Outline

Nuclear payloads

1. Land-launched intercontinental missiles

   A. Liquid propellant missiles

   B. Liquid propellant space planes

   C. Solid propellant missiles

2. Submarine-launched missiles

   A. Sub-launched cruise missiles

   B. Sub-launched ballistic missiles

3. Intercontinental jet bombers

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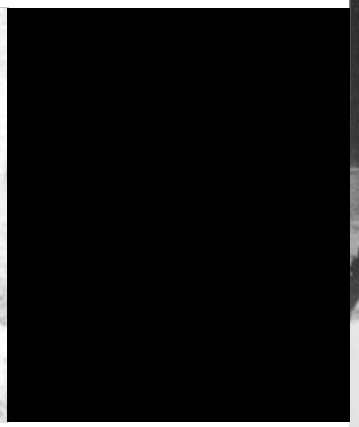
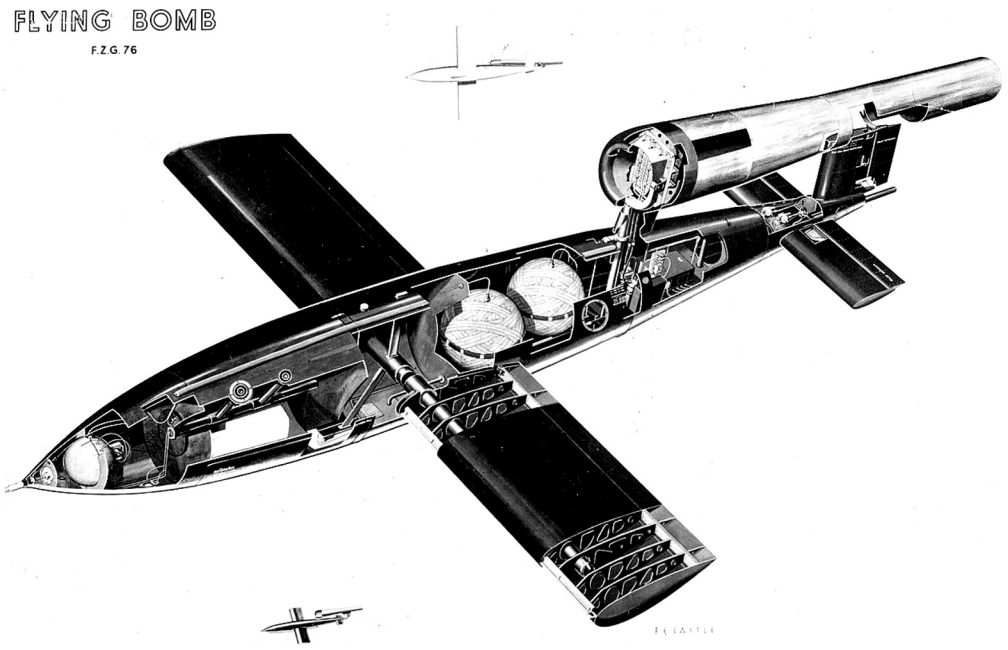
V-1 (Fieseler Fi 103) Cruise Missile, First Flown in 1942

Fritz Gosslau (1898–1965)

Robert Lusser (1899–1969)

Paul Schmidt (1898–1976)





Sub-Launched, Air-Launched, and Piloted V-1 Cruise Missiles

H. H. Smith, N. W. Dickson, V. P. Kovac, and E. H. Bennett. German Developments in the Guided Missile Field. 10 January 1946. Project 2874. NARA RG 319, Entry NM3-82, Box 2879, Folder Project 2784.

Surface-to-Surface Missiles

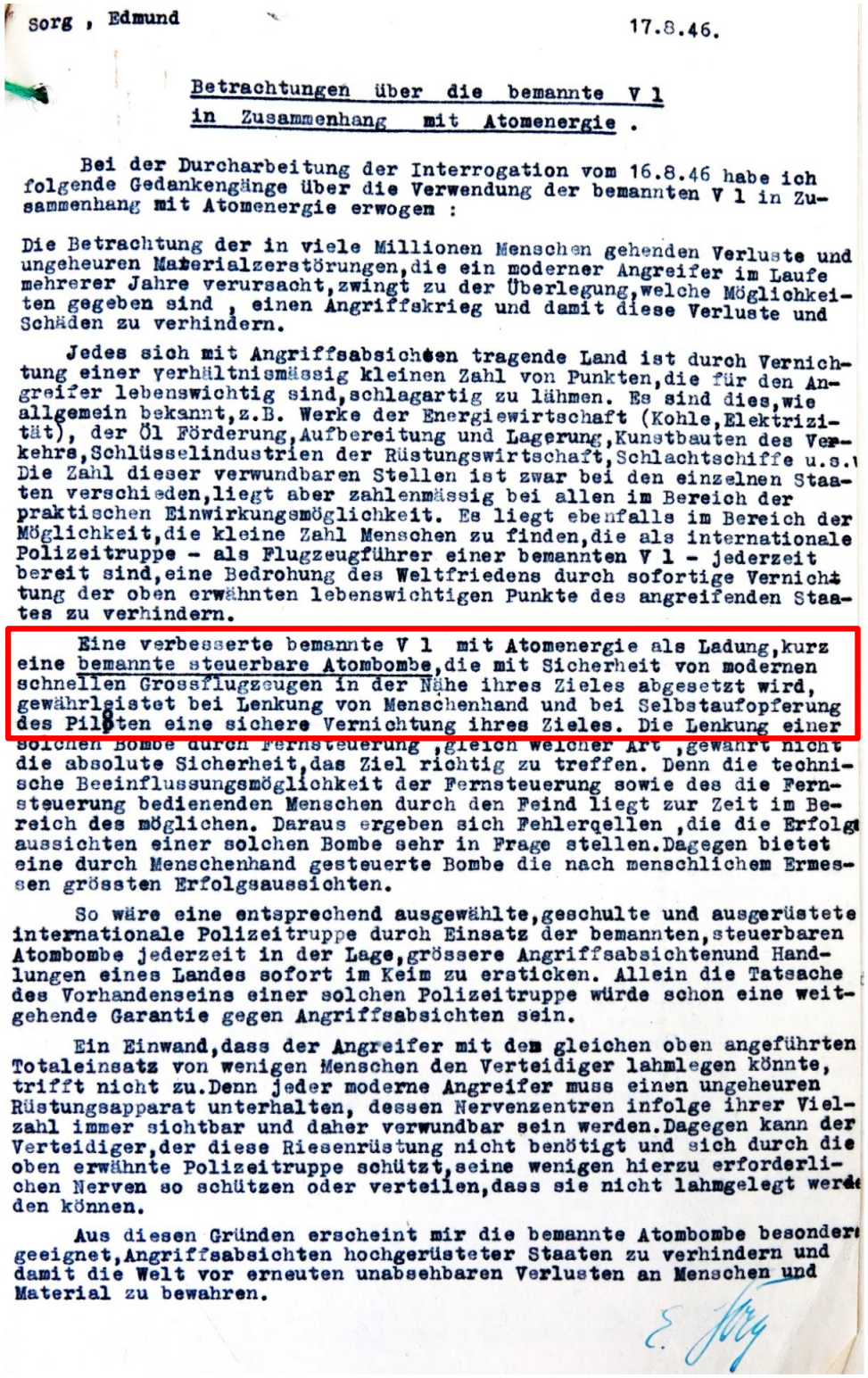
During the period of growth of the Allied air power, the heretofore visualized need of long range remote or self-controlled missiles for area bombing became an actual necessity. Resulting from the successive defeats the Luftwaffe was suffering, it became less and less advisable to send bombing squadrons against the enemy; therefore, increased effort was placed on the development of supersonic missiles which were visualized as early as 1936 as potential weapons. These were hastily and prematurely thrown into the fray. In addition to the development of long range supersonic weapons, there was simultaneously carried through development to operational use the V-1 weapon. The V-1 was the first long range missile operationally used as a self-contained, non-piloted or controlled weapon. It is estimated that over 20,000 of these were used against the Allies.

Two further developments of the V-1 program were an attempt to launch the missile from a ramp on the deck of a submarine and a project for a piloted V-1. In the first case a ramp was constructed though never used; it is believed that this was intended for attacks against coastal towns and defenses on the Eastern seaboard of the U.S.A. In the second instance, several models were constructed though, as far as is known, none were ever used. It was intended that the pilot should fly the missile to within a short range of the target, set the controls and then jump out.

During the same period the development of the A series (V-2 missiles) was continued in spite of the handicaps caused by Allied bombings. After the expenditure of a tremendous amount of money and energy on this project, the A-4 missile went into operational use in 1944. It is estimated that 3,000 to 5,000 of these missiles were built.

Piloted V-1

Heinkel He 111 with unpiloted V-1 under the wing as an air-launched cruise missile



Sorg , Edmund 17.8.46.

Betrachtungen über die bemannte V 1
in Zusammenhang mit Atomenergie .

Bei der Durcharbeitung der Interrogation vom 16.8.46 habe ich folgende Gedankengänge über die Verwendung der bemannten V 1 in Zusammenhang mit Atomenergie erwogen :

Die Betrachtung der in viele Millionen Menschen gehenden Verluste und ungeheuren Materialzerstörungen,die ein moderner Angreifer im Laufe mehrerer Jahre verursacht,zwingt zu der Überlegung,welche Möglichkeiten gegeben sind , einen Angriffskrieg und damit diese Verluste und Schäden zu verhindern.

Jedes sich mit Angriffsabsichten tragende Land ist durch Vernichtung einer verhältnismässig kleinen Zahl von Punkten,die für den Angreifer lebenswichtig sind,schlagartig zu lähmen. Es sind dies,wie allgemein bekannt,z.B. Werke der Energiewirtschaft (Kohle,Elektrizität), der Öl Förderung,Aufbereitung und Lagerung,Kunstbauten des Verkehrs,Schlüsselindustrien der Rüstungswirtschaft,Schlachtschiffe u.s.w. Die Zahl dieser verwundbaren Stellen ist zwar bei den einzelnen Staaten verschieden,liegt aber zahlenmässig bei allen im Bereich der praktischen Einwirkungsmöglichkeit. Es liegt ebenfalls im Bereich der Möglichkeit,die kleine Zahl Menschen zu finden,die als internationale Polizeitruppe - als Flugzeugführer einer bemannten V 1 - jederzeit bereit sind,eine Bedrohung des Weltfriedens durch sofortige Vernichtung der oben erwähnten lebenswichtigen Punkte des angreifenden Staates zu verhindern.

Eine verbesserte bemannte V 1 mit Atomenergie als Ladung,kurz eine bemannte steuerbare Atombombe,die mit Sicherheit von modernen schnellen Grossflugzeugen in der Nähe ihres Zieles abgesetzt wird, gewährleistet bei Lenkung von Menschenhand und bei Selbstaufopferung des Piloten eine sichere Vernichtung ihres Zieles. Die Lenkung einer solchen Bombe durch Fernsteuerung ,gleich welcher Art ,gewährt nicht die absolute Sicherheit,das Ziel richtig zu treffen. Denn die technische Beeinflussungsmöglichkeit der Fernsteuerung sowie des die Fernsteuerung bedienenden Menschen durch den Feind liegt zur Zeit im Bereich des möglichen. Daraus ergeben sich Fehlerqellen ,die die Erfolgsaussichten einer solchen Bombe sehr in Frage stellen.Dagegen bietet eine durch Menschenhand gesteuerte Bombe die nach menschlichem Ermessen grössten Erfolgsaussichten.

So wäre eine entsprechend ausgewählte,geschulte und ausgerüstete internationale Polizeitruppe durch Einsatz der bemannten,steuerbaren Atombombe jederzeit in der Lage,grössere Angriffsabsichtenund Handlungen eines Landes sofort im Keim zu ersticken. Allein die Tatsache des Vorhandenseins einer solchen Polizeitruppe würde schon eine weitgehende Garantie gegen Angriffsabsichten sein.

Ein Einwand,dass der Angreifer mit dem gleichen oben angeführten Totaleinsatz von wenigen Menschen den Verteidiger lahmlegen könnte, trifft nicht zu.Denn jeder moderne Angreifer muss einen ungeheuren Rüstungsapparat unterhalten, dessen Nervenzentren infolge ihrer Vielzahl immer sichtbar und daher verwundbar sein werden.Dagegen kann der Verteidiger,der diese Riesenrüstung nicht benötigt und sich durch die oben erwähnte Polizeitruppe schützt,seine wenigen hierzu erforderlichen Nerven so schützen oder verteilen,dass sie nicht lahmgelegt werden können.

Aus diesen Gründen erscheint mir die bemannte Atombombe besonders geeignet,Angriffsabsichten hochgerüsteter Staaten zu verhindern und damit die Welt vor erneuten unabsehbaren Verlusten an Menschen und Material zu bewahren.

E. Sorg

Nuclear-Armed V-1

Edmund Sorg. 17 August 1946. Betrachtungen über die bemannte V 1 im Zusammenhang mit Atomenergie. TNA (Kew) FO 1031/57.

An improved manned V1 with atomic energy as a charge, in short a manned controllable atomic bomb, which can certainly be released by modern, fast, large airplanes close to its target, ensures a safe destruction of this target given that it is steered by the hands of a pilot ready to sacrifice himself. Guiding such a bomb by a remote control of any kind does not ensure the absolute certainty of hitting the target correctly. This happens because at this time it is technically possible for the enemy to interfere with the remote control and also influence the people controlling the remote guidance. This results in sources of error that seriously jeopardize the success of such a bomb. On the other hand, a human-controlled bomb offers the greatest possible prospects of success.

