht. Manchmal war ein gewaltiges Getöse und Donnern zu hören. Die Ingenieure erzählten uns dann, dass sie Versuche mit Druckminderern durchführen.

There were two aluminum spheres, one placed inside the other, one large and one small, and they steamed. At first I thought they were boiling water in them. But of course I did not dare to ask, it was all so secret. We were then transferred to Friedland after the bomb attack. Lindemayer went to Nordhausen, and Johann Grüner took over the management of the group. In Friedland the spheres were turned in a large cauldron at high speed. Sometimes there was a tremendous roar and thunder. The engineers then told us that they were doing experiments with pressure reducers.

[Ilyichev's March 1945 description of the German implosion bomb design (see p. 4485) includes two hollow aluminum spheres, a large outer aluminum explosive case and a smaller aluminum pusher inside that.

"In addition to the Lindemayer group, a second research team headed by Dr. Ing. Wolfgang Steurer came to Friedland in 1944. He was considered to be one of the best experts in the field of material testing and was particularly well-known in aluminum alloys. His group consisted of 24 scientists, technicians and assistants. [...] Employees had been seen in protective suits during materials transport and at work. Details were not disclosed." [Karlsch 2005, p. 170]

See also:

Christoph Regel, Die Erprobungsstelle Rechlin, in: *Flugerprobungsstellen bis 1945*. Bonn 1998, pp. 60ff.

Heimatmuseum Friedland, Nr. 157: Karl Spietz to Gerhard Remdt 26.4.1966, 24.2.1967; Karl Spietz to *Neue Friedländische Zeitung* 15 September 1995.

Wer waren die Gummimänner von Friedland? *Neue Friedländer Zeitung* 7 June 1995.]

Heinrich Himmler's chief adjutant Werner Grothmann on nuclear weapon designs [Krotzky 2002]. See pp. 3396–3397 regarding the background and reliability of this source.

[S. 9] Was ich weiß ist die tatsächliche Vorbereitung für die Prototypenproduktion der zwei durchkonstruierten Atombombentypen für Uran und Plutonium. [...] Ich durfte davon nichts wissen, deshalb kann ich nur sagen, dass es um zwei Standardtypen für den Einsatz gegen Städte ging und noch zwei weitere unterschiedlich grosse, die sollten frontverwendungsfähig sein und kleinere Ladungen enthalten. Ich erfuhr erst nach dem Krieg davon, dass die eine von den beiden kleineren ein Ladungsäquivalent, also eine vergleichbare Sprengmaterialmenge, von ich glaube 130 Tonnen gehabt hätte. Die sollte gegen Bahntunnels, Hafenanlagen und Militäreinrichtungen eingesetzt werden. Der Punkt war, dass die kleinen Waffen nur ganz wenig Material benötigten, denn daran bestand ja erstmal der Mangel. Von der grösseren hörte ich nur eine Angabe, die ich nicht bestätigen kann, da ging es um drei Kilotonnen, das muss offen bleiben.

[S. 18] Was da im einzelnen alles gelaufen ist, erfuhr ich nie. Es war aber so, dass es zwei ganz verschiedene Konstruktionen gab, von einer dritten, zu der ich sonst nichts weiß, hörte ich erst recht nicht viel. Die muß wie eine aufgequollene Bombe ausgesehen haben. Zu den beiden anderen weiß ich, dass die kleinere ungefähr die Größe der SC 250 gehabt hatte, aber das Gewicht war höher. Die größere Waffe hätte eine Kugelform besessen mit einem Durchmesser von über einem Meter. Die war sehr schwer, obwohl der Bombenkörper selbst aus Aluminium gewesen sein soll. Es hieß, wenn man das Gewicht reduziert, geht die Ladung nicht hoch. Dann war eine Variante geplant, bei der der Bombenkörper selbst Bestandteil des Sprengsytems gewesen sein soll. Ich kann das jetzt nicht besser sagen, es ging jedenfalls darum, das Gewicht zu reduzieren und trotzdem eine richtig große Sprengkraft zu erhalten.

[p. 9] What I know is the actual preparation for the prototype production of the two fully constructed atomic bomb types for uranium and plutonium. [...] I was not allowed to know anything about it, so I can only say that there were two standard types for use against cities and two more of a different size, which were supposed to be front-usable [for tactical battlefield use] and contain smaller charges. I learned only after the war that one of the two smaller ones would have had a charge equivalent, that is a comparable explosive material quantity, of I believe 130 tons. This was supposed to be used against railway tunnels, port facilities and military installations. The point was that the small weapons required only very little material, which overcame first of all the shortage [of fission fuel]. Of the larger one I heard only a statement, which I cannot confirm, that it was about three kilotons, that must remain [an] open [question].

[p. 18] I never heard what all was going on in detail. It was true, however, that there were two entirely different constructions; of a third, about which I do not know anything else, I did not hear much. It must have looked like a swollen bomb. About the other two, I know that the smaller was about the size of the SC 250, but the weight was higher. The larger weapon would have possessed a spherical shape with a diameter of over one meter. It was very heavy, even though the bomb body itself was supposed to be out of aluminum. It was said, if one reduces the weight, the yield is not as high. For this purpose, a variant was planned, in which the bomb body itself was supposed to have been a component of the explosive system. I cannot say better now, it was anyway to reduce the weight and still get a really big explosive energy.

[S. 44] Ja, jetzt kommt noch das dritte Problem. Wir haben ja schon mal darüber gesprochen, dass die Wissenschaftler eine Zündung in der Luft in einer bestimmten Höhe haben wollten. Es sollte eine Höhe von ungefähr 400 Metern sein. Es gab aber erst mal keinen einzigen Zündmechanismus, der das zuverlässig schaffte, obwohl viele daran gearbeitet hatten. Es ist sogar überlegt worden, das mit Zeitzünder zu machen, ich weiß aber nicht, ob das durchgeführt worden ist. Das Problem war ja, wenn man einen Aufschlagzünder nimmt, verpufft der größte Teil der Wirkung. Dann wäre die Waffe die ganze Mühe nicht wert gewesen. Bei dem Versuch, der im Spätherbst 44 mit dem Fallschirmabwurf durchgeführt worden war, hatten sie etwas ausprobiert. Ich weiß aber nicht, ob das wirklich ein Annäherungszünder gewesen ist.

[S. 42] Übrigens, was die Physiker Himmler im Privatvortrag zur Wasserstoffbombe sagten, das hatte ihn wirklich elektisiert, weil er hörte, dass die Sprengwirkung hundertmal größer sein würde als bei der Uranbombe.

[p. 44] Yes, now comes the third problem. We have already talked about the fact that the scientists wanted to have an ignition in the air at a certain altitude. It should be an altitude of approximately 400 meters. But there was not even a single ignition mechanism that made it reliable, even though many had worked on it. It was even thought of doing this with a time fuse, but I do not know if this was done. The problem was, if one uses an impact fuse, most of the effect fizzles. Then the weapon would not have been worth the effort. In the test, which was carried out in late autumn 44 with the parachute drop, they had tried out something. But I do not know if this was really a proximity fuse.

[p. 42] By the way, what the physicists told Himmler in their private lecture on the hydrogen bomb had really electrified him, because he heard that the explosive effect would be a hundred times greater than that of the uranium bomb.

[Can other relevant documents from or about the following people be located in archives?

- Alfred Baubin
- Adolf Busemann
- Rolf Engel
- Siegfried Flügge
- Erich Purucker
- Rudi Schall
- Hubert Schardin
- Karel Staller
- Gustav Thomer
- Walter Trinks
- Others?]

[Grothmann appeared to describe work on at least five different types of nuclear weapons:

1. A tactical bomb using U-235 (produced in any of several uranium enrichment facilities that Grothmann alluded to) with an explosive yield of less than a kiloton (Grothmann thought he remembered 130 tons). He compared it to the size of an SC 250 bomb, a common cylindrical German bomb with a 37-cm diameter and 120-cm body length (Fig. D.601), but said it was heavier than an SC 250 (heavier than 250 kg). In principle, a bomb of that size might have been an implosion bomb design employing cylindrical compression as considered by Gottfried Guderley as well as Erich Schumann and Walter Trinks; see p. 4248. Alternatively it might have been a biconic implosion bomb design employing focused compression from each end, as considered by Schumann and Trinks; see p. 4246. R. P. Linstead and T. J. Betts, the U.K. and U.S. chairs of CIOS, wrote in their final report about German V-rockets armed with atomic bombs that were much smaller than the standard V-2 payload of 1000 kg (p. 5030). The bomb described by Grothmann and the CIOS chairs does not match the characteristics of a gun-type fission bomb. For example, the U.S. Little Boy had a mass of 4400 kg, diameter of 71 cm, and length of 300 cm, and because of its inherent physics used a very large amount of uranium, had a very low efficiency, and produced a large explosive yield, in contrast to the weapon that Grothmann described.

2. A tactical bomb using Pu-239 (produced in any of several plutonium breeding facilities that Grothmann alluded to). Other than the difference in fuel, presumably this bomb had the same design as the tactical uranium bomb, as well as a roughly comparable yield.

3. A strategic bomb using U-235 with an explosive yield of several kilotons. (Grothmann thought he remembered 3 kilotons, but he seemed uncertain; that value may have been the yield of one of the small tests, not the yield that a fully fueled and deployed version of the bomb would have.) The bomb was a sphere with a diameter of somewhat over 1 meter, an aluminum shell, and a large mass. It apparently used a sophisticated implosion system. All of these details are highly consistent with the bomb design reported by Ilyichev (pp. 4481 and 4485).

4. A strategic bomb using Pu-239. Presumably this bomb had the same design as the strategic uranium bomb, as well as a roughly comparable yield.

5. A hydrogen bomb or H-bomb using fusion reactions but initiated by reactions in fission fuel. According to Grothmann, its explosive yield would be a hundred times larger than a fission bomb, or on the order of a megaton. Grothmann knew much less about this bomb design, but he described it as “a swollen bomb.” That might be taken to mean an oversized spherical implosion bomb, which could match the description of a “sloika” or layer-cake H-bomb design. Alternatively, Grothmann’s wording might be construed to mean an ellipsoidal shape, which could match the description of a Prandtl-Meyer two- or three-stage H-bomb design (p. 4373). This bomb was expected to be operational by late 1945 (p. 4367) or early 1946 (p. 3401), which suggests that it was at a fairly advanced stage of development, not merely a paper design. For more information on German development of fusion fuels and fusion bombs, see Sections D.9 and D.15.6.]

Figure D.601: SC 250 bomb, which Grothmann said was comparable in size to the smallest German nuclear weapon. See pp. 4246 and 4248 for what the internal structure may have looked like.

PW Intelligence Bulletin 1/47, 13 March 1945 [NARA RG 165, Entry NM84-79, Box 1915]. See document photo with diagram on p. 4276.

16. Microbe Bombs

PW saw appr one hundred 250 kg bombs stored in a hall at Flughorst Ost, MAGDEBURG. PW was told that these were microbe bombs.

As described to PW, the bomb has two detonating chambers (one in front and one in back) with 2 side fuses. In the center of the shell is an empty lead lined chamber with threaded opening on the side into which a tube is screwed. The opening has 8 threads and when the tube is screwed into the last thread it is opened and the microbes which have been stored in the tube escape into the chamber. The opening is smeared with a gelatinous substance to prevent the escape of germs.

PW thinks the germs are of cholera type.

(Source: Gefr August KIEFFER, KG MATERN captured 1 Mar vic AMMERN)

Military Intelligence Service, 26 March 1945 [NARA RG 165, Entry NM84-187, Box 137, Folder BW 55]. See document photo with diagram on p. 4277.

G-2 COMMENT:

This (250 kg) seems quite large for a single BW bomb. Further interrogation is contemplated, and information will be forwarded.

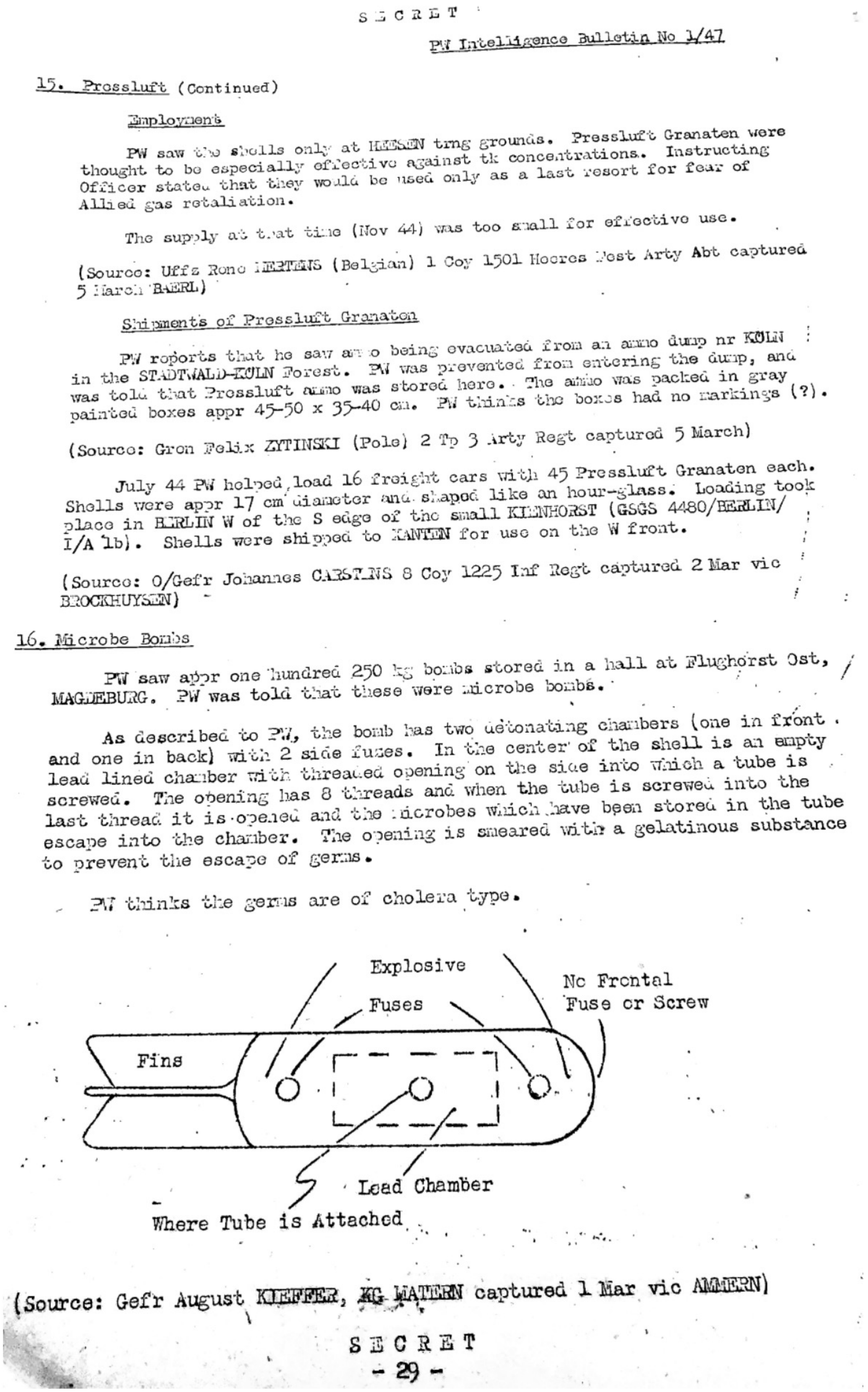
[The German PW said he had seen special bombs stored at a Luftwaffe base and gave a relatively detailed description of their design. The PW had heard and the Allied interrogators just assumed that the bombs were biological. Since the design was "only" biological, the report was ultimately declassified by the U.S. government.