Nuclear Armed V-1

5 a partial list of the members of Hanna REITSCH's V-1 suicide squad and their present whereabouts and a few other items.

TOP SECRET

Frau SORG appeared at FIAT and was allowed to see her husband on 3rd and 4th October, in the presence of the undersigned. Her statements, some of them previously made in her letters to her husband, revealed the imminence of the execution of a plot, possibly the evacuation of Luftwaffe personnel to PERU with the help of a Peruvian citizen of English extraction, who is now employed by UNRRA in MUNICH. Since immediate action seemed imperative a brief operational memorandum was written for C.I.C. on 6 Oct 46. Most of the information contained in the memorandum of 6 Oct 46 will be repeated and amplified in this report. The second report on SORG's knowledge of the latest Luftwaffe weapons, on his "vision" of a future defensive war by means of suicide V-1s with atomic charges, and on the hiding of the most secret documents of RECHLIN, will follow shortly after this report.

7. 4. SORG claims to have told all his secrets to the American and British officers who interrogated him in late spring and early summer 1945 and to have handed over to them all the RECHLIN documents he had hidden in Bavaria and Württemberg/for Colonel PETERSEN. In fact, he did reveal ~~many~~ some of his secrets and handed over a portion of the concealed documents. He has already admitted that he forgot to mention the latest fuse he tested, i.e. an acoustic or sonic fuse for aircraft to aircraft missiles. Apparently he had only given part of the story of Hanna REITSCH's "suicide squad" which was supervised and trained by SORG. Specially adapted models of V-1 manned by pilots prepared to sacrifice their lives were to receive a powerful charge with which to destroy key targets, such as vital war plants and large battleships. SORG stated that the training was abandoned, late in 1944, "because of German air inferiority". It is more likely that the charge for the warhead which had been envisaged was not available in sufficient quantities. Significantly SORG mentioned an atomic charge for these suicide V-1s as the ideal

TOP SECRET

- 6 -

explosive in a future "defensive" war. SORG has not been ... truthful in his account of the finding of the 25/27 boxes of hidden documents. Some of these boxes were opened by French soldiers ignorant of their value, others were "lost". The only other man who knew the whole truth, a Major GROSHOLZ, la to Colonel PETERSEN, was shot by the French in May 1945 and his body was disinterred by SORG in March 1946. It may safely be assumed that SORG has told some deliberate untruths about these documents and that he has not yet handed over to the allies all he had hidden in spring 1945.

TNA (Kew) FO 1031/112. Sorg V2.

Fernspruch - Fernschreiben - Funkspruch - Blinkspruch

Durch die Nachr.-Stelle auszufüllen

Nachr.-Stelle	Nr.	Befördert an	Tag	Zeit	durch	Rolle
Funkstelle SS-Oberabschnitt Süd	140		23.4.	1658		

Vermerke: ~~Geheim~~ Geheim 7/45

Angenommen oder aufgenommen: von / Tag / Zeit / durch

Abgang		Absende-Stelle
Tag: / Zeit: / Dringlichkeits-Vermerk: KR-Blitz	An ~~ϟϟ-Sturmbannführer Grosch~~ Bauinspektion der Waffen-ϟϟ und Polizei ~~Böhmen-Mähren~~ ~~P r a g~~ ~~Muspillistr. 19~~ zur Weiterleitung an ϟϟ-Ostuf. Schürmann Berlin	Fernsprech-Anschluß:

DH-43 O.U., den 23.4.1945

Immediately blow up V 1 devices near Berlin.

Geräte V 1 bei Berlin sofort sprengen.
ϟϟ-Ostuf. Schürmann sofort zum Meldekopf München-Oberföhring, Muspillistr. 19 in Marsch setzen.

(Dr.Ing.Kammler)
ϟϟ-Obergruppenführer und General der Waffen-ϟϟ

Where are the reports?

Erledigt:

Hans Kammler.
23 April 1945 telegram.
Bundesarchiv, Bestand NS 3/514, pp. 31-32.

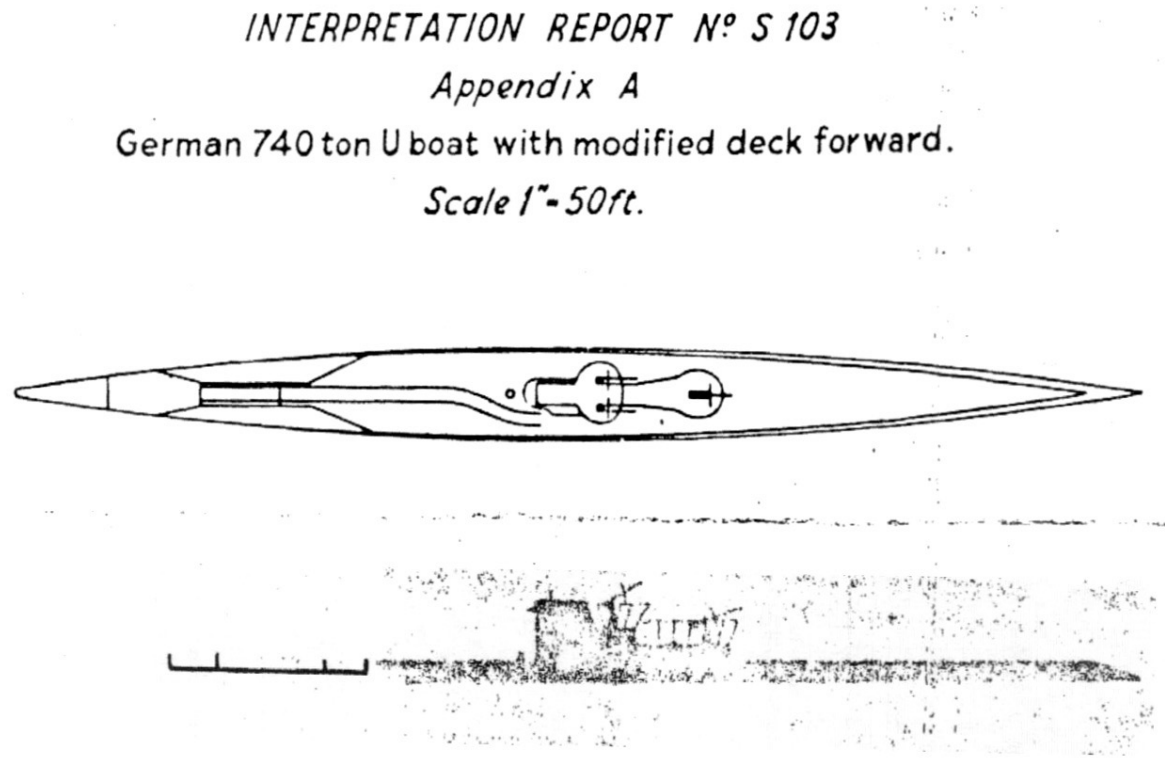
Quittung	Nr.	Von	An	Tag	Zeit	Annehmender Offz. (Uffz.) Name	Dienstgrad
Fernspruch / Fernschreiben / Funkspruch / Blinkspruch							

Bestell-Nr.: Wϟϟ - 2165a
ϟϟ-Vordruckverlag W. F. Mayr, (13b) Miesbach

Wartime Submarine-Launched V-1 Cruise Missiles

Clayton Bissell and Hewlett Thebaud to the Joint Chiefs of Staff. 9 December 1944. Subject: Agreed Joint Evaluation of the Possible Existence of the V-3 Rocket and Probability of Attack against the U.S. FDR Library, Hyde Park, New York. Map Room Files, Box 164, Folder Naval Aides. Files: A/16---General Correspondence.

[…] The V-3 may possibly be a rocket of smaller dimensions than the V-2 with a shorter range. It would be possible to launch such a missile from specially designed or modified submarines. Attached is a sketch of a German submarine based in a southern Norwegian port showing a pair of rails extending from conning tower to the bow and terminating at a flat, rectangular surface. The purpose of this is unknown.



Wartime Submarine-Launched V-1 Cruise Missiles

Where are the reports?

Dwight Eisenhower to AGWAR. 1 November 1944. Outgoing Cable. TNA (Kew) WO 219/298.

Special Force report quoting Danish source states U-boat will be leaving European waters shortly to launch V-1s against NEW YORK. Date of report 30 October.

Clayton Bissell to Stockholm Military Attaché. 3 November 1944. Outgoing Cable WAR 56799. FDR Library, Hyde Park, New York. Map Room Files, Box 49, Folder Rocket Bombs 1944.

Have been advised through OSS that Tykander their representative in Stockholm has received reliable information that German U boats are equipped with bomb launching platforms. Investigate and keep us fully informed.

Dwight Eisenhower to AGWAR. 13 November 1944. Outgoing Cable S-66672. TNA (Kew) WO 219/298.

Special Force Headquarters reports same source reported 7 November that he believed 4 U-Boats were to be used in operation against NEW YORK operating from BERGEN but course and rate unknown.

U-Boat Aimed V-Bomb Here, Army Paper Says. *NY Times*. 15 May 1945 p. 10.

A German submarine tried to V-bomb New York last election day, presumably with a jet-propelled or rocket-propelled weapon, the Army newspaper Stars and Stripes reported tonight, quoting "sources considered reliable." It was reported that the bomb was launched from the deck of a U-boat lying off the coast and that it fell short or was knocked down by fighter planes patrolling as a screen against any such projectiles. The Stars and Stripes said that "operators" at Mitchel Field were quoted as having said that it was determined that the bomb fell into the sea.

S. McClintic, Headquarters U.S. Strategic Air Forces in Europe, Office of the Director of Intelligence, to George C. McDonald. 6 January 1945. Big Ben (Rockets). AFHRA A5734 pdf p. 1093.

Again we receive reports of ships being constructed for the launching of flying bombs, this one a 6000 ton boat at Hamburg, and another report that the shipyards, DEUTSCHE WERFT BETRIEB FINKENWERDER are putting ramps on the decks.

J. Edgar Hoover to Harry Hopkins. 8 January 1945. FDR Library, Hyde Park, New York. Official File 10b. Box 20. Folder OF 10-b, Justice Department, FBI Reports 1944-45. 2597-2618.

During the interrogation of William Curtis Colepaugh, the enemy agent who was landed by German submarine off the coast of Frenchman's Bay, Maine, on the night of November 29, 1944, several interesting features have arisen concerning his submarine trip to the United States. [...] Upon arrival at Kristianson, Norway, on the U-1230 he learned that the U-1231 and the U-1233, both submarines of the same type as the U-1230, had just completed some sort of test at Kristianson, Norway.

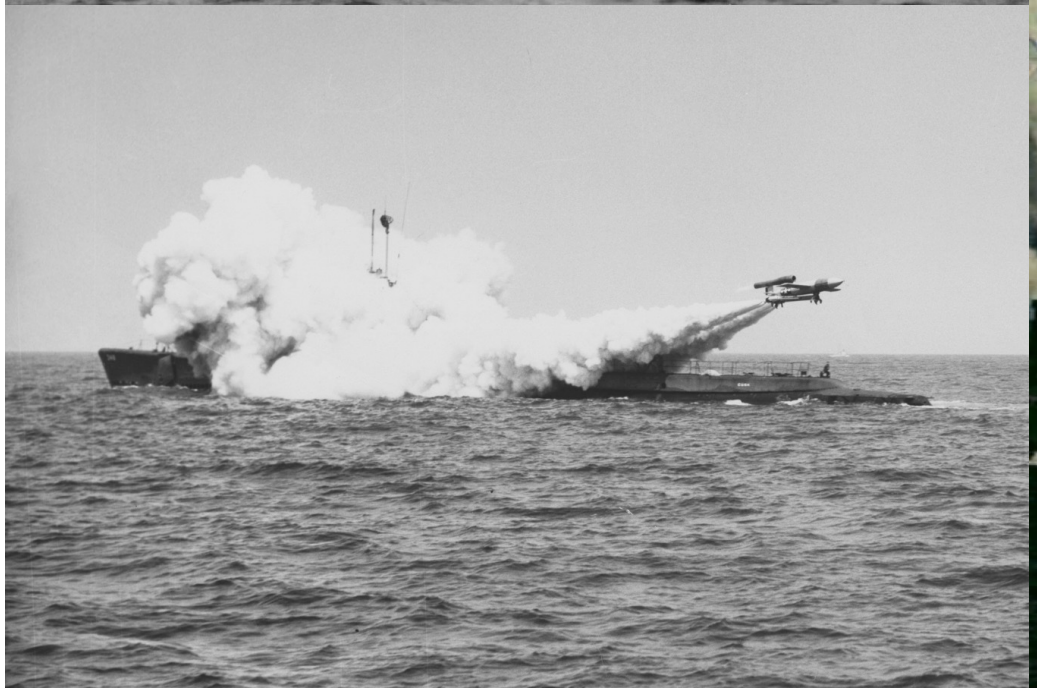
Colepaugh has said that members of the crew of the U-1230 indicated in conversation that they had observed at one of the submarine ports near Danzig some members of other submarine crews practicing in groups with equipment of a rocket or gun type on the deck and these crew members presumed this equipment would be used against the United States. He said the crew members he talked with were pretty definite about this stating that the submarines would proceed to within 100 or 200 miles of the United States and then fire these rockets.