The design as given by the PW makes absolutely no scientific sense if the small, dangerous, final component that must be inserted in the middle is biological. There is too much explosive, too little "biological agent," and a mysterious tamper in between made of lead or some other extremely dense metal. Any biological agent in the middle would be destroyed by the intense heat and intense pressure created by the explosives at both ends. The design also does not make any sense for chemical weapons or fuel-air explosives.

But what if that small, dangerous, final component in the PW's design is nuclear? Compare the PW's design with the descriptions from Werner Grothmann and Erich Schumann.

Notice how many of these special bombs the PW said he saw.]

**NARA RG 165, Entry NM84-79, Box 1915,
PW Intelligence Bulletin 1/47, 13 March 1945**



SECRET

PW Intelligence Bulletin No 1/47

15. Pressluft (Continued)

Employment

PW saw the shells only at HEESEN trng grounds. Pressluft Granaten were thought to be especially effective against tk concentrations. Instructing Officer stated that they would be used only as a last resort for fear of Allied gas retaliation.

The supply at that time (Nov 44) was too small for effective use.

(Source: Uffz Rene MERTENS (Belgian) 1 Coy 1501 Heeres Kust Arty Abt captured 5 March BAERL)

Shipments of Pressluft Granaten

PW reports that he saw ammo being evacuated from an ammo dump nr KÖLN in the STADTWALD-KÖLN Forest. PW was prevented from entering the dump, and was told that Pressluft ammo was stored here. The ammo was packed in gray painted boxes appr 45-50 x 35-40 cm. PW thinks the boxes had no markings (?).

(Source: Gren Felix ZYTINSKI (Pole) 2 Tp 3 Arty Regt captured 5 March)

July 44 PW helped load 16 freight cars with 45 Pressluft Granaten each. Shells were appr 17 cm diameter and shaped like an hour-glass. Loading took place in BERLIN W of the S edge of the small KIENHORST (GSGS 4480/BERLIN/I/A 1b). Shells were shipped to XANTEN for use on the W front.

(Source: O/Gefr Johannes CARSTENS 8 Coy 1225 Inf Regt captured 2 Mar vic BROCKHUYSEN)

16. Microbe Bombs

PW saw appr one hundred 250 kg bombs stored in a hall at Flughorst Ost, MAGDEBURG. PW was told that these were microbe bombs.

As described to PW, the bomb has two detonating chambers (one in front and one in back) with 2 side fuzes. In the center of the shell is an empty lead lined chamber with threaded opening on the side into which a tube is screwed. The opening has 8 threads and when the tube is screwed into the last thread it is opened and the microbes which have been stored in the tube escape into the chamber. The opening is smeared with a gelatinous substance to prevent the escape of germs.

PW thinks the germs are of cholera type.

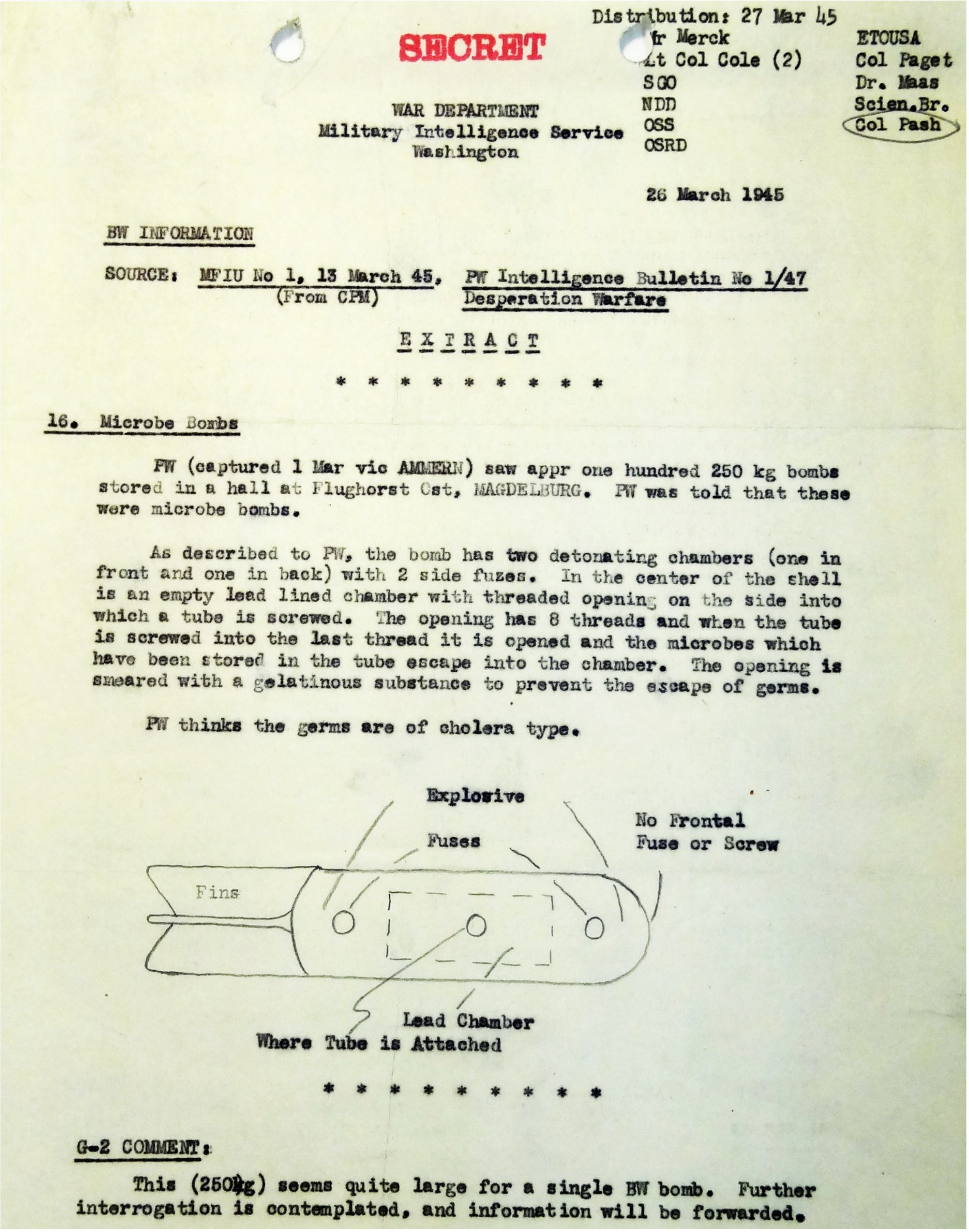
(Source: Gefr August KIEFFER, KG MATERN captured 1 Mar vic AMMERN)

SECRET
- 29 -

Figure D.602: PW Intelligence Bulletin 1/47, 13 March 1945 [NARA RG 165, Entry NM84-79, Box 1915].

DECLASSIFIED
Authority NWD 750122

NARA RG 165, Entry NM84-187, Box 137, Folder BW 55



SECRET

Distribution: 27 Mar 45
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Lt Col Cole (2)
SGO
NDD
OSS
OSRD

ETOUSA
Col Paget
Dr. Maas
Scien.Br.
Col Pash

WAR DEPARTMENT
Military Intelligence Service
Washington

26 March 1945

BW INFORMATION

SOURCE: MFIU No 1, 13 March 45, PW Intelligence Bulletin No 1/47
(From CPM) Desperation Warfare

EXTRACT

* * * * * * * * *

16. Microbe Bombs

PW (captured 1 Mar vic AMMERN) saw appr one hundred 250 kg bombs stored in a hall at Flughorst Ost, MAGDELBURG. PW was told that these were microbe bombs.

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PW thinks the germs are of cholera type.

* * * * * * * * *

G-2 COMMENT:

This (250kg) seems quite large for a single BW bomb. Further interrogation is contemplated, and information will be forwarded.

Figure D.603: Military Intelligence Service, 26 March 1945 [NARA RG 165, Entry NM84-187, Box 137, Folder BW 55].

D.9 Fusion Fuel and Bomb Design

[Wolfgang Ferrant (German?, ??–??), Ulrich Jetter (German, 1914–??), Alfred Klemm (German, 1913–2013), Karl Lintner (Austrian, 1917–2015), Josef Mattauch (Austrian, 1895–1976), Erich Schumann, Georg Stetter (Austrian, 1895–1988), Walter Trinks (German, 1910–1995), and many others worked in teams that researched and produced significant amounts of fusion fuels and potential methods to use them:

- German patents, articles, and other documents from 1933 through 1945 discussed how to produce fusion reactions in high-voltage tubes (pp. 3958–3970 and 4281–4327). That technology would have been very useful as a fusion neutron initiator in a fission bomb, as described by Kurt Diebner (p. 4261) and Ivan Ilyichev (p. 4485).

- In postwar papers apparently based on wartime work, Erich Schumann and Walter Trinks (pp. 4250–4255) and Kurt Diebner (pp. 4260–4267) independently described spherical implosion bomb designs with a center of fusion fuel inside a spherical shell of fission fuel. That "fusion boosting" approach could have greatly increased the yield of a fission bomb by supplying far more neutrons to induce fission reactions.

- A number of documents show that there was wartime work using lithium and deuterium together as fusion fuel (pp. 4305–4341). Because lithium deuteride is solid and not a gas or cryogenic liquid, it makes an ideal fuel for hydrogen bombs.

- During the war, Alfred Klemm (under the direction of Josef Mattauch) perfected a method to separate the lithium-6 isotope from the predominant lithium-7 in natural lithium (pp. 4344–4347). That would only be useful for nuclear applications. Klemm also stated that there was wartime work to produce tritium, another very potent fusion fuel (p. 4346).

- In 1950 Ulrich Jetter (German, 1914–??) published a detailed proposal that fusion bombs could use lithium-6 deuteride as readily storable solid fuel, rather than the much more troublesome cryogenic deuterium and tritium (p. 4348). Based on the other documents available, Jetter's description appears to be based on wartime German work. Officially, lithium-6 deuteride was first considered in the United States by Edward Teller in 1947 and in the Soviet Union by Vitaly Ginzberg in 1949, was first tested by the United States in 1954, and is commonly used in modern H bombs [Goncharov 1996a, 1996b; Chuck Hansen 1988, 2007; Rhodes 1995; Sublette 2019; Wellerstein and Geist 2017].

- In 1946, several scientists and engineers reported that during the war, Germany had been working on a 6-ton radioactive bomb, as well as methods to deliver it by rockets or aircraft (pp. 4338, 4350–4363, and 5343). Such a massive bomb would have been very challenging to deliver, and could presumably only have been justified if it were a hydrogen bomb. Conventional explosives, a dirty bomb of conventional explosives with radioactive material, chemical weapons, biological weapons, and even fission bombs could have been packaged into much smaller and much more easily deliverable sizes (and if necessary, several of them could have been delivered separately to the same target).

- A 1946 U.S. intelligence document mentioned wartime German research on H-bomb development as well as nuclear-armed ballistic missiles (p. 4368).

- In 1944–1945, several independent sources reported that Germany was developing a bomb with a six-mile blast radius, which is characteristic of the several-megaton energy of an H bomb, in stark contrast to the much smaller several-kiloton energy of a plain fission bomb (pp. 4365–4367).

- Friedwardt Winterberg, who worked very closely with Kurt Diebner after the war, published a highly distinctive ellipsoidal H-bomb design that looks rather different than standard U.S. H-bomb designs, but that is deeply steeped in earlier German hydrodynamics and physics research (p. 4373). A surviving 1944 sketch from Walther Gerlach shows an ellipsoid in conjunction with nuclear reactions involving deuterium, which seems to support the wartime origin of Winterberg's ellipsoidal H-bomb design (p. 4377).

- Werner Grothmann stated that the German nuclear program was developing several different bomb types, including a hydrogen bomb. He said that the hydrogen bomb looked like a "swollen bomb" (ellipsoidal?), would have been a hundred times more powerful than a fission bomb (megatons vs. tens of kilotons), and was expected to be ready in 1946 (which suggests that it had already progressed far in its development by 1945); see pp. 3401 and 4272. Other sources expected the German hydrogen bomb to be ready even sooner, sometime in 1945, if the war had continued (pp. 4367, 4334, 4359).

- In 1947, when Edward Teller was trying unsuccessfully to invent a workable design for the U.S. hydrogen bomb, he sent a highly unusual, specific, and urgent request for Siegfried Flügge to help him with a "physics... program... of interest and importance to the national security," stating that Flügge would "be of marked assistance in carrying out the aforementioned program" (p. 4996). In fact, the late-wartime and postwar influx of scientists and engineers who were from or at least had knowledge of the German nuclear program included Karl-Friedrich Bonhoeffer, Wernher von Braun, Rudolf Brill, Adolf Busemann, Walter Dornberger, Rudolf Edse, Krafft Ehricke, Wilhelm Eitel, Gerhard Falck, Karl Fiebinger, Wolfgang Finkelnburg, Rudolf Fleischmann, Siegfried Flügge, Walter Glaser, Wilhelm Groth, Gottfried Guderley, Paul Harteck, Otto Haxel, Richard Herzog, Johannes Hans Jensen, Willibald Jentschke, Ulrich Jetter, Georg Joos, Hartmut Kallmann, Hans Kammler, Gerald Klein, Stanley Kronenberg, Heinz Maier-Leibnitz, Werner Maurer, Hugo Neuert, Walter Nielsch (?), Edgar Petersen, Heinz Schlicke, Erich Schumann, Otto Schwede, Edmund Sorg, Kurt Starke, Ernst Stuhlinger, Hans Suess, Herbert Wagner, Wilhelm Westphal, Friedwardt Winterberg, Karl Wirtz, Gernot Zippe, etc. (p. 4992). Many of those scientists appear to have been closely tied to the wartime German work on H-bombs, and may have especially aided the U.S. H-bomb development program between 1945 and 1954.

Table D.3 summarizes some of the major sources and details regarding the megaton-level H-bomb that was under development during the war.]

Primary sources for hydrogen bomb design

	Sänger 1944	***Daily Mail* 44**	***Evening Std.* 45**	**Kober 1945**	**Ferrant 1945**	**Schumann 1945-52**	**Kästner 1946**	**Sorg 1946**	**Thirring 1946**	**von Braun 1946**	**Zumpe 1946**	**U.S. Intel 1946-51**	**Klemm '47, '04**	**Granziani 1948**	**Jetter 1950**	**Grothmann 2000-2002**
Bomb mass	6 tons					Tons	6 tons	6 tons	6 tons	6 tons	6 tons				Tons	"Swollen bomb" (apparently very large)
Explosive energy		6-mile blast radius (~1.6 megatons)	6-mile blast radius (~1.6 megatons)	10^6 greater than nitroglycerin (megatons)	Megatons potentially	Megatons potentially						"Even more deadly weapon than the atomic bomb" (>>20 kilotons)		6-mile blast radius (~1.6 megatons)	Megatons	"100x greater than that of the uranium bomb" (megatons)
Method of action	H-bomb implied by bomb mass and priority	H-bomb implied by blast radius	"Atomic" reactions; H-bomb implied by blast radius	H-bomb with lithium hydride (LiD?)	Explosive with lithium deuteride (LiD) and fission fuel	H-bomb with lithium deuteride (LiD) and fission fuel	Radioactive; H-bomb implied by bomb mass and parachute	H-bomb implied by bomb mass and priority	Lithium hydride (LiD?) H-bomb with fission bomb trigger	H-bomb implied by bomb mass and priority	H-bomb implied by bomb mass and priority	H-bomb with lithium hydride, deuterium and/or tritium	Highly secret military project using lithium -6 and tritium	H-bomb implied by blast radius	H-bomb with lithium deuteride (LiD) & fission bomb trigger	Hydrogen bomb; fission bomb as trigger
Vehicle	Rocket	Rocket					Parachute from plane	Plane		Rocket	Rocket	Rocket		Rocket		
Ready			Oct. 1945	"Test site" by 1945				Later 1945						Soon		1946
People involved	Austrian scientists		Groth	Stetter, other Austrian scientists, Gerlach, Tomaschek, AEG scientists	Ferrant, AEG scientists, Austrian scientists (implied)	Schumann, Trinks	Kästner, Petersen, Sorg, Austrian nuclear scientists, Schulz-Kampfhenkel	Petersen, Sorg	Jentschke and other Austrian nuclear scientists	von Braun, SS and Kammler (implied)	(Likely Purucker and his car full of bomb plans)	Stetter, Jentschke, Lintner, Mattauch, Ortner, Czulius, Schintlmeister	Klemm, Mattauch, Austrian nuclear scientists (implied), production elsewhere		Jetter	Himmler, SS, Kammler (implied), Austrian nuclear scientists
Places	Austria	French launch site	Celle	Austria, Berlin, Munich	Berlin, Austria	Berlin area	Austria	Austria and Baltic coast	Austria	Baltic coast		Austria	Tailfingen, Berlin, Austria			Austria, Berlin

Table D.3: Details about hydrogen bomb design from primary sources.

Rausch von Traubenberg. 1933. Die bei der Lithiumzertrümmerung auftretende durchdringende Strahlung. *Die Naturwissenschaften* 21:694.

Wie wir kürzlich zeigen konnten, treten bei der künstlichen Umwandlung des Lithiumkernes durch Protonen auch γ-Strahlen auf, deren Nachweis uns mit Hilfe des Geiger-Müllerschen Zählrohres gelang. Wir haben inzwischen die Versuche mit verbesserten Hilfsmitteln wiederholt und eine Abschätzung der Härte der γ-Strahlen vorgenommen. Die Messungen wurden wieder so gestaltet, daß Lithium und ein bei unseren geringen Protonengeschwindigkeiten nicht zertrümmerbares Element, in diesem Falle Eisen, abwechselnd in den Gang der Wasserstoffkanalstrahlen gestellt wurden. Durch solche Differenzmessungen machten wir uns ebenso wie bei den früheren Untersuchungen von der Röntgenstrahlen sowie von der NZ (= Höhenstrahlen + radioaktiven Strahlen) frei und maßen die Lithiumstrahlung allein. Es wurde durch Zwischenschalten verschieden dicker Bleischichten als Hauptanteil eine weiche Komponente nachgewiesen, deren Intensität durch etwas 0,3 mm Blei auf die Hälfte geschwächt wurde. Bei einer maximalen Röhrenspannung von 58 kV und einem Röhrenstrom von 1 mA erhielten wir bei 1 mm Blei und einem Abstand von 48 mm des Zählrohrendes vom Lithium etwa 3 Quanten pro Minute.

As we have recently shown, the artificial transformation of the lithium nucleus by protons also involves γ rays, which we were able to detect with the aid of the Geiger-Müller tube. In the meantime we have repeated the experiments with improved aids and made an estimate of the intensity of the γ rays. The measurements were again designed in such a way that lithium and an element which can not be broken down at our low proton velocities, in this case iron, were alternately placed in the path of the hydrogen beams. As a result of these differences, we were able to distinguish between the effects of the X-ray beams and the NZ (= cosmic radiation + radioactive rays) and the lithium. A soft component, the intensity of which was weakened by half by 0.3 millimeter of lead, was detected as a major component by interposing different thicknesses of lead. At a maximum tube voltage of 58 kV and a tube current of 1 mA, we obtained about 3 quanta per minute with 1 mm lead and a distance of 48 mm from the tube end of the lithium.

[H. Rausch von Traubenberg did important very early work on fusion reactions and tritium production. See also:

> H. Rausch von Traubenberg, A. Eckardt, and R. Gebauer. 1933. Über den Nachweis von γ-Strahlen bei der Zertrümmerung von Lithium. *Zeitschrift für Physik* 80:557–558.

Von Traubenberg and other German scientists began using neutron reflectors around their nuclear reaction experiments no later than 1936. See pp. 4158–4159. Neutron reflectors are important for both fission reactors and fission bombs.]

Arno Brasch and Fritz Lange, AEG, German Patent DE 662036. Verfahren zur Anregung und Durchführung von Kernprozessen [Process for the Excitation and Execution of Nuclear Processes]. Filed 21 December 1934. Issued 9 June 1938.

[See document photos on pp. 4286–4287.]

Die vorliegende Erfindung bezieht sich auf ein Verfahren, um Eingriffe in den Atomkern in erheblich größerem Umfange und vor allen Dingen mit größerem Nutzeffekt vorzunehmen, als dies bisher möglich war.

Erfindungsgemäß können nicht nur radioaktive Substanzen in wesentlicher Menge wirtschaftlich erzeugt werden, sondern es bietet sich auch die Möglichkeit, zur Energiegewinnung aus dem Atomkern zu gelangen. [...]

Die wesentlichen Methoden zur Erzeugung von Neutronen sind bisher:

1. Heliumteile werden auf Beryllium geworfen und lösen dort Neutronen aus.

2. Röntgen- oder Gammastrahlen von mehr als 1,5 Milionen Volt fallen auf Beryllium und rufen dort den gleichen Vorgang hervor.

3. Der kürzlich entdeckte sog. schwere Wasserstoff (Diplogen) wird auf Diplogen geschossen.

Das letzte Verfahren ist das weitaus ergiebigste und im Rahmen der vorliegenden Erfindung deshalb von Bedeutung, weil es damit möglich war, die Auslösung von Neutronen und anderen Kernreaktionen bei sehr niedrigen Spannungsbereichen bis hinunter zu einigen 1000 Volt zu erzielen.

The present invention relates to a method for carrying out reactions of the atomic nucleus to a considerably greater extent and, above all, with greater efficiency than was previously possible.

According to the invention, not only can radioactive substances be produced economically in a substantial amount, but there is also the possibility of getting energy from the atomic nucleus. [...]

So far the essential methods for the generation of neutrons are:

1. Helium particles impact on beryllium and release neutrons.

2. X-rays or gamma-rays of more than 1.5 million volts fall on beryllium and there cause the same process.

3. The recently discovered so-called heavy hydrogen (deuterium) is fired at deuterium.

The last method is by far the most productive and important in the present invention, since it has thus been possible to achieve the triggering of neutrons and other nuclear reactions at very low voltage ranges up to a few thousand volts.

Die kinetische Energie von Atomen oder Elektronen, die mit etwa 0.13 Volt beschleunigt sind, ist etwa gerade so groß wie die von Atomen oder Elektronen, deren Temperatur 1000^o C beträgt. Wenn man sich die Aufgabe stellt, Kernprozesse dadurch anzuregen und durchzuführen, daß man Stoffe niedriger Ordnungszahl hohen Temperaturen unterwirft, so gelingt dies nur, wenn man die Temperatur so hoch steigert, daß die kinetische Energie der Atome oder Elektronen etwa gerade so groß ist, wie zur Einleitung von Kernprozessen mit Hilfe von durch elektrische Felder beschleunigten Atomen oder Elektronen erforderlich wäre. Es ist somit zur Einleitung derartiger Prozesse eine Steigerung der Temperatur auf ungefähr 10 Millionen Grad Celsius erforderlich. [...]

Zur Herstellung des gleichzeitigen Auftretens beider Vorgänge wird man den Vorgang der Erzeugung des Vordrucks verhältnismäßig langzeitig im Vergleich zu dem eigentlichen Entladungsprozeß wählen. Wenn z.B. die Dauer des Funkenentladungsvorganges etwa 10^{-6} Sek. beträgt, wird man die Dauer des Vordrucks etwa zu 10^{-4} Sek. wählen.

Die Erzeugung des Vordrucks kann entweder mit dem Verfahren nach Ramsauer, wo Zeiten von ungefähr 10^{-4} Sek. gerade erreicht werden können, vorgenommen werden oder ebenfalls durch eine zweite länger dauernde Entladung, die räumlich von der eigentlichen Funkenentladung getrennt ist.

Zu ihrer Herstellung kann man sich mit Vorteil einer schnellaufenden Dynamomaschine bedienen, die durch Entnahme elektrischer Energie in sehr kurzer Zeit abgebremst wird und in Zeiten bis zu ⅒ Sek. Leistungen von der Größenordnung 1 Million kW zu entnehmen erlaubt.

The kinetic energy of atoms or electrons accelerated at about 0.13 volts is about the same as that of atoms or electrons whose temperature is 1000^o C. If the task is to stimulate and carry out nuclear processes by subjecting substances of low atomic number to high temperatures, this is only achieved by raising the temperature so high that the kinetic energy of the atoms or electrons is about the same as that for the initiation of nuclear processes by means of electrons accelerated by electric fields. Thus, an increase of the temperature to about 10 million degrees Celsius is required to initiate such processes. [...]

In order to produce the simultaneous occurrence of both processes, the process of producing the preliminary pressure will be selected relatively long in comparison with the actual discharge process. If, for example, the duration of the spark discharge process is approximately 10^{-6} seconds, the duration of the pre-pressurization will be chosen to be about 10^{-4} seconds.

The pre-pressurization can be produced either by means of the method of Ramsauer, where times of approximately 10^{-4} seconds can be achieved, or by a second longer-lasting discharge which is spatially separated from the actual spark discharge.

To establish the pre-pressurization, one can advantageously use a high-speed dynamo machine, which is decelerated by withdrawal of electrical energy in a very short time and in periods of up to ⅒ seconds, of the order of magnitude of a million kilowatts.

Die mit diesen Verfahren erzeugbaren Temperaturen und Drucke sollen nun erfindungsgemäß angewendet werden zur Einleitung von Kernreaktionen. Hierfür kommen insbesondere Elemente niederer Ordnungszahl in Betracht, also Wasserstoff, schwerer Wasserstoff, Lithium und Bor.

Die Reaktion, die mit den geringsten Hilfsmitteln einzuleiten ist, ist die Reaktion eines schweren Wasserstoffkernes mit einem anderen schweren Wasserstoffkern. In diesem Falle würde also entweder bei der Ramsauer Methode der Gewehrlauf, in den hineingeschossen wird, mit Diplogengas gefüllt sein bzw. bei dem Funkenverfahren würde die Entladung in schwerem Wasser oder vielleicht einem Kohlenwasserstoff, dessen Wasserstoffatome aus schwerem Wasserstoff bestehen, stattfinden. Hierbei bilden sich dann Neutronen, die natürlich in üblicher Weise zur Erzeugung radioaktiver Elemente verwendet werden können. Es ist auch denkbar, daß Reaktionen von dem Gas bzw. der Flüssigkeit mit Stoffen der Kammerwand bzw. in der Flüssigkeit suspendierter Teilchen eingeleitet werden. Es sind aber bekanntlich zu allen Prozessen mit Elementen höherer Ordnungszahl entsprechend höhere Temperaturen notwendig.

Als weitere Reaktionen kommen in Frage die Reaktion von Wasserstoff mit Lithium und Bor. Wenn es gelingt, überhaupt einmal so hohe Temperaturen zu erreichen, daß Kernreaktionen in Gang kommen, so ist die Möglichkeit gegeben, die aus diesen Reaktionen frei werdenden Energien wieder zu benutzen, um neue Stoffmengen auf die nötige Reaktionstemperatur zu bringen.

Im Falle des Arbeitens mit Gasen wird es erforderlich sein, beträchtliche Drucke anzuwenden.

The temperatures and pressures which can be produced with these processes are now to be used according to the invention for initiating nuclear reactions. Particularly suitable for this purpose are elements of low atomic number, such as hydrogen, heavy hydrogen, lithium and boron.

The reaction to be initiated with the slightest aid is the reaction of a heavy hydrogen nucleus with another heavy hydrogen nucleus. In this case, therefore, either the Ramsauer method's gun barrel, into which one would shoot, would be filled with deuterium gas, or the spark would be discharged in heavy water, or perhaps a hydrocarbon, the hydrogen atoms of which are composed of heavy hydrogen. In this case, neutrons are formed, which can, of course, be used in a conventional manner to generate radioactive elements. It is also conceivable that reactions from the gas or the liquid are introduced with substances of the chamber wall or in the liquid of suspended particles. However, as is known, correspondingly higher temperatures are necessary for all processes with elements of higher order number.

Further reactions are the reaction of hydrogen with lithium and boron. If it is possible at all to reach such high temperatures as to cause nuclear reactions to take place, the possibility exists of reusing the energies released from these reactions in order to bring new quantities of matter to the necessary reaction temperature.