Robot Bomb Attacks Here Held 'Probable' by Admiral. *New York Times*, 9 January 1945, pp. 1, 6.

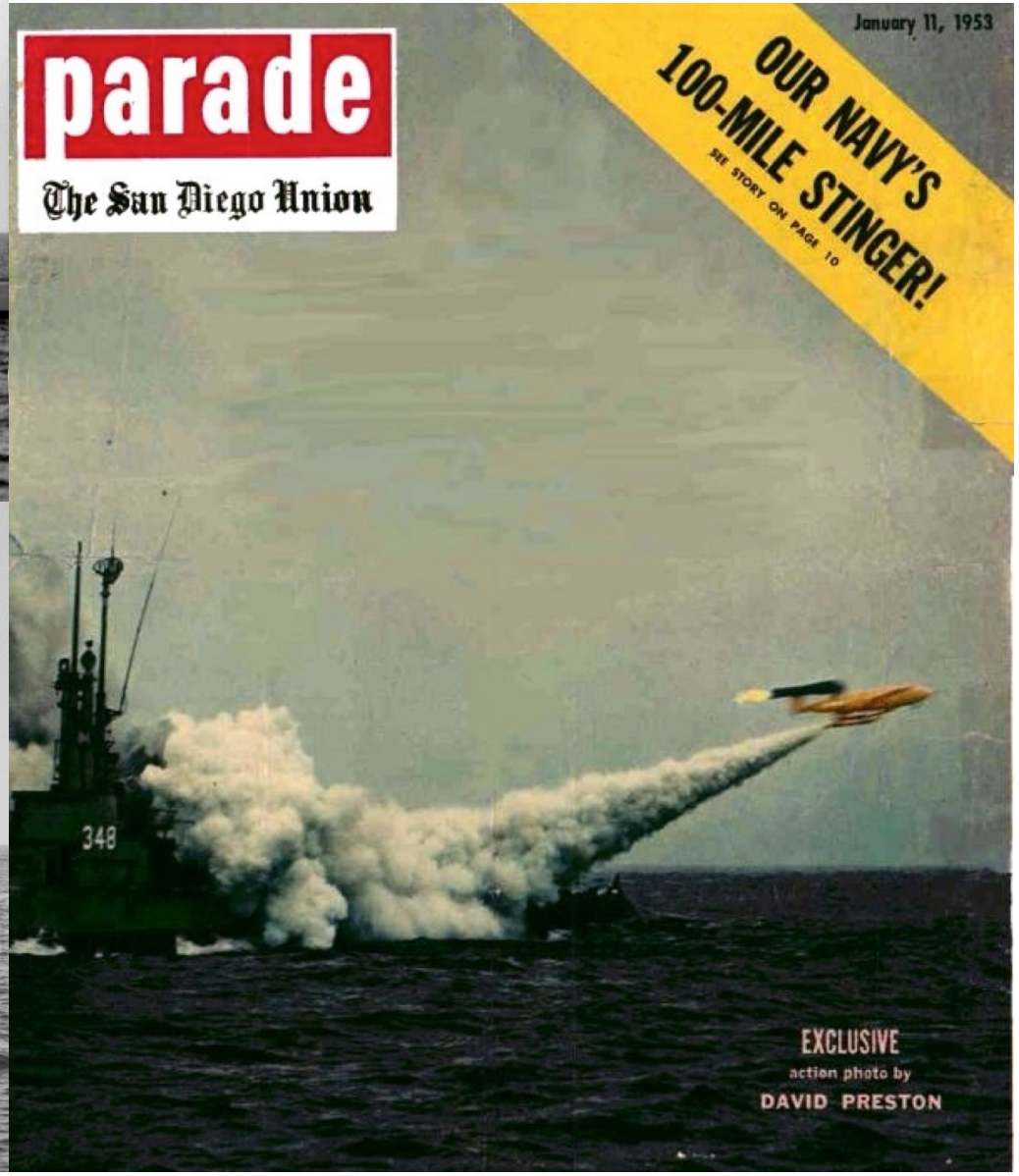
AN EAST COAST PORT, Jan. 8---A strategically futile attack on New York or Washington by robot bombs within thirty to sixty days was described today as not only "possible but probable" by Admiral Jonas H. Ingram, new Commander in Chief of the Atlantic Fleet, whose command stretches from the Arctic to the Falkland Islands. [...]

"And we know very definitely that there are three ways in which he might get robot bombs within range of either city. He might sneak a half dozen submarines off the coast. He might launch robots from the long-range planes we know he has. Or he might sneak a surface ship, disguised as a neutral, within range."

Postwar Submarine-Launched V-1 Cruise Missiles



U.S. copies of V-1 cruise missile ("Loon") launched from U.S. submarine USS *Cusk* (first launched 12 February 1947)



Postwar Cruise Missiles

Nazi Weapon Experts Now Aiding Navy

Seven of Germany's Scientists Working at Point Mugu Center

Seven German scientists—experts on Nazi secret weapons in World War II—today are working at the Navy's Guided Missile Test Center, Point Mugu, under voluntary government contracts, The Times learned yesterday.

They are Dr. Herbert Alois Wagner, Dr. Reinhard Natanael Lahde, Dr. Wilfred Hermann Hell, Dr. Theodore Friedrich Sturm, Dr. Ernest O. Freiderich, Dr. Edgar R. Kutsscher and Dr. Hane Erich Holman.

While they are not permitted to work on new Navy developments in the mysterious field of "push-button" warfare, their research parallels that of American scientists at the test center in that they are completing wartime projects begun for Hitler.

Their Work for Nazis

Exact nature of their studies was not disclosed, but it was learned Dr. Wagner directed Germany's program for development of air-to-ground and ground-to-air missiles, with Dr. Lahde and Dr. Hell as associates, while Dr. Sturm was in charge of remote control and guidance for rockets, bombs and other missiles.

Dr. Hell is said to be an authority on remote-control mechanisms while Dr. Lahde specializes in gas turbine and bomb-sight equipment.

All reportedly have applied for U.S. citizenship, and three of the scientists—Dr. Wagner, Dr. Lahde and Dr. Hell—have their families with them in nearby Oxnard.

Bid for Their Families

The others have asked that their families be brought to the United States, including some relatives who were in Russian-occupied territory at the war's end—when the scientists themselves were being questioned by U.S. intelligence officers.

The Point Mugu center is regarded as one of the Navy's top projects, and the House Armed Services Committee recently approved a $34,520,000 allocation for construction work at the base.

Primary purpose of the installation is to test and evaluate the many secret remote-controlled "birds" now being developed by the Navy to keep America abreast of similar weapons-of-the-future also sought by other nations.

Los Angeles Times (1947)

U.S. Air Force Matador cruise missile
(first flight 1949)

U.S. Navy Regulus cruise missile
(first flight 1951)

SECTION A, PAGE TEN — OXNARD PRESS-COURIER—PHONE HU 3-1101 — TUESDAY, OCTOBER 4, 1955

Former German Scientists Aid Defense Effort at Mugu

Top Missile Guidance Man under Hitler Escaped Nazi Troops to Join Americans

A former German scientist, who during World War II was coordinator and director of all electronic work on guided missiles in his homeland excepting the V-2 rocket, is now head of one of the important divisions at the Naval Air Missile Test Center.

Sliting at his desk in one of the sparsely-furnished offices in an unimpressive tenement wooden barracks near the missile launching area, Theodore F. Sturm, head of the Component Tests Guidance Division, spoke quietly and deliberately about his life in Germany.

Saw Germany Fall Twice

The speaker was a man who as a student remembered vividly Germany's defeat in World War I, who had gone through the economic tragedies of the 20's and early 30's, who had seen the arrogant Hitler and enslaving Nazism rise to power, who had been appointed to one of the most sensitive scientific posts during World War II, and who, in 1945, "escaped" from a family group of German soldiers to a little town occupied by American troops.

The broad-shouldered, middle-aged bachelor, who lives with his widowed sister in Port Hueneme, smoked one after another with deliberation as he related his life and replied to questions.

A native of Hitz Kaiserslautern, 60 miles west of Heidelberg, Sturm attended grammar and high schools in his home town before going to Maximilian University in Munich from which he received a degree in science.

After graduation, he went to Berlin as a member of the scientific staff at Heinrich Hertz Institute Technical University. From 1937 to 1945 he worked for various electric companies as project engineer in guided missile research and development.

Developed Glide Bombs

In that period of 1937-45, he developed the first guided missiles which really worked in being able to pinpoint and bomb a small target. These missiles were called the FX and Henschel 293 glide bombs. They became, unfortunately, too familiar to Allied fleets operating in the Atlantic. Not as spectacular as the V-1 and V-2 rocket bombs, the glide bombs nevertheless had three major successes in World War II, according to Sturm.

1. Henschel 293 missiles sank two British destroyers in the Bay of Biscay in 1943. The destroyers had German submarines bottled up. After the sinkings, the destroyers moved out and German subs began operating again.

2. The bombs delayed success of the Allies at the Anzio beachhead.

3. The bombs deterred the British plan of recapturing Dodecanese islands off of Greece and Greece itself until the war's end.

Theodore F. Sturm . . . guidance his specialty.

Also, it was an FX which sank the Italian battleship Roma in 1943. The Roma was part of the Italian fleet which was on its way to surrender to Allied forces.

Of course, Sturm said, if the Allies had wanted to enough, they could have prevented submarines from operating again and could have taken Greece. However, would have taken considerable more time plus expenditure of equipment and men than contemplated.

Working on a radio-controlled beam, the missiles were guided to their targets by a pilot flying an airplane approximately eight miles away from the target. Later effective counter-measures by the Allies included sending up radio frequency interferers which gave false commands to the bomb and made it impossible for the German pilot to keep the missile in sight. Sturm said glide bombs were not used more because their tactical use was geared to air supremacy. When development of the bombs began, the Germans did have their supremacy. However, by late 1943, it was almost impossible to get a German plane aloft.

Reached Americans

Sturm was working at hidden laboratories in the Harz mountains when American troops occupied the nearby town of Blankenburg. A german general and several hundred men had come to the mountains to fight a last ditch, suicidal battle.

"It was ridiculous," Sturm said. "Nothing was to be gained but more loss of life. But the general's adjutant thought I should be one of the men to rally around the crumbling building. The only thing that saved me was a paper I had from high authorities in the party which gave me free access to any part of Germany. I commandeered a car, drove into Stassfurt, and waited for American officers to come."

Brought to America

Sturm was picked up and interrogated by Signal Corps officers attached to Ninth Army Headquarters in Brunswick. Further interrogation was held in Paris. He was then given a contract to work for the American government and was sent to Boston as one of 10 German scientists, including Dr. Wernher Von Braun who was head of V-2 rocket development.

After two years, he was given government job at Point Mugu. He arrived at this base shortly after it was opened in 1946. Here, as in Germany, he is concerned with developing guidance systems for use in missiles.

On Dec. 10, 1954, he became an American citizen.

He described Hitler as a supreme egotist, a little mad, and a man with absolutely no sense of humor. He said Hitler managed to achieve power in 1933 because the German people were ready to accept anyone who promised a way out of their economic miseries.

'Operation Paper Clip'

New Ideas in Radar Come from Man Who Headed Lab Developing German Methods

Shortly after World War II, the United States began a race with Russia to recruit top German scientists—men who had contributed much in both the technical and productive ends of the German war effort.

America termed its program "Operation Paper Clip." It succeeded in bringing many of the experts from Germany to our country, several of whom were put under contract by the Navy and assigned to Point Mugu. The stories on this page reveal the backgrounds and personalities of four "Operation Paper Clip" scientists who still work at the Naval Air Missile Test Center.

Willy Fiedler . . . piloted buzz bomb.

Buzz Bomb Test Supervisor Flew in Desperation Missile

It was a cold, bleak day in November of 1944 when 36-year-old Willy Fiedler, now a Point Mugu scientist, stepped confidently into a tiny cockpit mounted atop a cigar-shaped missile. Fiedler was going to test a suicide-designed modification of the V-1 buzz bomb—a weapon for which 13,000 mechanical German youths had volunteered to fly to their deaths if the test was successful.

Fiedler's development of the suicide bomb was a desperation measure, but most Germans realized in November of 1944 that only desperation measures might clutch victory for the Reich from apparent defeat. The scientist and pilot, who during most of the war had been in charge of testing the V-1 at Peenemunde, strapped himself in the cockpit of the "Reichenberg" bomb attached to the belly of the mother bomber. The plane and its well-d-looking "teach" with stubby wings and pulse jet engine that resembled

Continued on page A-12)

Dr. Otto G. Schwede, technical director of the Range Instrumentation Department at Point Mugu, headed the laboratories of the company which developed German radar and produced practically all long-range radar and sonar equipment in Germany during the war.

As an American scientist, he is still developing new ideas in radar and other instrumentation. Only now his theoretical and practical genius channels itself into the scientific flow of American research.

At Technical University in Munich, Dr. Schwede took one of the toughest academic courses possible. Besides his natural interests in the fields of science and mathematics, he studied French, English, Latin, Spanish and German. In 1936 he graduated summa cum laude with a degree comparable to Bow Master of Applied Physics, and then in 1938, he took his doctorate degree summa cum laude in natural science.