In the case of working with gases, it will be necessary to apply considerable pressures.

Bei Reaktionen oder Radioaktivitäten, die mit der Emission schneller geladener Korpuskeln verbunden sind, besteht die Möglichkeit, die Energie dieser Teilchen auszunutzen, indem man sie in einem Vakuumentladungsgefäß für sehr hohe Spannungen, insbesondere einem Ring oder Lamellenrohr, gegen ein elektrisches Feld entsprechender Höhe anlaufen läßt. Als besondere Anwendungsgebiete der Strahlungen, die bei Kernreaktionen bzw. künstlicher Radioaktivität auftreten, muß die Möglichkeit der Wetterbeeinflussung durch Schaffung von Kondensationskernen in Luft, insbesondere vom Flugzeug aus, erwähnt werden. Dabei wird es zweckmäßig sein, die Strahler in möglichst großem Abstand vom Flugzeug zu halten (durch Nachschleppen).

Außerdem kommen die Strahlungen von den erwähnten und anderen Kernreaktionen für medizinische Zwecke in Frage. Dabei wird besonders eine schnelle Elektronenstrahlung von Wert sein.

Da bekanntlich das Geschwindigkeitsspektrum aller β-Strahlungen kontinuierlich ist und bis zu sehr geringen Geschwindigkeiten herabreicht, ist es erforderlich, für den erwähnten Zweck eine solche Strahlenquelle immer in Verbindung mit einer magnetischen Monochromatisierungseinrichtung zu verwenden.

Als wesentlichster Punkt kommt ganz allgemein die Gewinnung von Energie aus dem Atomkern in Frage, indem man z.B. die Wärmeentwicklung der auftretenden Strahlen benutzt, um damit eine Wärmekraftmaschine zu betreiben.

Hierbei ergibt sich die Möglichkeit, unter Verzicht auf großen Nutzeffekt Maschinen mit sehr großer Leistung pro Gewichtseinheit zu bauen.

In the case of reactions or radioactivities which are associated with the emission of fast charged particles, it is possible to utilize the energy of these particles by starting them in a vacuum charging vessel for very high voltages, in particular a ring or lamellar tube, against an electric field of corresponding magnitude. The possibility of influencing the weather by the formation of condensation nuclei in air, in particular from aircraft, must be mentioned as special fields of application of the radiation which occur during nuclear reactions or artificial radioactivity. In this case, it will be expedient to keep the radiators as far as possible from the aircraft (by towing them).

In addition, the radiations from the mentioned and other nuclear reactions for medical purposes come into question. A high-speed electron beam will be of particular value.

Since, as is known, the velocity spectrum of all beta-rays is continuous and runs down to very low velocities, it is necessary for such a purpose to always use such a radiation source in conjunction with a magnetic monochromatization device.

In general, the most important point is to obtain energy from the atomic nucleus, for example by using the heat produced by the emitted rays in order to operate a heat engine.

This makes it possible to build machines with both high efficiency and very high power per unit of weight.

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Allgemeine Elektricitäts-Gesellschaft in Berlin*)

Verfahren zur Anregung und Durchführung von Kernprozessen

Patentiert im Deutschen Reiche vom 21. Dezember 1934 ab

Die vorliegende Erfindung bezieht sich auf ein Verfahren, um Eingriffe in den Atomkern in erheblich größerem Umfange und vor allen Dingen mit größerem Nutzeffekt vorzunehmen, als dies bisher möglich war.

Erfindungsgemäß können nicht nur radioaktive Substanzen in wesentlicher Menge wirtschaftlich erzeugt werden, sondern es bietet sich auch die Möglichkeit, zur Energiegewinnung aus dem Atomkern zu gelangen.

Aus dem natürlichen Zerfall der radioaktiven Elemente ist zu ersehen, wie viel Energie grundsätzlich in 1 g Materie aufgehäuft sein kann und bis zum völligen Zerfall in mehr oder weniger langer Zeit entsprechend den jeweiligen Zerfallskonstanten frei wird.

Es sind dies Energiemengen, die etwa millionenfache Beträge dessen ausmachen, was beispielsweise bei der bisher üblichen Verbrennung unserer Treibmittel, Kohle, Öl usw., zur Wirkung gelangt.

Seit einigen Jahren beschäftigt sich die Physik damit, wenn auch bisher aus rein wissenschaftlichen Gründen, Atomumwandlungen unabhängig vom Spontanzerfall der relativ sehr seltenen radioaktiven Elemente auf künstlichem Wege zu erreichen. Diese Bestrebungen führten auch zum Erfolg, und zwar bisher dadurch, daß man auf elektrischem Wege Strahlen erzeugte, die den vom Radium ausgesendeten Strahlen gleich oder ähnlich waren und damit andere Stoffe bombardierte. Wenn auch die durch solche Versuche gewonnenen Erkenntnisse über die durch das Radium gezogenen Grenzen hinausgingen, so war doch grundsätzlich bisher an eine Energiegewinnung auf diesem Wege nicht zu denken, weil nur ein winziger Bruchteil der ausgesendeten Strahlen zum Kernprozeß führten.

Unter anderem eröffnete hier die kürzliche Entdeckung der Neutronen besondere Möglichkeiten, weil diese Teilchen Kernreaktionen mit 100%igem Nutzeffekt erlauben.

So ist es jetzt möglich, damit künstliche Radioaktivitäten, die etwa denen 1 mg Radium gleich sind, zu erzeugen.

Wenn auch, wie bereits ausgeführt, die Neutronen Kerneffekte mit großer Ausbeute hervorrufen, so ist doch die Herstellung der Neutronen selbst vorläufig nur mit relativ sehr geringem Nutzeffekt möglich.

Die wesentlichen Methoden zur Erzeugung von Neutronen sind bisher:

1. Heliumteile werden auf Beryllium geworfen und lösen dort Neutronen aus.
2. Röntgen- oder Gammastrahlen von mehr als 1,5 Milionen Volt fallen auf Beryllium und rufen dort den gleichen Vorgang hervor.
3. Der kürzlich entdeckte sog. schwere Wasserstoff (Diplogen) wird auf Diplogen geschossen.

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*) *Von dem Patentsucher sind als die Erfinder angegeben worden:*

Arno Brasch in New York, V. St. A.,

und Dr. Fritz Lange in Charkow, Union der Sozialistischen Sowjet-Republiken.

Das letzte Verfahren ist das weitaus ergiebigste und im Rahmen der vorliegenden Erfindung deshalb von Bedeutung, weil es damit möglich war, die Auslösung von Neutronen und anderen Kernreaktionen bei sehr niedrigen Spannungsbereichen bis hinunter zu einigen 1000 Volt zu erzielen.

Die kinetische Energie von Atomen oder Elektronen, die mit etwa 0,13 Volt beschleunigt sind, ist etwa gerade so groß wie die von Atomen oder Elektronen, deren Temperatur 1000° C beträgt. Wenn man sich die Aufgabe stellt, Kernprozesse dadurch anzuregen und durchzuführen, daß man Stoffe niedriger Ordnungszahl hohen Temperaturen unterwirft, so gelingt dies nur, wenn man die Temperatur so hoch steigert, daß die kinetische Energie der Atome oder Elektronen etwa gerade so groß ist, wie zur Einleitung von Kernprozessen mit Hilfe von durch elektrische Felder beschleunigten Atomen oder Elektronen erforderlich wäre. Es ist somit zur Einleitung derartiger Prozesse eine Steigerung der Temperatur auf ungefähr 10 Millionen Grad Celsius erforderlich.

In neuerer Zeit ist es beispielsweise durch die von C. Ramsauer entwickelte Methode möglich geworden, Temperaturen von außerordentlicher Höhe zu erzeugen.

Es wird hierbei folgendes Verfahren benutzt:

Ein Geschoß wird mit Geschwindigkeiten bis zu 1000 m/Sek. abgeschossen und in einen Gewehrlauf hineingeschossen. Hierbei entstehen gewaltige Drucke bis zu 10 Millionen Atm. und damit sehr hohen Temperaturen, die schon bei verhältnismäßig einfachen Hilfsmitteln bis zu 200 000° C betragen.

Es ist nun der Erfindungsgedanke, unter Verwendung solcher extremer Temperaturen und bei Benutzung geeigneter Substanzen Kernreaktionen sehr hoher Ausbeute herzustellen.

Hierfür gibt es eine Anzahl von Ausführungsbeispielen. Einmal der schon angedeutete Fall, daß in einen Gewehrlauf, in dem die zu behandelnde Substanz sich als Gas befindet, ein Projektil hineingeschossen wird.

Besonders ist es vorteilhaft, gemäß der Erfindung den Anfangsdruck nach Möglichkeit klein zu halten bis hinunter zu 1 mm Hg, da nicht die Erzeugung möglichst hoher Dichten, sondern vor allem hoher Temperaturen erstrebt wird. Die Höhe des erreichbaren Druckes ist, wie Ramsauer gezeigt hat, um so höher, je größer die Länge des Geschosses ist.

Außerdem wurden Versuche zur Erzeugung sehr hoher Drucke und Temperaturen unternommen, indem eine Kondensatorbatterie sehr großer Kapazität über einen Funken in einer schwer kompressiblen Flüssigkeit, Öl, Wasser usw., entladen wird. Hierbei entstehen tatsächlich außerordentlich hohe Drucke und Temperaturen. Dieses Verfahren ist besonders wirksam, wenn man dafür sorgt, daß die Spannung an dem Funken bzw. dem dadurch eingeleiteten Lichtbogen nicht sofort zusammenbricht.

Dies ist erreichbar einerseits durch Verwendung und Beimengung von Substanzen hoher Elektronenaffinität, besonders aber durch Anwendung sehr hoher Drucke. Solche hohen Drucke können bis zu einem gewissen Grade durch die Druckwelle in der inkompressiblen Flüssigkeit, die vom Funken selbst ausgelöst wird, erzeugt werden. Es wird sich aber empfehlen, noch unter Hinzunahme anderer Mittel den Druck über die hierdurch gegebenen Möglichkeiten zu steigern. Vor allen Dingen erscheint es als wesentlich, daß der Hochdruck sich nicht erst während des Ablaufs der Entladung allmählich aufbaut und auch hierzu wertvolle Energie verbraucht wird, sondern nach Möglichkeit auf anderem Wege und vor Beginn der eigentlichen Entladung hergestellt wird.

Dabei wird man zunächst an mechanische Hilfsmittel denken und ein Gefäß aus möglichst widerstandsfähigem Material (Stahl) mit einer gänzlich gasfreien nicht zusammendrückbaren Flüssigkeit füllen sowie es unter einen Druck setzen, wie er mit mechanischen Hilfsmitteln noch erreichbar ist (bis zu einigen 1000 Atm.).

Wesentlich weiter wird man kommen, wenn man diesen Vordruck nur stoßartig erzeugt sowie unter Ausnutzung der Trägheit von Flüssigkeit und Wand und der mechanischen Überbeanspruchbarkeit fester Körper in kurzen Zeiten.

Zur Herstellung des gleichzeitigen Auftretens beider Vorgänge wird man den Vorgang der Erzeugung des Vordrucks verhältnismäßig langzeitig im Vergleich zu dem eigentlichen Entladungsprozeß wählen. Wenn z. B. die Dauer des Funkenentladungsvorganges etwa 10^{-6} Sek. beträgt, wird man die Dauer des Vordrucks etwa zu 10^{-4} Sek. wählen.

Die Erzeugung des Vordrucks kann entweder mit dem Verfahren nach Ramsauer, wo Zeiten von ungefähr 10^{-4} Sek. gerade erreicht werden können, vorgenommen werden oder ebenfalls durch eine zweite länger dauernde Entladung, die räumlich von der eigentlichen Funkenentladung getrennt ist.

Zu ihrer Herstellung kann man sich mit Vorteil einer schnellaufenden Dynamomaschine bedienen, die durch Entnahme elektrischer Energie in sehr kurzer Zeit abgebremst wird und in Zeiten bis zu $^1/_{10}$ Sek. Leistungen von der Größenordnung 1 Million kW zu entnehmen erlaubt.

Figure D.604: Arno Brasch and Fritz Lange, AEG. German Patent DE 662036. Verfahren zur Anregung und Durchführung von Kernprozessen [Process for the Excitation and Execution of Nuclear Processes]. Filed 21 December 1934. Issued 9 June 1938.

662 036 3

Die mit diesen Verfahren erzeugbaren Temperaturen und Drucke sollen nun erfindungsgemäß angewendet werden zur Einleitung von Kernreaktionen. Hierfür kommen insbesondere Elemente niederer Ordnungszahl in Betracht, also Wasserstoff, schwerer Wasserstoff, Lithium und Bor.

Die Reaktion, die mit den geringsten Hilfsmitteln einzuleiten ist, ist die Reaktion eines schweren Wasserstoffkernes mit einem anderen schweren Wasserstoffkern. In diesem Falle würde also entweder bei der Ramsauer Methode der Gewehrlauf, in den hineingeschossen wird, mit Diplogengas gefüllt sein bzw. bei dem Funkenverfahren würde die Entladung in schwerem Wasser oder vielleicht einem Kohlenwasserstoff, dessen Wasserstoffatome aus schwerem Wasserstoff bestehen, stattfinden. Hierbei bilden sich dann Neutronen, die natürlich in üblicher Weise zur Erzeugung radioaktiver Elemente verwendet werden können. Es ist auch denkbar, daß Reaktionen von dem Gas bzw. der Flüssigkeit mit Stoffen der Kammerwand bzw. in der Flüssigkeit suspendierter Teilchen eingeleitet werden. Es sind aber bekanntlich zu allen Prozessen mit Elementen höherer Ordnungszahl entsprechend höhere Temperaturen notwendig.

Als weitere Reaktionen kommen in Frage die Reaktion von Wasserstoff mit Lithium und Bor. Wenn es gelingt, überhaupt einmal so hohe Temperaturen zu erreichen, daß Kernreaktionen in Gang kommen, so ist die Möglichkeit gegeben, die aus diesen Reaktionen frei werdenden Energien wieder zu benutzen, um neue Stoffmengen auf die nötige Reaktionstemperatur zu bringen.

Im Falle des Arbeitens mit Gasen wird es erforderlich sein, beträchtliche Drucke anzuwenden.

Bei Reaktionen oder Radioaktivitäten, die mit der Emission schneller geladener Korpuskeln verbunden sind, besteht die Möglichkeit, die Energie dieser Teilchen auszunutzen, indem man sie in einem Vakuumentladungsgefäß für sehr hohe Spannungen, insbesondere einem Ring oder Lamellenrohr, gegen ein elektrisches Feld entsprechender Höhe anlaufen läßt. Als besondere Anwendungsgebiete der Strahlungen, die bei Kernreaktionen bzw. künstlicher Radioaktivität auftreten, muß die Möglichkeit der Wetterbeeinflussung durch Schaffung von Kondensationskernen in Luft, insbesondere vom Flugzeug aus, erwähnt werden. Dabei wird es zweckmäßig sein, die Strahler in möglichst großem Abstand vom Flugzeug zu halten (durch Nachschleppen).

Außerdem kommen die Strahlungen von den erwähnten und anderen Kernreaktionen für medizinische Zwecke in Frage. Dabei wird besonders eine schnelle Elektronenstrahlung von Wert sein.

Da bekanntlich das Geschwindigkeitsspektrum aller β-Strahlungen kontinuierlich ist und bis zu sehr geringen Geschwindigkeiten herabreicht, ist es erforderlich, für den erwähnten Zweck eine solche Strahlenquelle immer in Verbindung mit einer magnetischen Monochromatisierungseinrichtung zu verwenden.

Als wesentlichster Punkt kommt ganz allgemein die Gewinnung von Energie aus dem Atomkern in Frage, indem man z. B. die Wärmeentwicklung der auftretenden Strahlen benutzt, um damit eine Wärmekraftmaschine zu betreiben.

Hierbei ergibt sich die Möglichkeit, unter Verzicht auf großen Nutzeffekt Maschinen mit sehr großer Leistung pro Gewichtseinheit zu bauen.

PATENTANSPRÜCHE:

1. Verfahren zur Anregung und Durchführung von Kernprozessen, dadurch gekennzeichnet, daß Stoffe niedriger Ordnungszahl Temperaturen unterworfen werden, bei denen die kinetische Energie der Atome oder Elektronen etwa gerade so groß ist, wie zur Einleitung von Kernprozessen mit Hilfe von durch elektrische Felder beschleunigten Atomen und Elektronen erforderlich wäre.

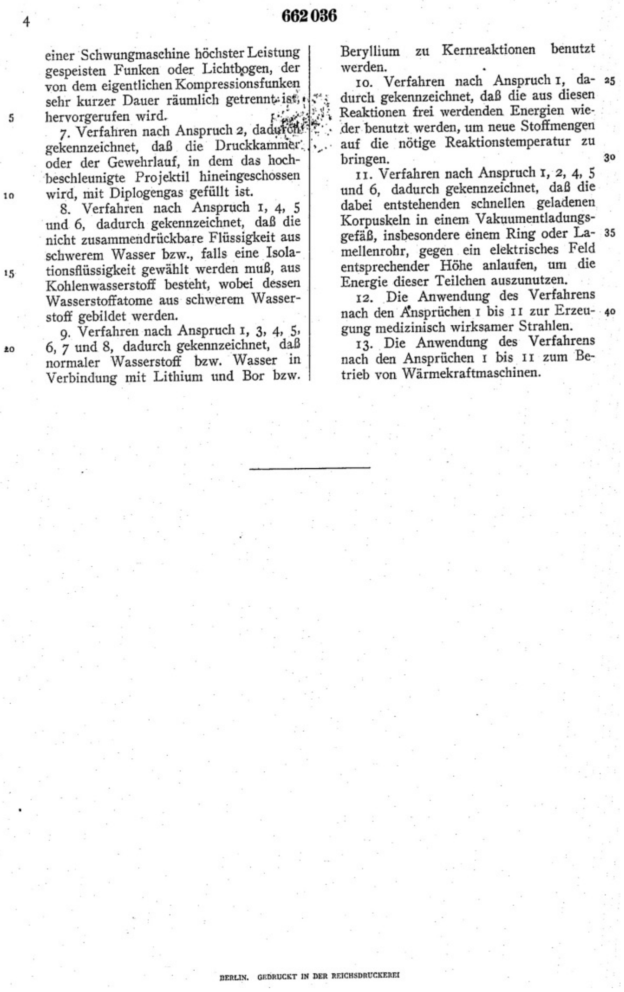
2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die hierzu nötigen Temperaturen hergestellt werden durch eine Anordnung, bei der ein hochbeschleunigtes Projektil in einen zweiten äußerst druckwiderstandsfähigen Gewehrlauf bzw. Kanonenrohr geschossen wird, und daß dieser zweite Lauf mit Substanzen gefüllt ist, die in Verbindung mit der hohen entstehenden Temperatur zu Kernreaktionen führen.

3. Verfahren nach Anspruch 2, dadurch gekennzeichnet, daß der Anfangsdruck klein gehalten wird.

4. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die erforderlichen hohen Drucke durch einen möglichst kurzzeitigen elektrischen Funken sehr hoher Leistung in einer nicht zusammendrückbaren Flüssigkeit hergestellt werden.

5. Verfahren nach Anspruch 4, dadurch gekennzeichnet, daß auf mechanischem Wege ein möglichst großer Vordruck angewendet wird, um das Zusammenbrechen des Funkens zu verhindern.

6. Verfahren nach Anspruch 4 und 5, dadurch gekennzeichnet, daß der gewünschte hohe Vordruck durch den von



4 **662 036**

einer Schwungmaschine höchster Leistung gespeisten Funken oder Lichtbogen, der von dem eigentlichen Kompressionsfunken sehr kurzer Dauer räumlich getrennt ist, hervorgerufen wird.

7. Verfahren nach Anspruch 2, dadurch gekennzeichnet, daß die Druckkammer oder der Gewehrlauf, in dem das hochbeschleunigte Projektil hineingeschossen wird, mit Diplogengas gefüllt ist.

8. Verfahren nach Anspruch 1, 4, 5 und 6, dadurch gekennzeichnet, daß die nicht zusammendrückbare Flüssigkeit aus schwerem Wasser bzw., falls eine Isolationsflüssigkeit gewählt werden muß, aus Kohlenwasserstoff besteht, wobei dessen Wasserstoffatome aus schwerem Wasserstoff gebildet werden.

9. Verfahren nach Anspruch 1, 3, 4, 5, 6, 7 und 8, dadurch gekennzeichnet, daß normaler Wasserstoff bzw. Wasser in Verbindung mit Lithium und Bor bzw. Beryllium zu Kernreaktionen benutzt werden.

10. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die aus diesen Reaktionen frei werdenden Energien wieder benutzt werden, um neue Stoffmengen auf die nötige Reaktionstemperatur zu bringen.

11. Verfahren nach Anspruch 1, 2, 4, 5 und 6, dadurch gekennzeichnet, daß die dabei entstehenden schnellen geladenen Korpuskeln in einem Vakuumentladungsgefäß, insbesondere einem Ring oder Lamellenrohr, gegen ein elektrisches Feld entsprechender Höhe anlaufen, um die Energie dieser Teilchen auszunutzen.

12. Die Anwendung des Verfahrens nach den Ansprüchen 1 bis 11 zur Erzeugung medizinisch wirksamer Strahlen.

13. Die Anwendung des Verfahrens nach den Ansprüchen 1 bis 11 zum Betrieb von Wärmekraftmaschinen.

BERLIN. GEDRUCKT IN DER REICHSDRUCKEREI

Figure D.605: Arno Brasch and Fritz Lange, AEG. German Patent DE 662036. Verfahren zur Anregung und Durchführung von Kernprozessen [Process for the Excitation and Execution of Nuclear Processes]. Filed 21 December 1934. Issued 9 June 1938.

R. S. Malton, a.k.a. Richard S. Morse. 2 June 1945 [NARA RG 77, Entry UD-22A, Box 171, Folder 32.7003-3 GERMANY: US Wartime Positive Int. (Nov. 44–June 45)].

In connection with investigational work now underway relative to the development of Manhattan District projects by the Germans, a certain amount of information probably can be obtained from Mr. A. Brasch of the Electronized Chemical Corporation at 122 East 42nd Street, New York City.

Mr. Brasch is a former German citizen, and I am sure he has been thoroughly investigated. As an atomic physicist in 1938 he was approached by members of the general German staff to initiate research along lines of interest to the Manhattan District. Because of his connections with Siemens Halske and A.E.G. and the University of Berlin some information might be forthcoming if required at this late date.

James E. Nolan to Francis J. Smith. 14 June 1945 [NARA RG 77, Entry UD-22A, Box 171, Folder 32.7003-3 GERMANY: US Wartime Positive Int. (Nov. 44–June 45)].

1. Inclosed is copy of the letter submitted by Confidential Informant No. 16 of the Boston Branch Office.

2. Siemens Halske and A.E.G. referred to are the German branches [sic, actually counterparts] of Westinghouse and General Electric respectively.

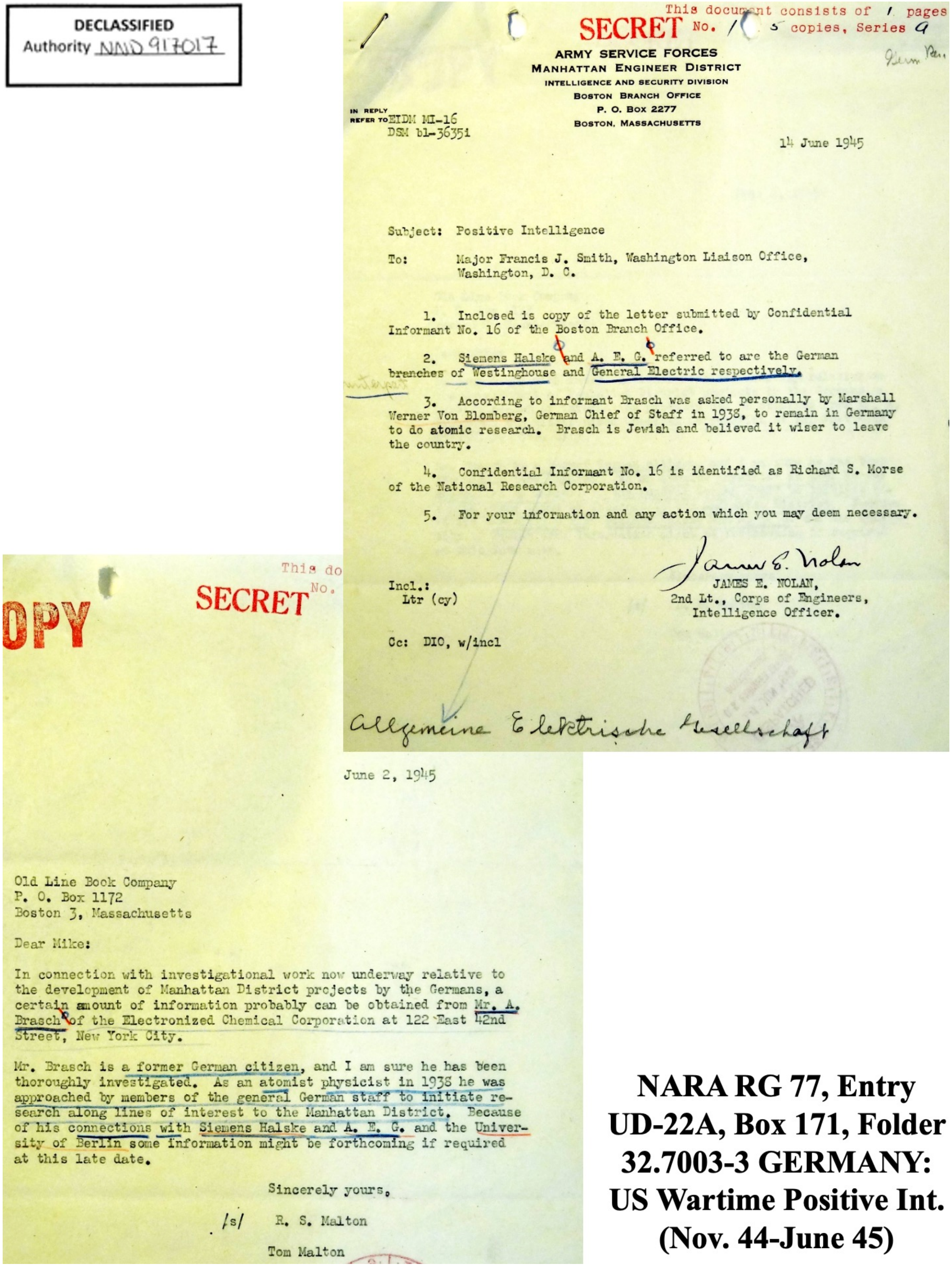
3. According to informant Brasch was asked personally by Marshall Werner von Blomberg, German Chief of Staff in 1938, to remain in Germany to do atomic research. Brasch is Jewish and believed it wiser to leave the country.

4. Confidential Informant No. 16 is identified as Richard S. Morse of the National Research Corporation.

5. For your information and any action which you may deem necessary.

[See document photos on p. 4289.

Werner von Blomberg was the Reichsminister of War from May 1935 to January 1938. Thus no later than January 1938, the German government, and in particular the German military, was actively pursuing nuclear weapons. They attempted to recruit Arno Brasch to work on that program despite the fact that he was Jewish. Similarly, Gustav Hertz appears to have held an important position in the German nuclear weapons program throughout the war despite his Jewish ancestry (Section D.4.4).]



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Germ. Res.

ARMY SERVICE FORCES
MANHATTAN ENGINEER DISTRICT
INTELLIGENCE AND SECURITY DIVISION
BOSTON BRANCH OFFICE
P. O. BOX 2277
BOSTON, MASSACHUSETTS

IN REPLY
REFER TO EIDM MI-16
DSM bl-36351

14 June 1945

Subject: Positive Intelligence

To: Major Francis J. Smith, Washington Liaison Office,
Washington, D. C.

1. Inclosed is copy of the letter submitted by Confidential Informant No. 16 of the Boston Branch Office.

2. Siemens Halske and A. E. G. referred to are the German branches of Westinghouse and General Electric respectively.

3. According to informant Brasch was asked personally by Marshall Werner Von Blomberg, German Chief of Staff in 1938, to remain in Germany to do atomic research. Brasch is Jewish and believed it wiser to leave the country.

4. Confidential Informant No. 16 is identified as Richard S. Morse of the National Research Corporation.

5. For your information and any action which you may deem necessary.

James E. Nolan
JAMES E. NOLAN,
2nd Lt., Corps of Engineers,
Intelligence Officer.

Incl.:
Ltr (cy)

Cc: DIO, w/incl

Allgemeine Elektrische Gesellschaft

OPY SECRET This do
No.

June 2, 1945

Old Line Book Company
P. O. Box 1172
Boston 3, Massachusetts

Dear Mike:

In connection with investigational work now underway relative to the development of Manhattan District projects by the Germans, a certain amount of information probably can be obtained from Mr. A. Brasch of the Electronized Chemical Corporation at 122 East 42nd Street, New York City.