Microwave Research

Research for his doctorate in microwave was done while working at the Institute of Wireless Telegraph and Telephony in Munich. He continued at this institute as a research scientist until 1940 when he took a position with the GEMA company in Berlin.

The GEMA company was given the responsibility for development and production of ground-based early warning radars, ship radars, and airborne radars. The company also worked on sonar and infra-red equipment. Dr. Schwede was in charge of the development laboratories.

Although some research in radar had been done as early as 1935, it wasn't until the war that mass-scale development and production began. Dr. Schwede emphasizes that German many wasn't the only pioneer in radar, but that he and his staff had to work as if they were the only scientists developing ideas and methods.

Studied Captured Equipment

Naturally, interchange of information among countries was at a minimum although studies of captured enemy equipment became common as the war progressed.

Otto G. Schwede . . . microwave expert.

In 1943 the GEMA company moved its labs out of Berlin into Silesia to escape Allied bombings. When the Russians began moving on Silesia in 1945 the labs were moved again, this time to Tyrol. "The company's personnel and equipment were evacuated with the Russians less than 16 miles away."

After Germany's surrender, Dr. Schwede and his wife went back to Bludch where they had a home prior to the war. They found the house almost completely destroyed by bombs. Dr. Schwede went to work. He chopped down trees from a nearby forest for lumber. Authorities allowed him to take bricks from demolished houses. He begged and borrowed mortar, pipe, and everything else necessary to rebuild his home. It was livable again before winter.

Repaired Army Radios

Meanwhile, Dr. Schwede worked as a radio repairman for the United States Army Signal Corps in Munich. In 1946-47, he was a radio instructor in a displaced person's camp near Munich. In August, 1947, the United States government offered him a job. He accepted the position and before the year was over he was personally enlisted at Point Mugu.

Author of several scientific papers dealing with highly classified material, Dr. Schwede also has been active in the patent field. In Germany, both before and during the war, he had 40 patents approved, or pending, fates of which are unknown. Since coming to Mugu, one patent application on a new electronic tube has been approved and several other applications are in the mill.

Dr. Schwede, with his wife and two children, lives in Ventura. He became an American citizen Nov. 11 of last year.

Oxnard Press-Courier (1955)

For more information, see *Forgotten Creators* 9.6 and E.4

Outline

Nuclear payloads

1. Land-launched intercontinental missiles

    A. Liquid propellant missiles

    B. Liquid propellant space planes

    C. Solid propellant missiles

2. Submarine-launched missiles

    A. Sub-launched cruise missiles

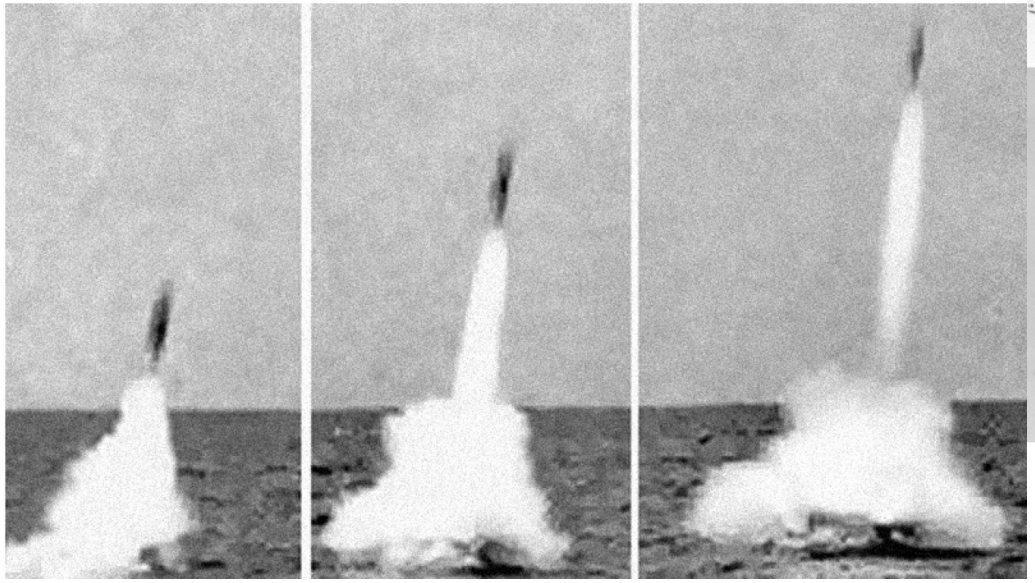
    B. Sub-launched ballistic missiles

3. Intercontinental jet bombers

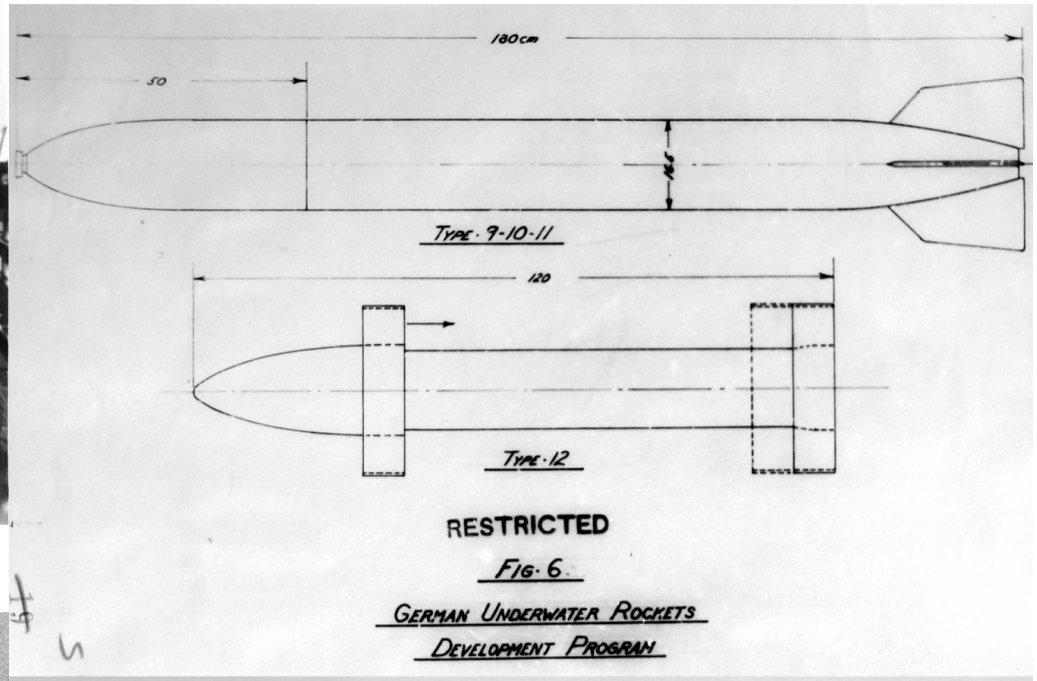
Wartime Submarine-Launched Ballistic Missiles (SLBMs)

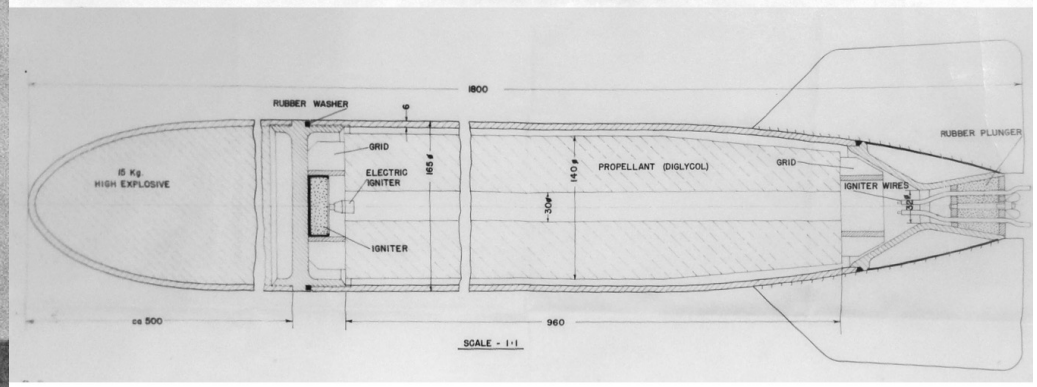
Bundesarchiv Militärarchiv
Freiburg RH 8/369

Nebelwerfer rockets launched from U-511 U-boat 12 meters underwater (May 1942)



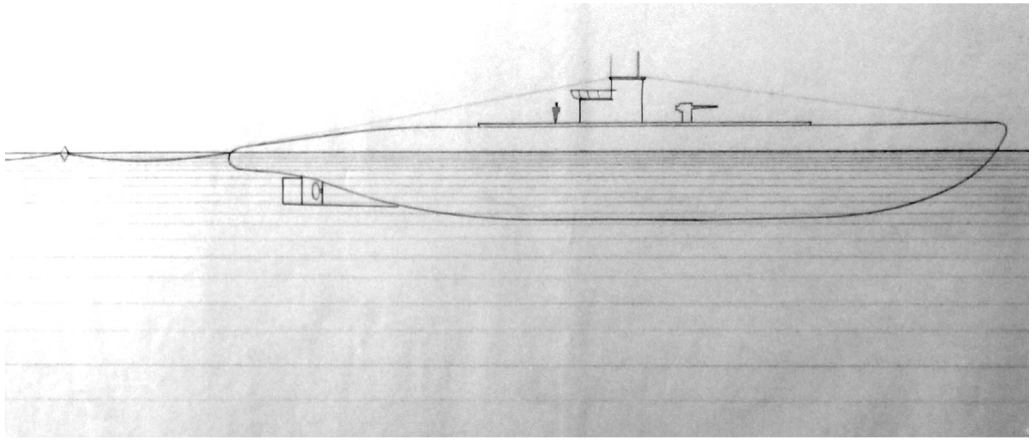
A long series of increasingly sophisticated submarine-launched rockets were developed and successfully demonstrated at Toplitz See, Austria (1942–1945)





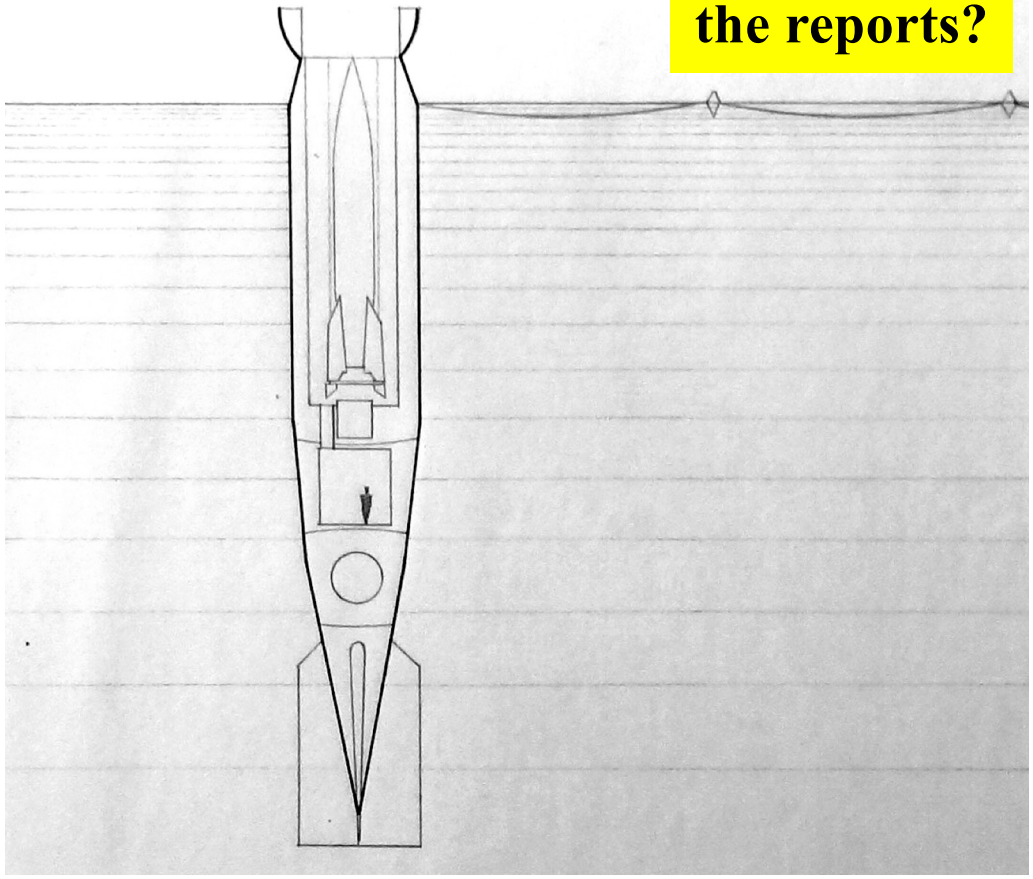
NARA RG 38, Entry P5, NavTecMisEu 500-45

Submarine-Towed Launch Platform for V-2 (1943-1945)



Bundesarchiv Militärarchiv
Freiburg RH 8/4067K

Where are the reports?