Mr. Brasch is a former German citizen, and I am sure he has been thoroughly investigated. As an atomist physicist in 1938 he was approached by members of the general German staff to initiate research along lines of interest to the Manhattan District. Because of his connections with Siemens Halske and A. E. G. and the University of Berlin some information might be forthcoming if required at this late date.

Sincerely yours,

/s/ R. S. Malton

Tom Malton

NARA RG 77, Entry UD-22A, Box 171, Folder 32.7003-3 GERMANY: US Wartime Positive Int. (Nov. 44-June 45)

Figure D.606: R. S. Malton, a.k.a. Richard S. Morse, 2 June 1945. James E. Nolan to Francis J. Smith, 14 June 1945. [NARA RG 77, Entry UD-22A, Box 171, Folder 32.7003-3 GERMANY: US Wartime Positive Int. (Nov. 44–June 45)]

Auergesellschaft. U.K. Patent GB 508,233. Method for Carrying Out Nuclear Reactions. Filed 7 February 1937. Issued 28 June 1939.

We, DEGEA AKTIENGESELLSCHAFT (AUERGESELLSCHAFT), of 16–19, Rotherstrasse, Berlin, 0.17, Germany, a German Company, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:-

Artificial nuclear reactions are initiated by the bombardment of nuclei with light elementary particles. With the use of charged particles (protons, α particles) energies of 10^3 to 10^7 volts are necessary for overcoming the coulombic repulsion powers, in order to ensure a sufficient yield for the penetration of the particles into the bombarded nucleus.

Such a repulsion does not exist for neutrons, so that neutrons of small speed can penetrate into nuclei and produce reactions, as experiments actually show.

Unfortunately, there are no direct sources producing neutrons; they arise, if nuclei, for example, Be, are irradiated with α-particles of high energies (about 10^6 volts) or γ-rays very rich in energy (about $2{\cdot}10^6$ volts) or by bombardment of certain nuclei with fast particles of the heavy isotope of hydrogen. As sources of α-particles of sufficiently high energy, only the naturally radioactive elements have hitherto been available. In the two other cases, for accelerating elementary particles it is necessary to have recourse to the use of very considerable amounts of energy. With the remaining hitherto known methods for the production of elementary particles rich in energy, which have been used directly, or indirectly through the production of very hard Röntgen rays, for the production of neutrons and generally for the initiation of nuclear reactions, there came to be used an acceleration of the desired particles in high vacuum. This method indeed produces definite speeds, but only at the expense of very heavy outlay in the matter of electro-technical apparatus for building up an increase in the current density of the accelerated particles, and also gives a greater absolute yield from the nuclear reactions. The output attained in this way probably corresponds, at best, to that of a few grams of radium. The method of repeated secondary acceleration by means of high frequency alternating fields (Cyclotron) certainly produces greater absolute yields than those just stated, but necessitates however a great increase in the expense of apparatus (extremely large magnets).

The present invention therefore proposes to allow the nuclear reactions to take place under completely different conditions, namely, in the gas phase, under a mean numerical concentration of more than 10^{19} molecules of the gas per cubic centimetre, and preferably under a concentration corresponding to a pressure of one atmosphere at normal temperature of 18^o C. 70 Since in this case, a selective acceleration of elementary particles is not possible, the attainment of a thermal equilibrium with very high temperatures (greater than $10^{7\,o}$ C.) is the objective. For reasons of energy consumption such conditions can only be maintained by extraordinarily high momentary outputs and only for very short times. Accordingly, this invention contemplates the production of energies of 100 watt seconds and more during intervals of 10^{-6} second and less, corresponding to momentary outputs of 100,000 kilowatts and more.

Theoretical calculations based on experiments with exploding wires, and also observations made in connection with mercury discharges in which the number of glowing atoms could be determined with some degree of certainty, lead to the conclusion that high temperatures of the order specified occur with condenser discharges in the gaseous phase. Such operating conditions have in themselves the advantage that because of the practically complete ionisation in the discharge canal the braking action of the electron cloud falls away, and therefore still larger yields of the nuclear reactions are to be expected than have been observed hitherto with neutral atoms. It is therefore proposed for the realisation of the operating conditions set forth above, to utilise condenser discharges. For this it is necessary that

1) the gas concentration (number of molecules per cubic centimetre) be so great that thermal equilibrium can be established within the time of discharge of the condenser.

2) the momentary output, which is given by the size and charging voltage of the condenser, be made so great that the equilibrium temperature becomes established at the desired level.

The experimenter is at liberty to increase the action of the individual extremely short condenser discharge (duration of 10^{-6} second), after the lapse of a certain time which might be approximately of the order of magnitude of 10^{-3} second by allowing a further condenser discharge to traverse the gas. In this way it is possible to intensify the total effect of the method within the limits imposed by the thermal resistance of the discharge vessel used. A discharge rate of 5 discharges per second is probably about as high a rate as can normally be expected to be endured by a glass vessel.

The deciding factors given by these two conditions, viz., gas concentration and the size and charging voltage of the condensers, can be calculated for each individual process.

This calculation has been carried out for the production of neutrons by means of condenser discharge in heavy hydrogen gas. It gives, for about 1 atmosphere pressure, C=50,000 cm. $V=10^5$ volts (C being the capacity of the condenser and V being the charging voltage) and with a discharge rate of 5 discharges per second, an efficiency which is equivalent to about 50 gms. Ra + Be. Similar results are obtained when using a mixture of heavy and light hydrogen gas.

The method is naturally not limited to the production of neutrons but is equally applicable to a great number of nuclear reactions which may be carried out in this manner on a large scale, for example, the production of helium. For this purpose a discharge of the nature described above may be effected in a mixture of lithium vapour and light hydrogen, the resulting reaction being typified by the following equations:

$$^7_3\mathrm{Li} + ^1_1\mathrm{H} = ^4_2\mathrm{He}; \qquad ^6_3\mathrm{Li} + ^1_1\mathrm{H} = ^4_2\mathrm{He} + ^3_2\mathrm{He}$$

The pressures and outputs used are the same as in the above described reaction for the production of neutrons by condenser discharges in heavy hydrogen gas.

It is also possible to obtain helium indirectly through neutron irradiation in accordance with the following reaction formula:

$$^{10}_5\mathrm{B} + ^1_0\mathrm{n} = ^4_2\mathrm{He} + ^7_3\mathrm{Li}$$

For this purpose the vessel in which the neutron producing discharge takes place requires to be lined on the inside with a substance containing boron and hydrogen, e.g., $B(OCH_3)_3$ or the discharge vessel has to be arranged adjoining an outer flask filled with such substance.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:-

1. Method of carrying out nuclear reactions in which the energy requisite for activating the elementary particles to be caused to participate in a desired reaction is produced in a gas discharge under a mean gas concentration of more than 10^{19} molecules per cubic centimetre, and energies of 100 watt seconds and more during intervals of 10^{-6} second and less are produced, corresponding to momentary outputs of 100,000 kilowatts and more.

2. Method as claimed in claim 1 wherein the reaction is carried out under a gas concentration which corresponds to a pressure of one atmosphere at normal temperature of 18^o C.

3. Method as claimed in claim 1 for producing neutrons, wherein heavy hydrogen gas or a mixture of light and heavy hydrogen gas is utilised as reagent gas.

[See document photos on p. 4293.

This patent did not name any specific inventors, but Nikolaus Riehl was probably the inventor, or at least one of the inventors.

The patent reported that this high-voltage fusion neutron generator had a neutron output comparable to a 50-gram radium-beryllium source, which produces approximately $7.6 \cdot 10^8$ neutrons/second.

The patent also reported that this fusion neutron generator could produce five pulses per second, each with a duration of 10^{-6} second.

Thus the pulses would produce approximately $1.5 \cdot 10^8$ neutrons per pulse, or a neutron intensity of $1.5 \cdot 10^{14}$ neutrons/second during each pulse.]

PATENT SPECIFICATION

Convention Date (Germany): Feb. 9, 1937.

Application Date (in United Kingdom): Feb. 7, 1938. *No. 3845/38.*

508,233

Complete Specification Accepted: June 28, 1939.

COMPLETE SPECIFICATION

Method for Carrying out Nuclear Reactions

We, DEGEA AKTIENGESELLSCHAFT (AUERGESELLSCHAFT), of 16—19, Rotherstrasse, Berlin, O.17, Germany, a German Company, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

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Unfortunately, there are no direct sources producing neutrons; they arise, if nuclei, for example, Be, are irradiated with α-particles of high energies (about 10^6 volts) or γ-rays very rich in energy (about 2.10^6 volts) or by bombardment of certain nuclei with fast particles of the heavy isotope of hydrogen. As sources of α-particles of sufficiently high energy, only the naturally radioactive elements have hitherto been available. In the two other cases, for accelerating elementary particles it is necessary to have recourse to the use of very considerable amounts of energy. With the remaining hitherto known methods for the production of elementary particles rich in energy, which have been used directly, or indirectly through the production of very hard Röntgen rays, for the production of neutrons and generally for the initiation of nuclear reactions, there came to be used an acceleration of the desired particles in high vacuum. This method indeed produces definite speeds, but only at the expense of very heavy outlay in the matter of electro-technical apparatus for building up an increase in the current density of the accelerated particles, and also gives a greater absolute yield from the nuclear reactions. The output attained in this way probably corresponds, at best, to that of a few grams of radium. The method of repeated secondary acceleration by means of high frequency alternating fields (Cyclotron) certainly produces greater absolute yields than those just stated, but necessitates however a great increase in the expense of apparatus (extremely large magnets).

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2) the momentary output, which is given by the size and charging voltage of the condenser, be made so great that the equilibrium temperature becomes established at the desired level.

[Price 1/-]

2 508,233

The experimenter is at liberty to increase the action of the individual extremely short condenser discharge (duration of 10^{-6} second), after the lapse of a certain time which might be approximately of the order of magnitude of 10^{-3} second by allowing a further condenser discharge to traverse the gas. In this way it is possible to intensify the total effect of the method within the limits imposed by the thermal resistance of the discharge vessel used. A discharge rate of 5 discharges per second is probably about as high a rate as can normally be expected to be endured by a glass vessel.

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For this purpose the vessel in which the neutron producing discharge takes place requires to be lined on the inside with a substance containing boron and hydrogen, e.g., $B(OCH_3)_3$, or the discharge vessel has to be arranged adjoining an outer flask filled with such substance.

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2. Method as claimed in claim 1 wherein the reaction is carried out under a gas concentration which corresponds to a pressure of one atmosphere at normal temperature of 18° C.

3. Method as claimed in claim 1 for producing neutrons, wherein heavy hydrogen gas or a mixture of light and heavy hydrogen gas is utilised as reagent gas.

Dated this 7th day of February, 1938.

BARON & WARREN,
231, Strand, London, W.C.2,
Chartered Patent Agents.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1939.

Figure D.607: Auergesellschaft. U.K. Patent GB 508,233. Method for Carrying Out Nuclear Reactions. Filed 7 February 1937. Issued 28 June 1939.

Hartmut Kallmann and Ernst Kuhn. U.S. Patent 2,251,190. Method of Producing Neutrons. Filed 16 March 1938. Issued 29 July 1941.

This invention relates to a method for the production of neutrons, particularly by the interaction of deuterons.

In order to obtain neutrons with the aid of ions with relatively slight acceleration (for instance 300 kv.) the nuclear reaction

$$\mathrm{D} + \mathrm{D} = \mathrm{He}_3 + \mathrm{n} \tag{D.12}$$

is employed. The procedure in this connection is to bombard a layer containing heavy hydrogen nuclei with heavy hydrogen ions or deuterons. For the layer containing hydrogen, use is often made of ice, sal ammoniac, phosphoric acid and similar substances in which ordinary hydrogen is replaced by heavy hydrogen. These layers very rich in hydrogen have the disadvantage that they conduct heat and electricity poorly and are therefore easily destroyed by ionic bombardment. It would be better if more resistant layers were used, for instance, metallic layers. That is possible, however, only when metals that contain large amounts of dissolved or adsorbed hydrogen are employed. These are a few such metals, but they have the disadvantage that they gradually give off hydrogen in the vacuum. It would be still better therefore if substances could be used that contain hydrogen adsorbed only on the surface or in a surface layer but give it off to the outside less easily. These substances placed in the ion stream give only a small output of neutrons when impinged on vertically since the thickness of the adsorbed hydrogen layer is very small in comparison with the range of the ions projected into the metal. Nuclear processes can occur therefore only in a fractional portion of the path of the ions. In case, however, the path of the ions is maintained as nearly as possible entirely within the thin hydrogen layer, a large neutron output is obtained with the aid of these thin adsorbed hydrogen layers.

A principal purpose of the invention is the provision of a highly efficient method for the production of neutrons by the interaction of deuterons. According to the invention this is attained by allowing the stream of ions to impinge on the layer at an angle—preferably in as grazing a manner as possible.

The adsorption layer containing hydrogen need not consist of pure hydrogen. It might under certain conditions be more advantageous if the adsorption layer consists of gases or vapors containing hydrogen, for instance, methane or water. This is particularly satisfactory when these substances are adsorbed especially strongly.

The body impinged on by the ions is preferably made of a substance that strongly adsorbs the molecules containing heavy hydrogen and at the same time possesses only a slight retarding capacity for the impinging ions. Carbon and beryllium have been found useful for these reasons. It is especially desirable to employ substances that adsorb the molecules containing hydrogen in as thick a layer as possible. This can be accomplished for instance by using, as adsorption body, a substance that is porous or roughened at least at the surface.

The surface of the adsorbing body is heated up by the energy of the impinging ions. In this way the giving off of the adsorbed substance is promoted. It is, therefore, advisable to cool the adsorbing body. This cooling has the advantage, moreover, that at low temperature the adsorbed layer adheres much more firmly. A reduction of the temperature of only 10^oC., for instance from 20^oC. room temperature to 10^oC., can produce a considerable improvement. In many cases, it is advisable to use solid carbon dioxide or even liquid air for the cooling.

The adsorbed layer can be produced in the usual way, for instance by taking up heavy hydrogen or molecules containing heavy hydro gen from the surroundings, for instance from the gas chamber; but it may also be produced by bombarding the surface with heavy hydrogen ions. It is advisable to free the surface intended for the adsorption of heavy hydrogen as far as possible from other adsorbed molecules, such as ordinary hydrogen, for example, by heating in vacuum.

The replacement of the hydrogen given off during the ion bombardment can be accomplished, for instance, by simultaneous or subsequent bombardment with ions containing heavy hydrogen. This bombardment can be accomplished, for instance, with advantage from a different direction, for example, from the back or at a more acute angle from the front, than the bombardment for producing neutrons. The replacement of the heavy hydrogen may be accomplished, for example, by diffusion or by adsorption from the surroundings.