Deutsches U-Boot-Museum. U 511 and Missiles: U 511, U 1063 and plans for U-boats armed with seabased missiles. http://dubm.de/en/u-511-and-missiles/

Also, the vision, born after the US entered the war, to fire at the US an advanced multiple stage version of the V-2 (the project A-9/A-10 with ranges of more than 5,000 km) gained some momentum following a proposal brought forward by a director of the "Deutsch Arbeitsfront" (= German Labor Front, a sort of national socialistic controlled trade union), Otto Lafferenz. After a visit of the facilities at Peenemünde and a meeting with the Military Commander, Major General Walter Dornberger, in the Autumn of 1943, he proposed to develop floating containers to accommodate V-2s and to tow them by U-boats before the US Eastern coast, to fire at New York and other area targets utilizing on their range up to 300 km. This arms project now called "Lafferenz-Project" (somewhat irritating, various authors in historic writing use other project names such as "Schwimmweste" = "Life Vest", "Apparat F", or "Prüfstand XII" = "Test Stand XII") was consequently developed further, and as a first step a floating container was invented able to transport and launch, to be towed by U-boats. The end status of the concept envisaged an operation, where up to three containers were towed simultaneously by U-boats across the Atlantic Ocean, to be erected in some distance before the coasts into a vertical firing position by partial flooding---and to launch the V-2s.

For that the Weapons Test Command No. 10 at Stetting developed a container with a length of about 32 meters, a diameter of about 5.5 meters and a displacement of some 300 tons, to be constructed at the Vulcan shipyard at Stettin. At the turn of 1944 to 1945 successful towing trials were actually executed using the type VII C/41 U-boat U 1063, which went through its basic and combat readiness training with the 5th U-boat (Training) Flotilla at Stetting at that time, after it had been commissioned on 08 July 1944 at the end of its construction by the Germania shipyard at Kiel. Following its training period until the end of February 1945 the U-boats came frontal unit as of 01 May 1945 at Bergen, Norway.

Albert Ducrocq. 1947. *Les Armes Secrètes Allemandes.* Paris: Berger-Levrault. pp. 161-163.

What is more, in addition to A-9 bombing, the Germans wanted to undertake direct bombing of the American coastline using submarine-launched V-2s. This was their second new weapon against America. It was to come into action at the same time as the A-9, i.e. in early summer 1945. [...]

The idea of using submarines to transport V-2s dates back to 1942. At the same time as industrial production of the V-2s was being undertaken, Hitler's entourage had paid close attention to the amphibious V-2 project that von Braun's team had just drawn up. But the practical development work was long and tedious, and was not completed until 1944, when the first submarine capable of launching V-2s was actually built. [...]

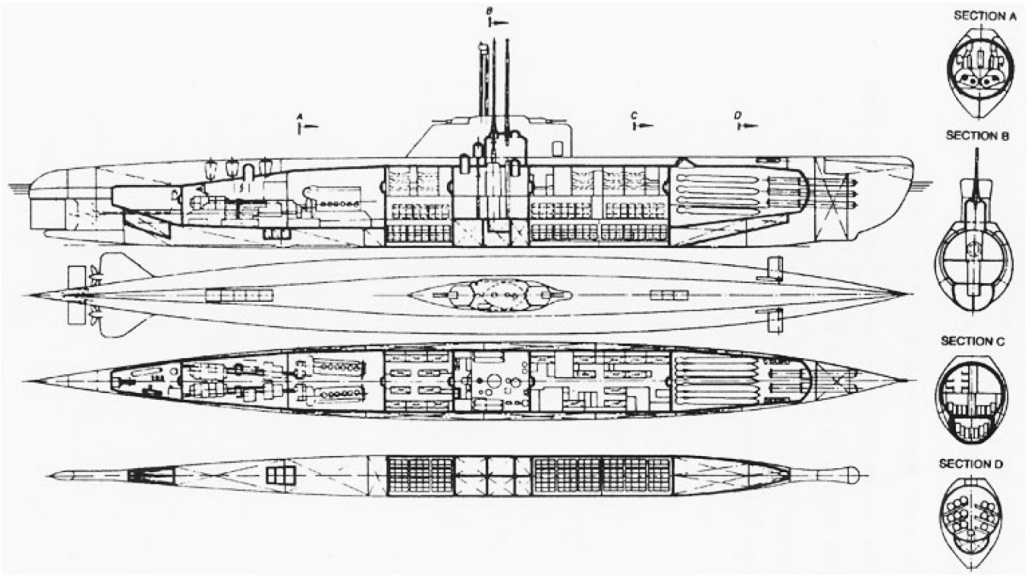
It transpires that the tests were to be completed by the time of the German collapse in 1945, and that the Germans were preparing to continue the tests on America itself. What area would have been threatened? It seems that the range of the amphibious V-2, at least in the state left by the experimental research at Lake Toplitz, was considerably less than that of the ordinary V-2, of the order of only 150 to 200 kilometers. Needless to say, this would still have been more than sufficient for bombing American ports such as Boston, New York, Philadelphia, Baltimore, and Charleston. Obviously, the greater the depth at which the submarines operated, the shorter their range. We have seen that the latest German submarines could operate at a depth of 300 meters; however, it doesn't seem that an amphibious V-2 launch could have been envisaged from such a depth.

In any case, the threat would have been extremely serious for the American coast, since, on the one hand, once the V-2 had been launched, it has so far been impossible to defend against it, and, on the other hand, detecting and combating the new German submarines would have been no small matter, independently of the V-2's self-guidance by infra-red ray detection or other means. [...]

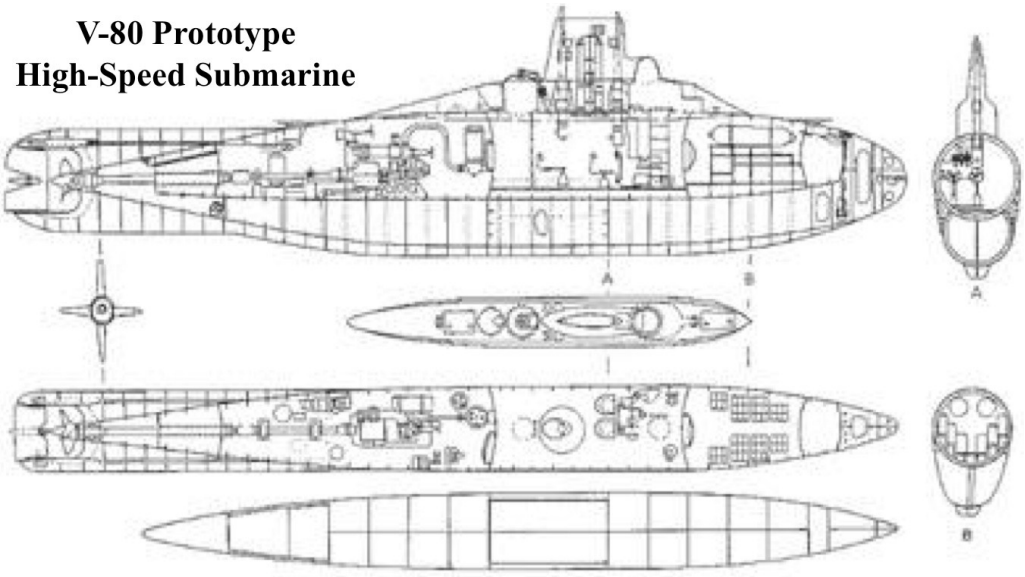
Germany was probably thinking of attacking American territory beginning in June 1945. It should be noted that while the use of other secret weapons, such as flying bombs and new rocket planes, was literally imminent, this threat to the United States must be located six weeks or two months after the date of the collapse of the Reich. We are allowed to consider it almost as dangerous, especially since the amphibious V-2s, too, could very well have carried atomic bombs.

Advanced Submarines (1938-1945)

Type XXI U-Boat (1943–1945)



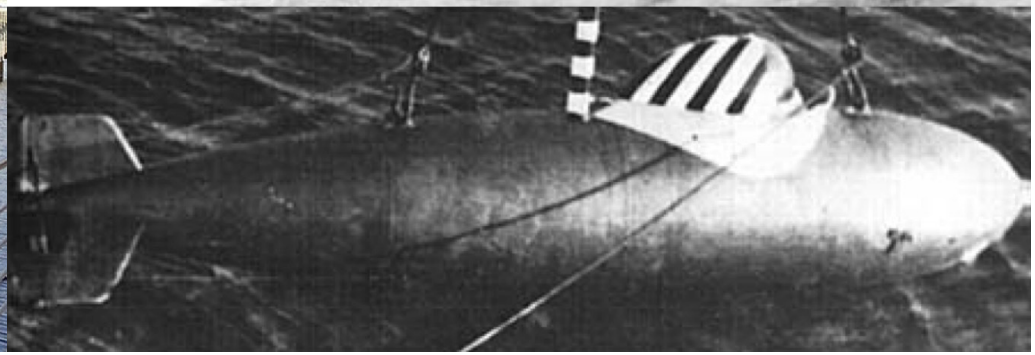
V-80 Prototype
High-Speed Submarine



V-80
(1940)

U-2540 Type XXI U-Boat, German Maritime Museum, Bremerhaven

Delphin
(1944)



Sonar

Alexander Behm (1880–1952) invented sonar (1912)

Sophisticated sonar systems were developed by:

1. **Atlas Werke (Bremen)**
2. **ELAC (Kiel)**
3. **GEMA (Berlin)**
4. **AEG (Berlin)**

N° 17,109 A.D. 1914

(*Under International Convention.*)

Date claimed for Patent under Patents and Designs Act, 1907, being date of first Foreign Application (in Germany), 21st July, 1913

Date of Application (in the United Kingdom), 18th July, 1914

At the expiration of twelve months from the date of the first Foreign Application, the provision of Section 91 (3) (a) of the Patents and Designs Act, 1907, as to inspection of Specification, became operative

Accepted, 15th July, 1915

COMPLETE SPECIFICATION.

Improvements in or relating to a Method of and Apparatus for Measuring Distances under Water by means of Reflected Sound Waves.

I, ALEXANDER BEHM, of Hardenbergstrasse 31, Kiel, German Empire, Physicist, 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:—

It has been repeatedly suggested to measure the depth at sea and distances under water, by determining the time between the sending off of an acoustic signal and the arrival of the echo. In this method the direction is determined by turning a funnel situated at the transmitter or at the receiver, in which case the ear of the observer has to decide when the intensity of sound of the echo is the greatest. As the velocity of sound under water is about 1435 meters per second, this method could be utilised only in very deep water or for large distances, whilst in the case of small distances it failed completely. Moreover, in this and similar methods, the measurements are uncertain as the returning sound is received by the ear directly or indirectly by means of a microphone.

These disadvantages are obviated according to this invention,

1) By using a sonometer *viz.* an instrument for measuring the strength of sound waves by observation of the deflections of a body caused to vibrate by the sound waves which does away with the source of error lying in observation by the ear, and

2) By measuring the strength of the echo, which decreases with the distance, instead of taking as a basis the time elapsing between the emission and return of the signal. If the intensity of sound of the transmitter remains constant, the receiver can be provided with a graduation on which the distance or the depth of the sea can be read directly. The intensity of the transmitter could however also be increased or reduced until a given intensity of echo, determined beforehand, is obtained. The intensity of the source of sound, which can be measured by means of the sonometer, then gives the measure of the depth or the distance.

[*Price* 6*d.*]

Fig.1.

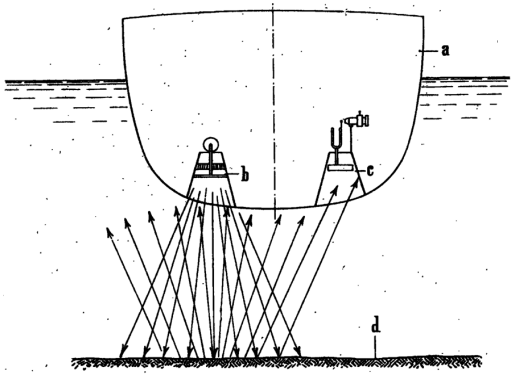


Fig.2.

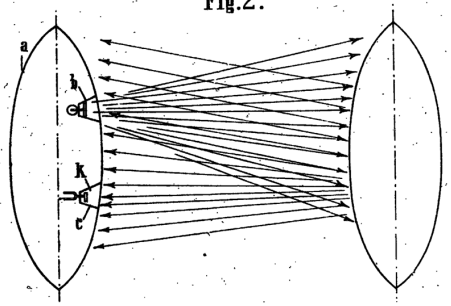


Fig.3.

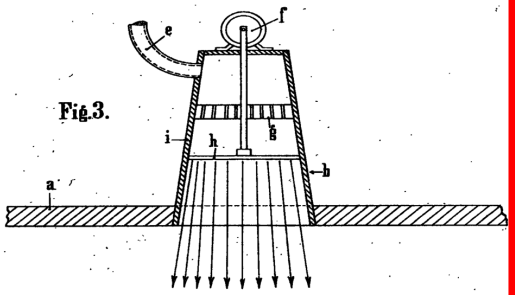
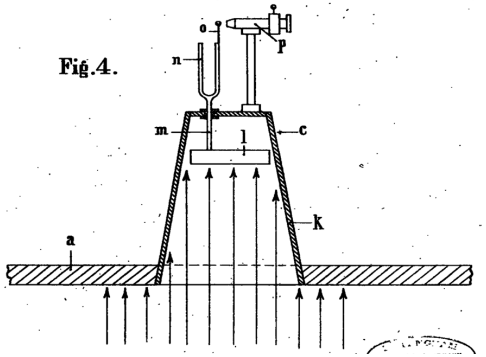


Fig.4.