The principles of the invention are illustrated in the accompanying drawing in which:

Fig. l is a diagrammatic representation of apparatus embodying the principles of the invention; and

Fig. 2 is a partial diagrammatic representation of a modified embodiment of the invention.

In Fig. 1 a beam of high velocity ions of heavy hydrogen 14 is produced by the device described in copending application Serial No. 234,504 of Kuhn and Kallmann, filed October 11, 1938. In this device a beam of negative ions 4 generated at cathode 1 and focussed at 2 by electrode 16 is transformed into a beam of positive heavy hydrogen ions of increased velocity by means of the transforming electrode 5, supported in space 3 by tube 7 and insulator 15. A low pressure is maintained in 3 by means of a pump (not shown) connected at 8. A stream of heavy hydrogen is supplied to channel 6 through tube 7. The high velocity beam of heavy hydrogen ions obtained in this manner passes through apertured member 9 into cathode 10 where they impinge at a grazing angle on the target 11. The high velocity heavy hydrogen ions in the beam react with heavy hydrogen adsorbed on the surface of 11 to produce neutrons.

In the form shown in Fig. 2, a supply of heavy hydrogen is maintained on target 11 by diffusion into 11 of a substance 13 containing heavy hydrogen which is maintained in capsule 12.

[See document photos on pp. 4296–4297.]

Patented July 29, 1941 **2,251,190**

UNITED STATES PATENT OFFICE

2,251,190

METHOD OF PRODUCING NEUTRONS

Hartmut Israel Kallmann, formerly known as Hartmut Kallmann, Berlin-Charlottenburg, and Ernst Kuhn, Berlin, Germany, assignors to I. G. Farbenindustrie Aktiengesellschaft, Frankfort-on-the-Main, Germany, a corporation of Germany

Application March 10, 1939, Serial No. 261,156
In Germany March 16, 1938

16 Claims. (Cl. 250—84)

This invention relates to a method for the production of neutrons, particularly by the interaction of deuterons.

In order to obtain neutrons with the aid of ions with relatively slight acceleration (for instance 300 kv.) the nuclear reaction

$$D+D=He_3+n$$

is employed. The procedure in this connection is to bombard a layer containing heavy hydrogen nuclei with heavy hydrogen ions or deuterons. For the layer containing hydrogen, use is often made of ice, sal ammoniac, phosphoric acid and similar substances in which ordinary hydrogen is replaced by heavy hydrogen. These layers very rich in hydrogen have the disadvantage that they conduct heat and electricity poorly and are therefore easily destroyed by ionic bombardment. It would be better if more resistant layers were used, for instance, metallic layers. That is possible, however, only when metals that contain large amounts of dissolved or adsorbed hydrogen are employed. These are a few such metals, but they have the disadvantage that they gradually give off hydrogen in the vacuum. It would be still better therefore if substances could be used that contain hydrogen adsorbed only on the surface or in a surface layer but give it off to the outside less easily. These substances placed in the ion stream give only a small output of neutrons when impinged on vertically since the thickness of the adsorbed hydrogen layer is very small in comparison with the range of the ions projected into the metal. Nuclear processes can occur therefore only in a fractional portion of the path of the ions. In case, however, the path of the ions is maintained as nearly as possible entirely within the thin hydrogen layer, a large neutron output is obtained with the aid of these thin adsorbed hydrogen layers.

A principal purpose of the invention is the provision of a highly efficient method for the production of neutrons by the interaction of deuterons. According to the invention this is attained by allowing the stream of ions to impinge on the layer at an angle,—preferably in as grazing a manner as possible.

The adsorption layer containing hydrogen need not consist of pure hydrogen. It might under certain conditions be more advantageous if the adsorption layer consists of gases or vapors containing hydrogen, for instance, methane or water. This is particularly satisfactory when these substances are adsorbed especially strongly.

The body impinged on by the ions is preferably made of a substance that strongly adsorbs the molecules containing heavy hydrogen and at the same time possesses only a slight retarding capacity for the impinging ions. Carbon and beryllium have been found useful for these reasons. It is especially desirable to employ substances that adsorb the molecules containing hydrogen in as thick a layer as possible. This can be accomplished for instance by using, as adsorption body, a substance that is porous or roughened at least at the surface.

The surface of the adsorbing body is heated up by the energy of the impinging ions. In this way the giving off of the adsorbed substance is promoted. It is, therefore, advisable to cool the adsorbing body. This cooling has the advantage, moreover, that at low temperature the adsorbed layer adheres much more firmly. A reduction of the temperature of only 10° C., for instance from 20° C. room temperature to 10° C., can produce a considerable improvement. In many cases, it is advisable to use solid carbon dioxide or even liquid air for the cooling.

The adsorbed layer can be produced in the usual way, for instance by taking up heavy hydrogen or molecules containing heavy hydrogen from the surroundings, for instance from the gas chamber; but it may also be produced by bombarding the surface with heavy hydrogen ions. It is advisable to free the surface intended for the adsorption of heavy hydrogen as far as possible from other adsorbed molecules, such as ordinary hydrogen, for example, by heating in vacuum.

The replacement of the hydrogen given off during the ion bombardment can be accomplished, for instance, by simultaneous or subsequent bombardment with ions containing heavy hydrogen. This bombardment can be accomplished, for instance, with advantage from a different direction, for example, from the back or at a more acute angle from the front, than the bombardment for producing neutrons. The replacement of the heavy hydrogen may be accomplished, for example, by diffusion or by adsorption from the surroundings.

The principles of the invention are illustrated in the accompanying drawing in which:

Fig. 1 is a diagrammatic representation of apparatus embodying the principles of the invention; and

Fig. 2 is a partial diagrammatic representation of a modified embodiment of the invention.

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2 2,251,190

In Fig. 1 a beam of high velocity ions of heavy hydrogen 14 is produced by the device described in copending application Serial No. 234,504 of Kuhn and Kallmann, filed October 11, 1938. In this device a beam of negative ions 4 generated at cathode 1 and focussed at 2 by electrode 16 is transformed into a beam of positive heavy hydrogen ions of increased velocity by means of the transforming electrode 5, supported in space 3 by tube 7 and insulator 15. A low pressure is maintained in 3 by means of a pump (not shown) connected at 8. A stream of heavy hydrogen is supplied to channel 6 through tube 7. The high velocity beam of heavy hydrogen ions obtained in this manner passes through apertured member 9 into cathode 10 where they impinge at a grazing angle on the target 11. The high velocity heavy hydrogen ions in the beam react with heavy hydrogen adsorbed on the surface of 11 to produce neutrons.

In the form shown in Fig. 2, a supply of heavy hydrogen is maintained on target 11 by diffusion into 11 of a substance 13 containing heavy hydrogen which is maintained in capsule 12.

We claim:

1. A method for the production of neutrons which comprises bombarding a body containing heavy hydrogen adsorbed in its surface with heavy hydrogen ions impinging thereon at a substantial angle to the normal.

2. A method for the production of neutrons which comprises bombarding a body containing heavy hydrogen adsorbed in its surface with heavy hydrogen ions impinging thereon at a grazing angle.

3. A method for the production of neutrons which comprises bombarding a body containing heavy hydrogen adsorbed in its surface with heavy hydrogen ions impinging thereon at a substantial angle to the normal while cooling the body to a temperature below room temperature.

4. A method for the production of neutrons which comprises bombarding a body containing heavy hydrogen adsorbed in its surface with heavy hydrogen ions impinging thereon at a substantial angle to the normal and replacing the adsorbed heavy hydrogen by bombardment of said body with heavy hydrogen ions.

5. A method for the production of neutrons which comprises bombarding a body containing heavy hydrogen adsorbed in its surface with heavy hydrogen ions impinging thereon at a substantial angle to the normal and replacing the adsorbed heavy hydrogen by diffusion of substances containing heavy hydrogen into the body.

6. A method for the production of neutrons which comprises bombarding a body containing heavy hydrogen adsorbed in its surface with heavy hydrogen ions impinging thereon at a substantial angle to the normal and continuously replacing the adsorbed heavy hydrogen during the bombardment.

7. A method for the production of neutrons which comprises bombarding a body comprising carbon and containing heavy hydrogen adsorbed in its surface with heavy hydrogen ions impinging thereon at a substantial angle to the normal.

8. A method for the production of neutrons which comprises bombarding a body comprising beryllium and containing heavy hydrogen adsorbed in its surface with heavy hydrogen ions impinging thereon at a substantial angle to the normal.

9. A method for the production of neutrons which comprises bombarding a body, at least the surface portion of which is porous, containing heavy hydrogen adsorbed in its surface with heavy hydrogen ions impinging thereon at a substantial angle to the normal.

10. A device for the production of neutrons comprising means for generating a beam of heavy hydrogen ions, and a body containing heavy hydrogen adsorbed in the surface thereof positioned in said beam with said surface at an acute angle to the direction of travel thereof.

11. A device for the production of neutrons comprising means for generating a beam of heavy hydrogen ions, and a body containing heavy hydrogen adsorbed in the surface thereof positioned in said beam with said surface at a grazing angle to the direction of travel thereof.

12. A device for the production of neutrons comprising means for generating a beam of heavy hydrogen ions, a body containing heavy hydrogen adsorbed in the surface thereof positioned in said beam with said surface at an acute angle to the direction of travel thereof, and means for supplying heavy hydrogen to said body.

13. A device for the production of neutrons comprising means for generating a beam of heavy hydrogen ions, and a body comprising carbon and containing heavy hydrogen adsorbed in the surface thereof positioned in said beam with said surface at an acute angle to the direction of travel thereof.

14. A device for the production of neutrons comprising means for generating a beam of heavy hydrogen ions, and a body comprising beryllium and containing heavy hydrogen adsorbed in the surface thereof positioned in said beam with said surface at an acute angle to the direction of travel thereof.

15. A device for the production of neutrons comprising means for generating a beam of heavy hydrogen ions, and a body having a porous surface and containing heavy hydrogen adsorbed in the surface thereof positioned in said beam with said surface at an acute angle to the direction of travel thereof.

16. A method for the production of neutrons which comprises bombarding a body with heavy hydrogen ions impinging on the body at a substantial angle to the normal, said body having a high adsorptive capacity for a substance containing heavy hydrogen and having a low retarding effect upon impinging heavy hydrogen and containing heavy hydrogen adsorbed in its surface.

HARTMUT ISRAEL KALLMANN,
Formerly known as Hartmut Kallman.
ERNST KUHN.

Figure D.608: Hartmut Kallmann and Ernst Kuhn, AEG and I.G. Farben. U.S. Patent 2,251,190. Method of Producing Neutrons. Filed 16 March 1938. Issued 29 July 1941.

Fig.1

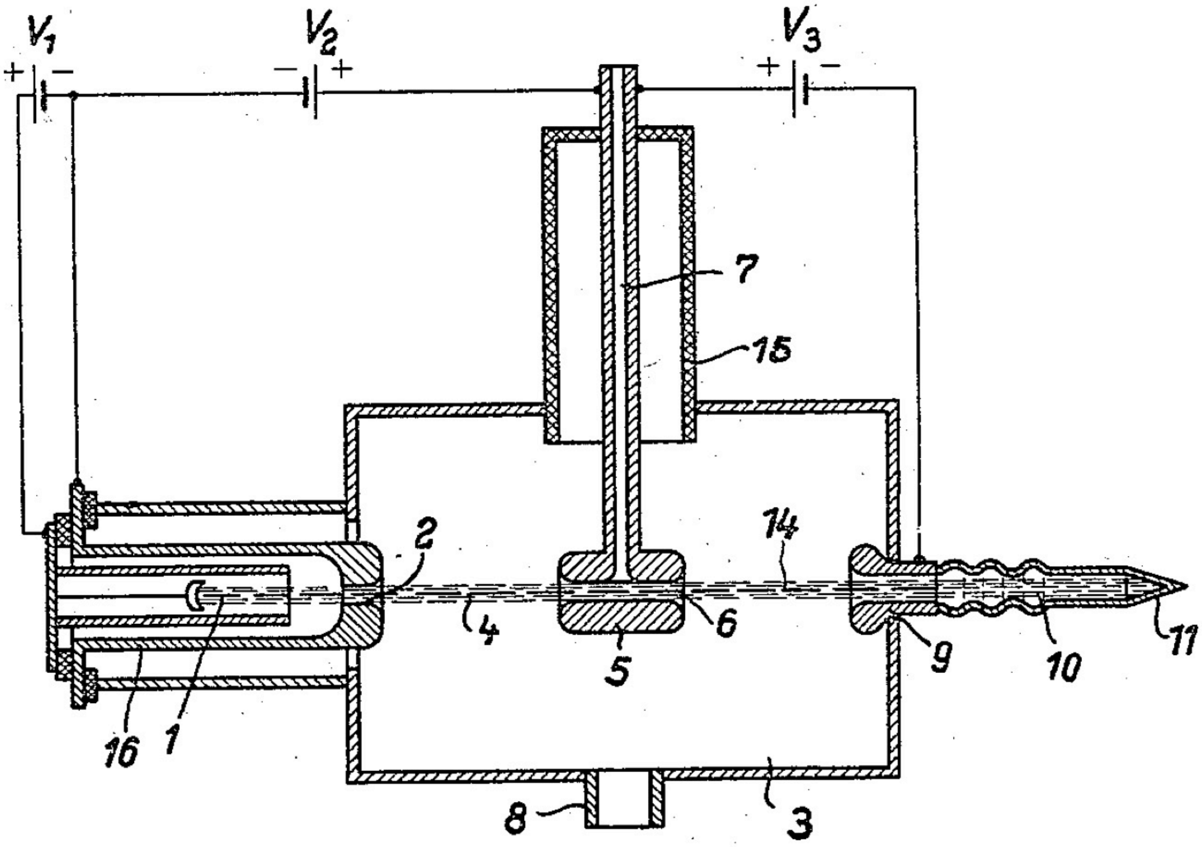


Fig.2

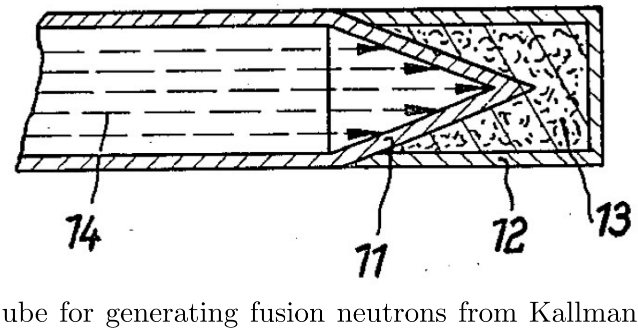


Figure D.609: High-voltage tube for generating fusion neutrons from Kallmann and Kuhn's U.S. Patent 2,251,190.