Anti-Sonar

U-480 submarine covered with Alberich anti-sonar rubber tiles (1943)

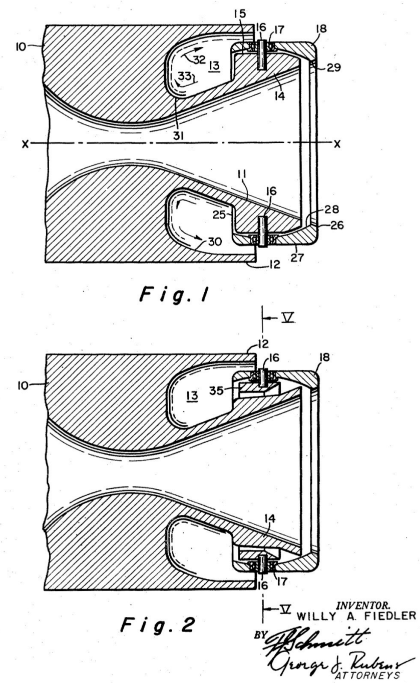
Postwar U.S. Submarine-Launched Missiles

Willy Fiedler (1908–1998)

Feb. 5, 1957 W. A. FIEDLER 2,780,059

JET DIRECTION CONTROL DEVICE

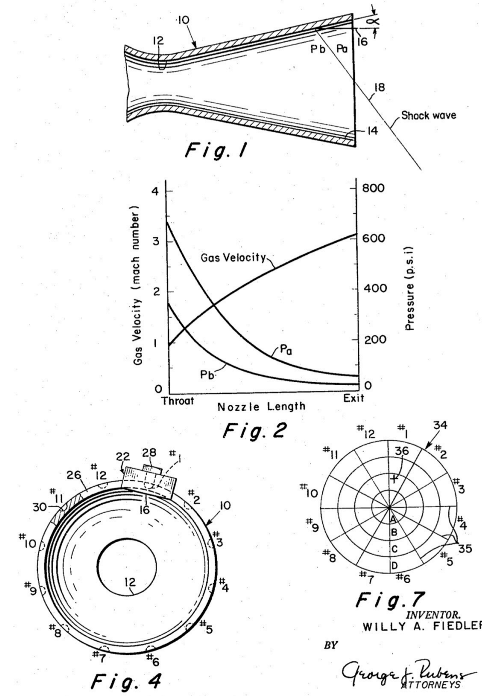
Filed Nov. 29, 1955 3 Sheets-Sheet 1



Sept. 15, 1959 W. A. FIEDLER 2,903,851

JET DEFLECTOR

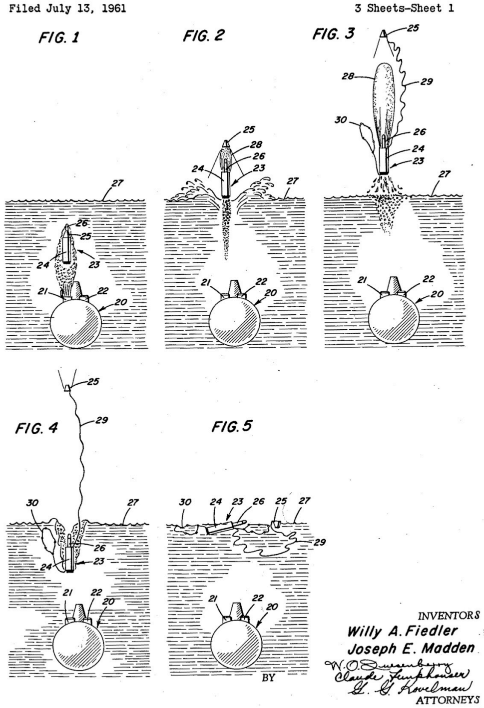
Filed May 7, 1956 2 Sheets-Sheet 1



Jan. 29, 1963 W. A. FIEDLER ET AL 3,075,301

LAUNCH AND UNDERWATER TRAJECTORY TEST VEHICLE

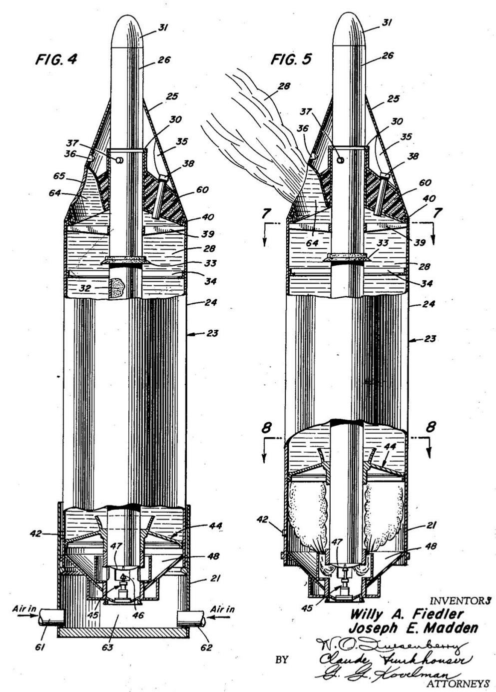
Filed July 13, 1961 3 Sheets-Sheet 1



Jan. 29, 1963 W. A. FIEDLER ET AL 3,075,302

UNDERWATER PITCH-OVER LAUNCH TEST VEHICLE

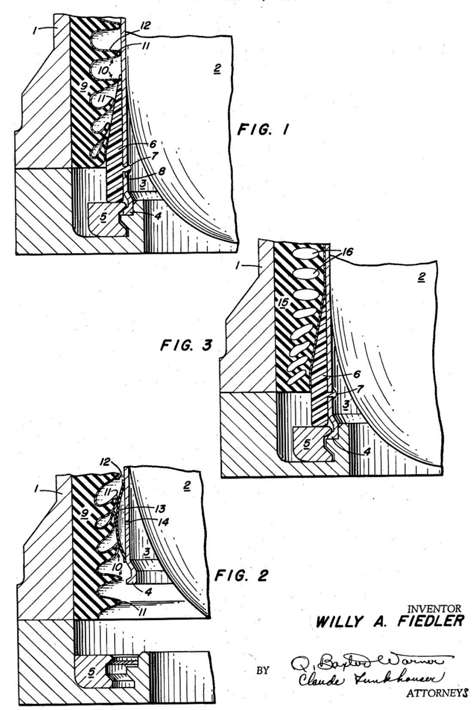
Filed Aug. 17, 1961 3 Sheets-Sheet 2



March 10, 1964 W. A. FIEDLER 3,124,040

SUPPORT SYSTEM FOR TUBE LAUNCHED MISSILE

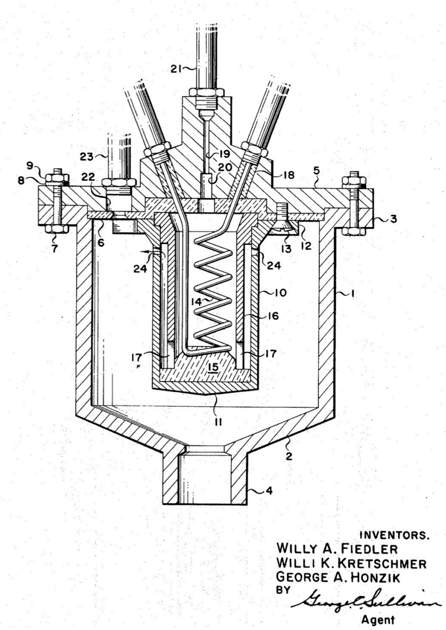
Filed Feb. 26, 1962



Oct. 13, 1970 W. A. FIEDLER ET AL 3,533,233

HOT GAS GENERATOR UTILIZING A MONO-PROPELLANT FUEL

Filed Sept. 13, 1967



Postwar U.S. Sub-Launched Missiles

Karl Klager (1908–2002)

United States Patent [19]

Klager

[11] **Patent Number: 5,811,725**

[45] **Date of Patent: Sep. 22, 1998**

[54] **HYBRID ROCKET PROPELLANTS CONTAINING AZO COMPOUNDS**

[75] Inventor: **Karl Klager**, Sacramento, Calif.

[73] Assignee: **Aerojet-General Corporation**, Rancho Cordova, Calif.

[21] Appl. No.: **748,738**

[22] Filed: **Nov. 18, 1996**

[51] **Int. Cl.**[6] **C06B 45/10**

[52] **U.S. Cl.** **149/19.4**, 149/19.1; 149/19.5; 149/36; 149/109.4; 60/219

[58] **Field of Search** 60/219; 149/19.1, 149/19.4, 36, 19.5, 109.4

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Primary Examiner—Edward A. Miller

Attorney, Agent, or Firm—Townsend and Townsend and Crew LLP

[57] **ABSTRACT**

Hybrid rocket propellants are disclosed that contain azo compounds, i.e., compounds containing the group R—N=N—R' as part of their structure, where R and R' represent a variety of groups including aliphatic, alicyclic and heterocyclic groups. The azo compounds are mixed with the other solid components of the propellant grain and serve either as plasticizers, binders, fuels, or fillers. The effect of including the azo compounds is an increase in the regression rate of the grain as the propellant burns.

26 Claims, 2 Drawing Sheets

United States Patent Office 3,214,474 Patented Oct. 26, 1965

3,214,474
PREPARATION OF UNSYMMETRICAL HYDRAZINES

Karl Klager, Monrovia, Calif., assignor to Aerojet-General Corporation, Azusa, Calif., a corporation of Ohio

No Drawing. Filed Sept. 28, 1953, Ser. No. 382,828
6 Claims. (Cl. 260—583)

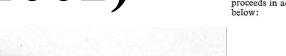
This invention relates to an improved process for preparing unsymmetrical alkyl hydrazines.

Unsymmetrical alkyl hydrazines have been known for many years and their properties as fuels have been well recognized in the art. However all of the known processes for their production produce poor yields of low purity. Accordingly, the use of alkyl hydrazines as fuels, in particular as propellant fuels, has been somewhat restricted for economic as well as for safety reasons, since a high degree of purity is required for this use in order to lessen the possibility of explosive reactions.

It is an object of this invention to provide an improved method for the preparation of unsymmetrical alkyl hydrazines which will provide increased yields of greater purity.

Classically unsymmetrical alkyl hydrazines are prepared by the reduction of nitroso dialkylamines. This reaction proceeds in accordance with the reaction scheme set forth below:

wherein R and R' are the same or different alkyl radicals. However, it is known that the hydrazine bond may be dissolved under reductive conditions, this reaction taking place according to the following reaction scheme:



where R and R' are the same as above.

Hence it becomes apparent that a catalyst or set of reaction conditions which favors the former reaction and disfavors the latter will result in a successful method for the preparation of such substituted hydrazines.

Alkyl hydrazines have been prepared by reducing the nitroso group in the classical manner with zinc and acetic acid, however these conditions usually result in a complicated work up, a yield of approximately 65%, and in a product of relatively low purity.

In recent years it has been found that lithium aluminum hydride may also be employed to effect this reaction. However the lithium aluminum hydride method is very expensive, ordinarily yields a product of low purity and generally provides a theoretical yield of only about 75%.

We have discovered that by using palladium catalysts to effect the reduction, a yield of approximately 85% of the theoretical may be obtained and that the product thus obtained possesses a high degree of purity. Suitable palladium catalysts are: palladium charcoal, palladium-calcium carbonate and palladium-barium sulfate. Colloidal palladium may also be used as well as finely divided palladium on carriers such as silica gel, infusorial earth, alumina and other commonly used catalyst carriers. Because of these improved results, this method is applicable to large scale production with considerable decrease in the overall cost of production. Moreover our reaction catalyst has been found to be useful for the preparation of any of the unsymmetrical alkyl hydrazines. The following examples are provided to more clearly illustrate the invention:

Example I.—Preparation of palladium charcoal catalyst

1 part of 10% palladium charcoal and 10 parts of water was stirred in a hydrogen atmosphere until the catalyst was activated, that is, until no additional hydrogen was absolved.

Example II.—Preparation of dimethyl hydrazine

5 parts of nitroso dimethyl amine in 90 parts of water were added to the catalyst as prepared above and subjected to hydrogen atmosphere with rapid stirring. After a quantity equivalent to 2 moles of hydrogen had been absorbed the reaction was stopped, the catalyst filtered, and the water solution neutralized with hydrochloric acid. After evaporation of the water a yield equivalent to 81% of the theoretical of dimethyl hydrazine hydrochloride was isolated.

Example III.—Preparation of ethyl methyl hydrazine

5 parts of nitroso ethyl methyl amine in 90 parts of water were added to the catalyst as prepared in Example I and subjected to hydrogen atmosphere with rapid stirring. After an amount of hydrogen gas equivalent to 2 moles of hydrogen had been absorbed the reaction was stopped. The catalyst was filtered off and the water solution neutralized with hydrochloric acid. The water was distilled off and a theoretical yield of 79.2% ethyl methyl hydrazine hydrochloride was isolated.

In the same fashion simply by selecting the appropriate alkyl substituted nitroso amine and reducing it in accordance with the examples set forth above, any of the alkyl substituted hydrazines may be prepared.

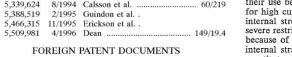
The concentration of the catalyst has not been found to be critical, however, we have found that optimum results are obtained when the palladium-charcoal catalyst is present in an amount below 2.0% by weight. No appreciable differences where observed when amounts in excess of 2.0% were used, however, when amounts below 0.2% were used, a slight decrease in the rate of reaction was observed.