Hartmut Kallmann and Ernst Kuhn. U.S. Patent 2,288,717. Method for Investigation of Substances with the Aid of Neutrons. Filed 10 March 1939. Issued 7 July 1942.

The present invention relates to improvements in methods of, and means for, investigating objects or substances with the aid of neutrons.

It has already been suggested to investigate substances by depicting them with the aid of neutrons. This investigation may be carried out by directing a beam of neutrons through the body or substance under investigation and causing the neutrons that emerge from it to encounter a layer in which heavy charged particles or electrons (+ and -) or gamma rays are produced under the action of the impinging neutrons upon an element, contained in said layer, which is reactive toward neutrons. These particles are in turn caused to act upon a layer of fluorescent material, or an adjacent photographic layer or a combination thereof, thus depicting the investigated body or substance visibly or photographically. Neutron reactive layers particularly suited for this purpose are, for instance, such containing lithium or boron. In these two substances the following reactions take place under the influence of the impinging neutrons:

$$1.\quad n_0^1 + Li_3^6 \;=\; He_2^4 + H_1^3 \tag{D.13}$$

$$2.\quad n_0^1 + B_5^{10} \;=\; Li_3^7 + He_2^4 \tag{D.14}$$

In the lithium or lithium compounds existing in nature the contents of the effective Li_3^6 amounts only to about 10%, and in the boron and boron compounds existing in nature the contents of the effective B_5^{10} amounts only to about 20%. The main mass of these elements consists of Li_3^7, or B_5^{11}, respectively.

It is an object of the present invention to increase the sensitiveness of the above-mentioned method of depicting objects by means of neutrons. Another object of the invention is to provide improved means for depicting objects by means of neutrons.

This inventive object is attained by using as neutron reactive layer containing an element in which the neutron reactive sort of isotopes is enriched beyond the proportion corresponding to the natural distribution of this isotope in the respective element. Using the above mentioned special reactions the neutron reactive sorts of isotopes being artificially enriched are Li_3^6 or B_5^{10}. The enrichment may be accomplished by any of the known methods for separating or concentrating isotopes, i.e. diffusion, mass spectrograph, electrolysis and chemical processes.

With a given intensity of the neutron radiation the number of the emitted heavy particles and therewith the blackening of the photographic plate, or the excitation of the fluorescent screen respectively, is determined not by the thickness of the intermediate layer, but by the range of the heavy particles liberated from said layer if the thickness of said intermediate layer is larger than said range. The number of the heavy particles emitted per neutron is the greatest if within a layer adjacent to the surface the thickness of which corresponds to the range as many neutrons as possible cause the emission of heavy particles by collision with neutron reactive atomic nuclei. As in general within a layer the thickness of which being equal to the range of said particles only a small fraction of the neutrons passing through liberate heavy particles, it is extremely important, as regards the output, to provide in said layer as many neutron reactive atomic nuclei as possible. An increase of the number of the neutron reactive atomic nuclei is obtained, by artificially enriching the intermediate element with Li_3^6 or B_5^{10}, respectively, beyond the proportion of its natural distribution in the respective element.

This method can advantageously be used also in connection with intermediate layers which do not emit heavy particles, but which emit electrons or gamma rays under the action of impinging neutrons, if the mixture of isotopes of the respective element, as existing in nature, is not the most favorable one for one of said neutron reactions. Therefore, the present improved method is not restricted to boron and lithium, but it will prove advantageous with every other neutron reactive element if only a fraction of all neutrons passing through the neutron-reactive layer is being absorbed in it, or if very thin neutron-reactive layers are used, or if the neutrons in the neutron-reactive layer are also absorbed by atomic nuclei which only contribute very little to the blackening of the photographic layer, or to the excitation of the fluorescent screen respectively by the emission of particles or gamma rays. The present improved method becomes particularly important if the neutron reactive element is applied as an emulsion upon the photographic layer or upon the fluorescent screen. Such emulsions are able to contain a small concentration of the neutron reactive element only. If, therefore the element contained in the emulsion is artificially enriched with the effective sort of isotopes beyond the proportion of its nature distribution in the respective element, an extraordinarily great increase of the sensitiveness can be attained.

Also neutron reactive layers containing cadmium may be used in which the cadmium is artificially enriched with its active isotope beyond the proportion corresponding to its natural distribution in cadmium. The isotope of cadmium to be used in each instance depends upon the neutron energy employed. The choice is made by observing which gives the greatest effect.

The accompanying drawing is a diagrammatic representation of an embodiment of the invention. The neutron beam 2 emitted by the neutron source 1 passes through the investigated substance or body 3. The emerging neutrons 4 impinge upon the neutron reactive layer 5 which is enriched with the effective sort of isotopes beyond the proportion corresponding to its natural distribution in the respective elements. In this layer 5 the neutrons liberate charged particles or gamma rays which energize the adjacent layer 6 which consists of fluorescent or photo-sensitive material thus producing a visible or photographic image of the investigated substance or body 3.

[See document photos on pp. 4300–4301.

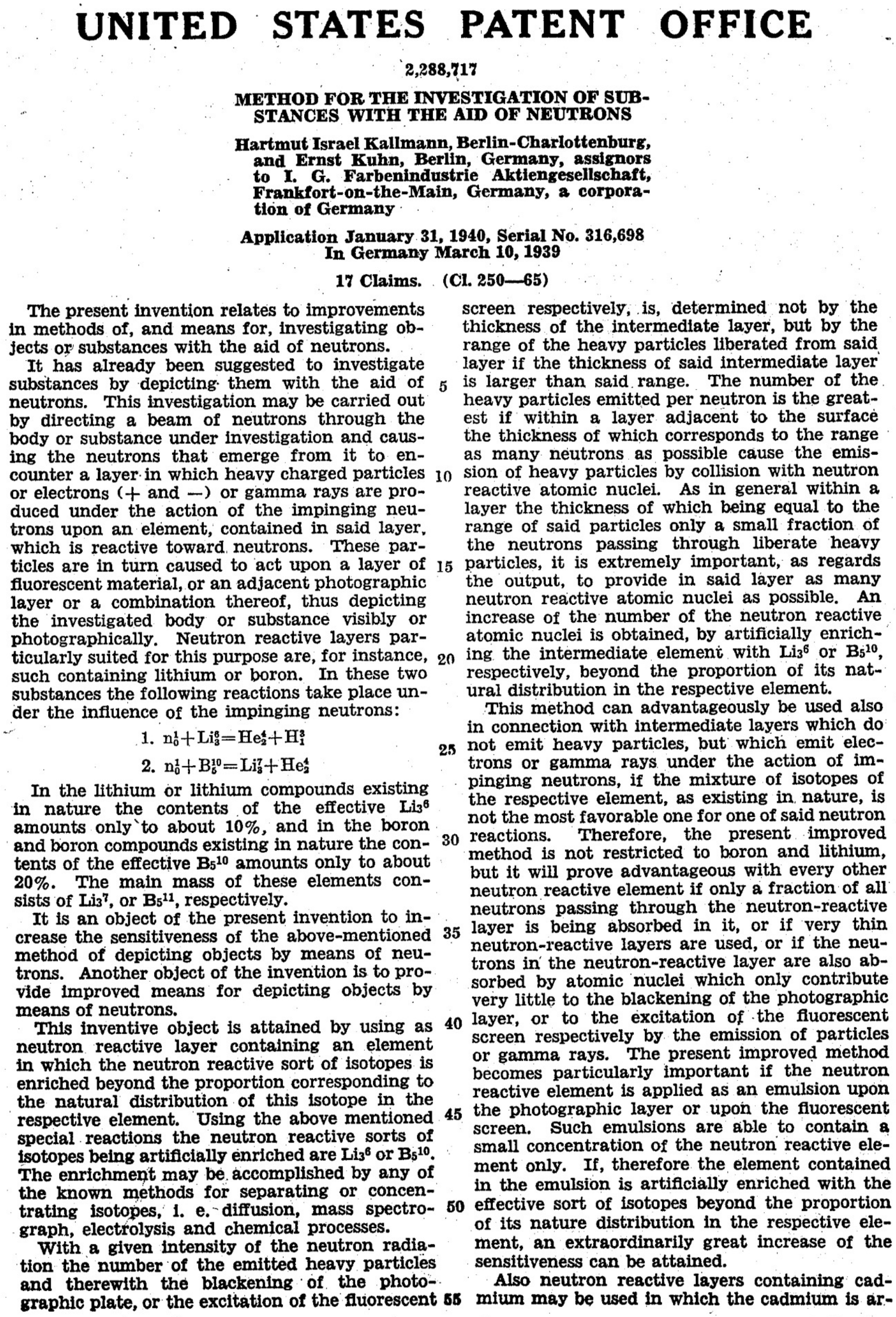
The patents of Kallmann and Kuhn are directly relevant to high-voltage fusion neutron initiators for fission bombs, but also to neutron imaging, analysis of materials, well logging, etc. These technologies have had wide-reaching influence from the postwar period to the modern world. In connection to nuclear weapons, note that in March 1939 Kallmann and Kuhn specifically described:

- The reaction $\mathrm{n}_0^1 + \mathrm{Li}_3^6 \rightarrow \mathrm{He}_2^4 + \mathrm{H}_1^3$, half of the Jetter cycle (p. 4348 of this appendix).
- The need to enrich the lithium-6 isotope from naturally occurring lithium, as Alfred Klemm did in 1942–1943 (p. 4344).

See also numerous other related patents by Kallmann and Kuhn, such as:

> U.S. Patent 2,219,033. Method and Device for Generating a Beam of Ions of High Velocity. Filed 21 October 1937. Issued 22 October 1940.
>
> U.S. Patent 2,188,115. Investigation of Materials with Neutrons. Filed 25 March 1937. Issued 23 January 1940.

How far did Kallmann and Kuhn or others take these technologies during the war? Note that Kallmann and Kuhn worked for AEG in Berlin.]



UNITED STATES PATENT OFFICE

2,288,717

METHOD FOR THE INVESTIGATION OF SUBSTANCES WITH THE AID OF NEUTRONS

Hartmut Israel Kallmann, Berlin-Charlottenburg, and Ernst Kuhn, Berlin, Germany, assignors to I. G. Farbenindustrie Aktiengesellschaft, Frankfort-on-the-Main, Germany, a corporation of Germany

Application January 31, 1940, Serial No. 316,698
In Germany March 10, 1939

17 Claims. (Cl. 250—65)

The present invention relates to improvements in methods of, and means for, investigating objects or substances with the aid of neutrons.

It has already been suggested to investigate substances by depicting them with the aid of neutrons. This investigation may be carried out by directing a beam of neutrons through the body or substance under investigation and causing the neutrons that emerge from it to encounter a layer in which heavy charged particles or electrons (+ and −) or gamma rays are produced under the action of the impinging neutrons upon an element, contained in said layer, which is reactive toward neutrons. These particles are in turn caused to act upon a layer of fluorescent material, or an adjacent photographic layer or a combination thereof, thus depicting the investigated body or substance visibly or photographically. Neutron reactive layers particularly suited for this purpose are, for instance, such containing lithium or boron. In these two substances the following reactions take place under the influence of the impinging neutrons:

1. $n_0^1 + Li_3^6 = He_2^4 + H_1^3$

2. $n_0^1 + B_5^{10} = Li_3^7 + He_2^4$

In the lithium or lithium compounds existing in nature the contents of the effective Li_3^6 amounts only to about 10%, and in the boron and boron compounds existing in nature the contents of the effective B_5^{10} amounts only to about 20%. The main mass of these elements consists of Li_3^7, or B_5^{11}, respectively.

It is an object of the present invention to increase the sensitiveness of the above-mentioned method of depicting objects by means of neutrons. Another object of the invention is to provide improved means for depicting objects by means of neutrons.

This inventive object is attained by using as neutron reactive layer containing an element in which the neutron reactive sort of isotopes is enriched beyond the proportion corresponding to the natural distribution of this isotope in the respective element. Using the above mentioned special reactions the neutron reactive sorts of isotopes being artificially enriched are Li_3^6 or B_5^{10}. The enrichment may be accomplished by any of the known methods for separating or concentrating isotopes, i. e. diffusion, mass spectrograph, electrolysis and chemical processes.

With a given intensity of the neutron radiation the number of the emitted heavy particles and therewith the blackening of the photographic plate, or the excitation of the fluorescent screen respectively, is, determined not by the thickness of the intermediate layer, but by the range of the heavy particles liberated from said layer if the thickness of said intermediate layer is larger than said range. The number of the heavy particles emitted per neutron is the greatest if within a layer adjacent to the surface the thickness of which corresponds to the range as many neutrons as possible cause the emission of heavy particles by collision with neutron reactive atomic nuclei. As in general within a layer the thickness of which being equal to the range of said particles only a small fraction of the neutrons passing through liberate heavy particles, it is extremely important, as regards the output, to provide in said layer as many neutron reactive atomic nuclei as possible. An increase of the number of the neutron reactive atomic nuclei is obtained, by artificially enriching the intermediate element with Li_3^6 or B_5^{10}, respectively, beyond the proportion of its natural distribution in the respective element.

This method can advantageously be used also in connection with intermediate layers which do not emit heavy particles, but which emit electrons or gamma rays under the action of impinging neutrons, if the mixture of isotopes of the respective element, as existing in nature, is not the most favorable one for one of said neutron reactions. Therefore, the present improved method is not restricted to boron and lithium, but it will prove advantageous with every other neutron reactive element if only a fraction of all neutrons passing through the neutron-reactive layer is being absorbed in it, or if very thin neutron-reactive layers are used, or if the neutrons in the neutron-reactive layer are also absorbed by atomic nuclei which only contribute very little to the blackening of the photographic layer, or to the excitation of the fluorescent screen respectively by the emission of particles or gamma rays. The present improved method becomes particularly important if the neutron reactive element is applied as an emulsion upon the photographic layer or upon the fluorescent screen. Such emulsions are able to contain a small concentration of the neutron reactive element only. If, therefore the element contained in the emulsion is artificially enriched with the effective sort of isotopes beyond the proportion of its nature distribution in the respective element, an extraordinarily great increase of the sensitiveness can be attained.

Also neutron reactive layers containing cadmium may be used in which the cadmium is ar-

Figure D.610: Hartmut Kallmann and Ernst Kuhn, AEG and I.G. Farben. U.S. Patent 2,288,717. Method for Investigation of Substances with the Aid of Neutrons. Filed 10 March 1939. Issued 7 July 1942.