Any of the aforementioned catalysts may be used successfully in the performance of my invention. The palladium metal, itself, being the catalytic substance, is substantially unaffected by the particular carrier or means of introduction employed.

My process, as is evident, lends itself equally well to continuous or batch processes, hence is well adapted to commercial production of unsymmetrical hydrazine compounds.

I claim:

1. The method of preparing unsymmetrical lower alkyl hydrazines which comprises reducing a nitroso amine having the general formula:



wherein R and R' are lower alkyl radicals, with hydrogen in aqueous solution in the presence of a hydrogen activated palladium metal catalyst.

2. The method of claim 1 wherein the hydrogen activated palladium catalyst used is a catalyst selected from the group consisting of palladium on charcoal, palladium on calcium carbonate, palladium on barium sulfate, colloidal palladium metal, and finely divided palladium metal a catalyst carrier.

3. The method of claim 1 wherein the catalyst used is hydrogen activated palladium on charcoal.

4. The method of claim 1 wherein the hydrogen activated palladium catalyst is present in an amount of from about 0.2% to 2.0% by weight.

5. The method of preparing unsymmetrical dimethyl

United States Patent Office 3,000,968 Patented Sept. 19, 1961

3,000,968
METHOD OF PREPARING NITRO COMPOUNDS

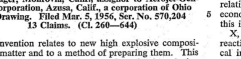
Karl Klager, Monrovia, Calif., assignor to Aerojet-General Corporation, Azusa, Calif., a corporation of Ohio

No Drawing. Filed Mar. 5, 1956, Ser. No. 570,204
13 Claims. (Cl. 260—644)

This invention relates to new high explosive compositions of matter and to a method of preparing them. This invention also relates to a new process for introducing nitroalkyl groups into organic compounds.

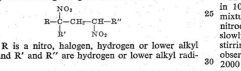
This application is a continuation-in-part of my copending application Serial No. 337,212, filed February 16, 1952, now abandoned.

The new compositions of matter of this invention are trinitroalkane compositions, having the general formula:



wherein R and R'' are hydrogen or lower alkyl radicals.

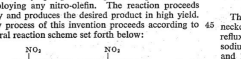
The new process of this invention is useful in preparing the compounds having the general formula:



wherein R is a nitro, halogen, hydrogen or lower alkyl radical and R' and R'' are hydrogen or lower alkyl radicals.

This process can be used to prepare the new compounds of this invention, as well as a variety of other known compounds having different utilities and properties. The conventional method for introducing nitroalkyl groups into organic compounds has been to react the compound with a nitro-olefin. This process generally leads to relatively poor yields due to the tendency of nitro-olefins to polymerize, thereby preventing the occurrence of the reaction and at times even rendering separation of the desired product, if any, difficult.

The new process of this invention permits the introduction of nitroalkyl groups into organic compounds without employing any nitro-olefin. The reaction proceeds smoothly and produces the desired product in high yield. The new process of this invention proceeds according to the general reaction scheme set forth below:



wherein R is a nitro, halogen, hydrogen or lower alkyl radical, R' and R'' are hydrogen or lower alkyl radicals, and M is a monovalent radical of an alkali or alkaline earth metal. The reaction is preferably conducted at a temperature of about 40° C., however, the reaction temperature can be varied over an extremely wide range of temperatures if desired. Methanol is the preferred solvent, however, any inert organic solvent can be used if desired. While any of the alkali or alkaline earth metal hydroxides can be used in the preparation of the aci-salt, it is preferred to use sodium hydroxide for reasons of economy, and because

United States Patent Office 3,132,976 Patented May 12, 1964

3,132,976
SOLID PROPELLANT COMPOSITIONS CONTAINING POLYURETHANE RESINS

Karl Klager, Richard D. Geckler, and Richard L. Parrette, Sacramento, Calif., assignors to Aerojet-General Corporation, Azusa, Calif., a corporation of Ohio

No Drawing. Filed July 20, 1959, Ser. No. 829,182
17 Claims. (Cl. 149—19)

This invention relates to novel solid propellant compositions and in particular to novel propellant compositions comprising a polyurethane binder with a finely divided oxidizing agent dispersed therein.

Solid propellant compositions are ordinarily composed of a resin fuel and an oxidizing material, the oxidizing material being intimately dispersed in the fuel. The ignition and burning properties of such propellant compositions, as well as their physical properties, are dependent to a large extent upon the particular resins employed as fuels.

In the novel propellant compositions of this invention polyurethanes are used as the resin fuel component to produce propellants of unexpectedly superior physical properties and performance characteristics. Our novel polyurethane propellants have substantially no internal strains due to the fact that there is little shrinkage and low heat of reaction during polymerization of the polyurethane fuel component. This lack of internal strain is important in that it assures substantial freedom of the propellant grain from cracking during burning. As those skilled in the art realize, propellant cracking is highly undesirable and dangerous and can result in erratic burning or even explosion of the propellant grain.

In addition to their freedom from cracking, the polyurethane propellants of this invention are superior in other ways. For example, they are possessed of sufficiently tenacious adhesive properties to enable them to be bonded directly to the rocket chamber lining, thus permitting optimum utilization of the available space in the rocket motor and simplifying manufacturing techniques. The novel polyurethane propellants of our invention are also possessed of many other desirable physical properties, for example: rubbery mechanical properties, low brittle point, excellent resilience and superior aging properties.

Our novel solid propellants can be used as the primary propulsion source in rocket-propelled vehicles or as a propellant for artillery missiles. When used as the primary propulsion source for rocket vehicles, they can be conveniently ignited by a conventional igniter, as for example, the igniter disclosed in assignee's copending application Serial No. 306,030, filed August 23, 1952 now, Patent No. 3,000,312. The propellant is preferably cast directly in the rocket chamber in which it is to be fired and restricted on one or both ends in the conventional manner with a relatively slow burning inert resin, such as a polyurethane or a polyester resin. The restriction is preferably accomplished by applying a relatively thin coating of the inert resin to the inner surfaces of the rocket chamber lining prior to casting the propellant therein. Rocket chambers such as those in which our novel solid propellants are employed are ordinarily of the conventional type having one end open and leading into a venturi rocket nozzle. Upon ignition, large quantities of gases are produced and exhausted through the nozzle creating propulsive force.

The polyurethane binders of our invention are prepared by reacting a compound having two or more active hydrogen groups capable of polymerized with an isocyanate, with an organic compound having as the sole reacting groups, two or more isocyanate or isothiocyanate groups. The compound having the active hydrogen groups is preferably an organic compound having as its sole reacting groups, hydroxyl or thiol groups.

It will be apparent that, where there are more than two active hydrogen, isocyanate, or isothiocyanate groups present on any of the polyurethane reactions, the resulting molecular structure of the polyurethane binder will be at least to a certain extent of a cross-linked rather than a linear nature. The cross-linking is accomplished when all three functional groups of a sufficient number of the trifunctional molecules undergo the urethane reaction with other groups present in the mixture, thereby resulting in a product having a "three-dimensional" molecular structure rather than mere aggregates of linear chains as is the case when bifunctional reactants are employed.

Where bifunctional reactants, such as dihydroxy compounds and diisocyanates, are employed to produce the polyurethane binders for our novel propellants, it is necessary to also employ a "cross-linking" agent to assure a product having the cross-linked structure essential to this invention. Cross-linking agents can also be used with polyurethane reactants having more than two functional groups, such as triols and/or triisocyanates, within the scope of this invention. Compounds suitable as cross-linking agents for our polyurethane binders are those organic compounds having as the sole reacting groups three or more groups polymerizable with hydroxy or isocyanate groups.

It will be appreciated that in any given batch of propellant the individual polyurethane molecules may vary in number of repeating units from several to tens of thousands of these units, hence molecular weight figures on polyurethanes represent statistical averages. The exact nature of terminal groupings is not known and will vary depending upon whether catalysts, polymerization catalysts, etc., are present. Moreover, a given molecule may even form a ring and thus leave no dangling radicals.

The isocyanate starting materials for our polyurethane binders are preferably diisocyanates but not necessarily so since, as explained above, other polyisocyanates (such as triisocyanates) or polyisothiocyanates may be employed within the scope of the invention if desired.

Our preferred diisocyanate compounds can be saturated or unsaturated; aliphatic or aromatic; open or closed chain, and, if the latter, monocyclic or polycyclic; and substituted or not by groups substantially unreactive with isocyanate or hydroxyl groups such as, for example, ketone, halogen, ester, sulfide, or ether groups. The following diisocyanate compounds are particularly suitable as reactants for the preparation of binders for our novel polyurethane propellants:

(a) Alkane diisocyanates, such as:

Ethylene diisocyanate;
Trimethylene diisocyanate;
Propylene-1,2-diisocyanate;
Tetramethylene diisocyanate;
Butylene-1,3-diisocyanate;
Decamethylene diisocyanate;
Octadecamethylene diisocyanate;
etc.

(b) Alkene diisocyanates such as:

1-propylene-1,2-diisocyanate;
2-propylene-1,2-diisocyanate;
1-butylene-1,4-diisocyanate;
3-butylene-1,2-diisocyanate;
1-butylene-1,3-diisocyanate;
1-butylene-2,3-diisocyanate;
etc.

(c) Alkylidene diisocyanates such as:

Ethylidene diisocyanate;
Propylidene-1,1-diisocyanate;
Propylidene-2,2-diisocyanate;
etc.

(d) Cycloalkylene diisocyanates such as:

Cyclopentylene-1,3-diisocyanate;
Cyclohexylene-1,2-diisocyanate;
Cyclohexylene-1,3-diisocyanate;
Cyclohexylene-1,4-diisocyanate;
etc.

(e) Cycloalkylidene diisocyanates such as:

Cyclopentylidene diisocyanate;
Cyclohexylidene diisocyanate;
etc.

(f) Aromatic diisocyanates such as:

m-Phenylene diisocyanate;
o-Phenylene diisocyanate;
p-Phenylene diisocyanate;
1-methyl-2,4-phenylene diisocyanate;
Naphthylene-1,4-diisocyanate;
Diphenylene-4,4'-diisocyanate;
2,4-tolylene diisocyanate;
2,6-tolylene diisocyanate;
4,4'-diphenylmethane diisocyanate;
1,5-naphthalene diisocyanate;
Methylene-bis-(4-phenylisocyanate);
2,2-propylene-bis-(4-phenylisocyanate);
Xylene-1,4-diisocyanate;

United States Patent Office 3,245,849 Patented Apr. 12, 1966

3,245,849
SOLID PROPELLANT COMPOSITIONS CONTAINING POLYURETHANE RESINS OF LOW CURE TEMPERATURE

Karl Klager, Richard D. Geckler, and Richard L. Parrette, Sacramento, and Aerojet-General Corporation, Azusa, Calif., a corporation of Ohio

No Drawing. Filed July 20, 1959, Ser. No. 829,180
32 Claims. (Cl. 149—19)

This invention relates to novel solid propellant compositions and in particular to novel propellant compositions comprising a cross-linked polyurethane binder with a finely divided oxidizing agent dispersed therein.

Solid propellant compositions are ordinarily composed of a resin fuel and an oxidizing material, the oxidizing material being intimately dispersed in the fuel. The ignition and burning properties of such propellant compositions, as well as their physical properties, are dependent to a large extent upon the particular resins employed as fuels.

In the novel propellant compositions of this invention, cross-linked polyurethanes are used as the resin fuel component to produce propellants of unexpectedly superior physical properties and performance characteristics.

The novel polyurethane propellants of our invention can be cured at low cure temperatures and in addition exhibit no measurable heat of reaction. As a result of these unique properties they are not subject to shrinkage and have no internal strains. Composite propellant systems heretofore used have all been severely restricted in their use because of high heats of reaction and the need for high cure temperatures which produce shrinkage and internal stresses. These faults have heretofore imposed severe restrictions upon the size of solid propellant motors because of their tendency toward cracking as a result of internal strains. We have produced a propellant which constitutes a major breakthrough in rocket technology in that solid propellant motors are no longer subject to size limitations and can be manufactured in sizes as large as desired using the novel propellant compositions of our invention.

In addition to their freedom from cracking, the polyurethane propellants of this invention are superior in other ways. For example, they are possessed of sufficiently tenacious adhesive properties to enable them to be bonded directly to the rocket chamber lining, thus permitting optimum utilization of the available space in the rocket motor and simplifying manufacturing techniques. The novel polyurethane propellants of our invention are also possessed of many other desirable physical properties, for example: rubbery mechanical properties, low brittle point, excellent resilience and superior aging properties.

Our novel solid propellants can be used as the primary propulsion source in rocket-propelled vehicles or as a propellant for artillery missiles. When used as the primary propulsion source for rocket vehicles, they can be conveniently ignited by a conventional igniter, as for example, the igniter disclosed in assignee's copending application Serial No. 306,030, filed August 23, 1952 now, Patent No. 3,000,312. The propellant is preferably cast directly in the rocket chamber in which it is to be fired and restricted on one or both ends in the conventional manner with a relatively slow burning inert resin, such as a polyurethane or a polyester resin. The restriction is preferably accomplished by applying a relatively thin coating of the inert resin to the inner surfaces of the rocket chamber lining prior to casting the propellant therein. Rocket chambers such as those in which our novel solid propellants are employed are ordinarily of the conventional type having one end open and leading into a venturi rocket nozzle. Upon ignition, large quantities of gases are produced and exhausted through the nozzle creating propulsive force.

The polyurethane binders of our invention are prepared by reacting a compound having two or more active hydrogen groups capable of polymerized with an isocyanate, with an organic compound having as the sole reacting groups, two or more isocyanate or isothiocyanate groups. The compound having the active hydrogen groups is preferably an organic compound having as its sole reacting groups, hydroxyl or thiol groups.

It will be apparent that, where there are more than two active hydrogen, isocyanate, or isothiocyanate groups present on any of the polyurethane reactions, the resulting molecular structure of the polyurethane binder will be at least to a certain extent of a cross-linked rather than a linear nature. The cross-linking is accomplished when all three functional groups of a sufficient number of the trifunctional molecules undergo the urethane reaction with other groups present in the mixture, thereby resulting in a product having a "three-dimensional" molecular structure rather than mere aggregates of linear chains as is the case when bifunctional reactants are employed.

Where bifunctional reactants, such as dihydroxy compounds and diisocyanates, are employed to produce the polyurethane binders for our novel propellants, it is necessary to also employ a "cross-linking" agent to assure a product having the cross-linked structure essential to this invention. Cross-linking agents can also be used with polyurethane reactants having more than two functional groups, such as triols and/or triisocyanates, within the scope of this invention. Compounds suitable as cross-linking agents for our polyurethane binders are those organic compounds having as the sole reacting groups three or more groups polymerizable with hydroxy or isocyanate groups.

It will be appreciated that in any given batch of propellant the individual polyurethane molecules may vary in number of repeating units from several to tens of thousands of these units, hence molecular weight figures on polyurethanes represent statistical averages. The exact nature of terminal groupings is not known and will vary depending upon whether catalysts, polymerization catalysts, etc., are present. Moreover, a given molecule may even form a ring and thus leave no dangling radicals.

It is evident from the above that a wide variety of polyurethane binders for the propellants of this invention can be prepared simply by varying the particular isocyanate and hydroxy starting materials.

The isocyanate starting materials for our polyurethane binders are diisocyanate compounds which can be saturated or unsaturated; aliphatic or aromatic; open or closed chain; and, if the latter, monocyclic or polycyclic; and substituted or not by groups substantially unreactive with isocyanate or hydroxyl groups, such as, for example, ketone, halogen, ester, sulfide or ether groups. The following diisocyanate compounds are particularly suitable as reactant for the preparation of binders for our novel polyurethane propellants.

(a) Alkane diisocyanates such as:

Ethylene diisocyanate;
Trimethylene diisocyanate;
Propylene-1,2-diisocyanate;
Tetramethylene diisocyanate;
Butylene-1,3-diisocyanate;
Decamethylene diisocyanate;
Octadecamethylene diisocyanate;
etc.

(b) Alkene diisocyanates such as:

1-propylene-1,2-diisocyanate;
2-propylene-1,2-diisocyanate;
1-butylene-1,4-diisocyanate;
3-butylene-1,2-diisocyanate;
1-butylene-1,3-diisocyanate;
1-butylene-2,3-diisocyanate;
etc.

(c) Alkylidene diisocyanates such as:

Ethylidene diisocyanate;
Propylidene-1,1-diisocyanate;
Propylidene-2,2-diisocyanate;
etc.

(d) Cycloalkylene diisocyanates such as:

Cyclopentylene-1,3-diisocyanate;
Cyclohexylene-1,2-diisocyanate;
Cyclohexylene-1,3-diisocyanate;
Cyclohexylene-1,4-diisocyanate;
etc.

(e) Cycloalkylidene diisocyanates such as:

Cyclopentylidene diisocyanate;
Cyclohexylidene diisocyanate;
etc.

(f) Aromatic diisocyanates such as:

m-Phenylene diisocyanate;
o-Phenylene diisocyanate;
p-Phenylene diisocyanate;
1-methyl-2,4-phenylene diisocyanate;
Naphthylene-1,4-diisocyanate;
Diphenylene-4,4'-diisocyanate;
2,4-tolylene diisocyanate;
2,6-tolylene diisocyanate;
4,4'-diphenylmethane diisocyanate;
1,5-naphthalene diisocyanate;
Methylene-bis-(4-phenylisocyanate);
2,2-propylene-bis-(4-phenylisocyanate);
Xylene-1,4-diisocyanate;

United States Patent Office 3,187,053 Patented June 1, 1965

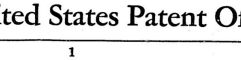
3,187,053
4-NITRO-4-PENTENAL

Karl Klager, Sacramento, Calif., assignor to Aerojet-General Corporation, Azusa, Calif., a corporation of Ohio

No Drawing. Filed Dec. 21, 1959, Ser. No. 861,138
1 Claim. (Cl. 260—601)

This application is a continuation-in-part of my copending application Serial No. 387,023, filed October 19, 1953 and now abandoned, which was a continuation-in-part of application Serial No. 235,569, filed July 6, 1951, and now abandoned.

This invention relates to a novel method of preparing nitroolefins having the general formula



wherein R is an alkyl, halogen, ω-carboxyalkyl, ω-acyloxyalkyl, ω-carboalkoxyalkyl, cyanoalkyl, or ω-formyl-alkyl radical, and to nitroolefins prepared thereby.

The nitroolefins prepared by the method of this invention in which R is an ω-acyloxyalkyl radical, such as nitroallyl acetate, readily condense with nitro compounds having a labile hydrogen function, such as methyl 4,4-dinitrobutyrate, to form highly nitrated compounds, such as dimethyl 4,4,6,8,8-pentanitro-1,11-undecanedioate, useful as high explosives. A more complete description of this process can be found in my copending application Serial No. 636,839, filed January 28, 1957 and now Patent No. 3,000,932. In addition, all of the nitroolefins prepared by the method of this invention undergo an addition reaction with polynitro compounds having a labile hydrogen function, such as 2,2,4,4-tetranitropentyl acetate, to form highly nitrated compounds useful as high explosives. 2,2,4,4-tetranitrobutyl acetate is disclosed in assignee's copending application Serial No. 617,667, filed October 22, 1956 and now Patent No. 2,978,455. The addition reaction is conducted according to the method set forth in copending application Serial No. 636,839.

The highly nitrated compounds obtained by the above-described methods are useful as high explosives and can be used in any conventional explosive missile, projectile, rocket, or the like, as the main explosive charge. An example of such a missile is disclosed in United States Patent 2,470,162, issued May 17, 1949. One way of using the high explosives of this invention is in the form as that disclosed in United States Patent 2,470,162 is to pack the crystalline explosive in powder form into the warhead of the missile. Alternatively, the crystals can be first pelletized and then packed. A charge thus prepared is sufficiently insensitive to withstand the shock entailed on the ejection of a shell from a gun barrel or from a rocket launching tube under the pressure developed from ignition of a propellant charge, and can be caused to explode on operation of an impactor time-fuse mechanism firing a detonating explosive such as lead azide or mercury fulminate.

The novel method of this invention comprises the simple pyrolysis of nitro-substituted endo anthracene compounds to decompose them into anthracene and the corresponding nitroolefins, in accordance with the general reaction scheme set forth below:

wherein R is as defined above.

The pyrolysis is preferably conducted under a vacuum so as to avoid the possibility of undesirable oxidation. The heat, as may be seen above, breaks the nitroolefin-

anthracene bonds to yield anthracene and the desired nitroolefins.

The following examples are provided to more clearly illustrate my invention. It should be understood, however, that these examples are provided purely for purposes of illustration and are not intended to limit the scope of the invention in any way.

EXAMPLE I

Preparation of methyl-4-nitro-4-pentenoate

One part of 11-(2-carbomethoxyethyl)-11-nitro-9,10-ethanoanthracene was heated in vacuum at 21 mm. to 185–200° C. A slightly yellow oily liquid was distilled and condensed in a receiver. The weight was 0.28 part of the starting material. At 230–240° C., at the same pressure, 0.62 gm. solid material distilled which was identified as anthracene (M.P. 215° C., mixed melting point 215° C.). The first fraction was redistilled at 96° C. and 4 mm. The analysis indicated that methyl-4-nitro-4-pentenoate was formed, n_D^{25}=1.4612.

EXAMPLE II

Preparation of nitroallyl acetate

A bulb tube charged with 1 gm. 11-acetoxymethyl-11-nitro-9,10-ethanoanthracene, prepared by acetylation of 11-methylol-11-nitro-9,10-ethanoanthracene with acetic anhydride, M.P. 103–105° C., was heated to 200–220° C. at 29 mm. in an airbath. Decomposition was observed and a greenish-yellow liquid distilled, accompanied by crystals. After redistillation at 90–120° C. airbath temperature and 5 mm. the light-yellow liquid (0.1 gm.) gave the following analysis for nitroallyl acetate:

Analysis.—Calc'd for $C_5H_7O_4N$: percent C, 41.38; percent H, 4.86; percent N, 9.65. Found: percent C, 41.53; percent H, 5.45; percent N, 8.83.

The anthracene fraction was purified by crystallization from tetrahydrofuran and methanol. The melting point and mixed melting point with pure anthracene were 214–216° C.

EXAMPLE III

Preparation of 4-nitro-4-pentenonitrile

A bulb tube was filled with 0.8 gm. 11-(2-cyanoethyl)-11-nitro-9,10-ethanoanthracene and heated to 195–200° C. at 28 mm. A yellow liquid and crystals distilled. The distillate was dissolved in ether and filtered from the insoluble anthracene. The extract was evaporated and distilled at 120° C. airbath temperature and 5 mm. producing a greenish-yellow liquid with a refractive index, n_D^{25} 1.4735.

Analysis.—Calc'd for $C_5H_6O_2N_2$: percent C, 47.61; percent H, 4.80; percent N, 22.22. Found: percent C, 47.97; percent H, 4.94; percent N, 22.60.

The ether insoluble portion was crude anthracene. It was dissolved in tetrahydrofuran and methanol was added. After two recrystallizations the melting point was 213–214° C. and the mixed melting point with anthracene (M.P. 214–216° C.) was 214–216° C.

It will be apparent that any nitroolefin within the scope of the general formula given above can be prepared by heating the corresponding nitro-substituted 9,10-ethanoanthracene in the manner described in the above examples. For example, 2-nitro-1-butene; 2-nitro-1-hexene; 2-nitropropylene; 1-chloro-1-nitroethylene; 1-bromo-i-nitroethylene; 1-fluoro-1-nitroethylene; ethyl-4-nitro-4-pentenoate; methyl-2-methyl-3-nitro-3-butenoate; 4-nitro-pentenoic acid; and 4-nitro-4-pentenal can be prepared by heating 11-ethyl-11-nitro-9,10-ethanoanthracene; 11-butyl-11-nitro-9,10 - ethanoanthracene; 11-methyl-11-nitro-9,10-ethanoanthracene; 11-chloro-11-nitro-9,10 - ethanoanthracene; 11-bromo-11-nitro-9,10-ethanoanthracene; 11-fluoro-

974805

PATENT OFFICE

NO DRAWINGS

974805

Inventor: KARL KLAGER

Date of Application and filing Complete Specification: April 5, 1961.

No. 12241/61.

Complete Specification Published: Nov. 11, 1964.

Index at acceptance:—C2 C(1F3C3, 1F3D1, 2B29)

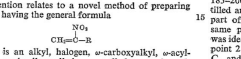
International Classification:—C 07 c

COMPLETE SPECIFICATION

Polynitro-Substituted Dibasic Acids and Esters

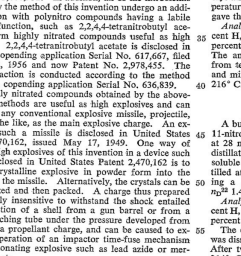
We, AEROJET-GENERAL CORPORATION, a corporation duly organized and existing under the laws of the State of Ohio, United States of America, of 6352 North Irwindale Avenue, Azusa, State of California, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to new compounds, and in particular, to polynitro-substituted dibasic acids and esters thereof having the general formula:



wherein R is an alkyl group or hydrogen atom, A is a lower alkylene radical and X is hydrogen atom or nitro radical. The term "lower alkylene radical" we mean an alkylene radical having from 1 to 4 carbon atoms.

The new compounds of this invention are prepared by condensing esters of nitroallyl alcohol with ω,ω-dinitroalkanoic acids or esters thereof, and in accordance with the general reaction scheme set forth below:



wherein R is hydrogen or alkyl, Y is an organic radical, preferably alkyl, M is an ion of an alkali or alkaline earth metal, A is a lower alkylene radical and R^1 is an alkyl radical.

In place of the ester of nitroallyl alcohol, a diester of 2 - nitro - 1,3 - propanediol can be used, as for example, 2 - nitro - 1,3 - diacetoxypropane. It is believed that the diester generates the nitroallyl alcohol ester *in situ* and then reacts in the manner illustrated above.

Since the acid portion of the nitroallyl ester does not enter into or affect the reaction, Y can be any organic radical including phenyl, benzyl, heterocyclic, aliphatic, cycloaliphatic, or the like, without departing from the scope of the invention. Similarly, when a diester of 2 - nitro - 1,3 - propanediol is used as the starting material, the acid portion can be any organic acid inasmuch as this portion of the diester does not enter into or affect the reaction in any way.

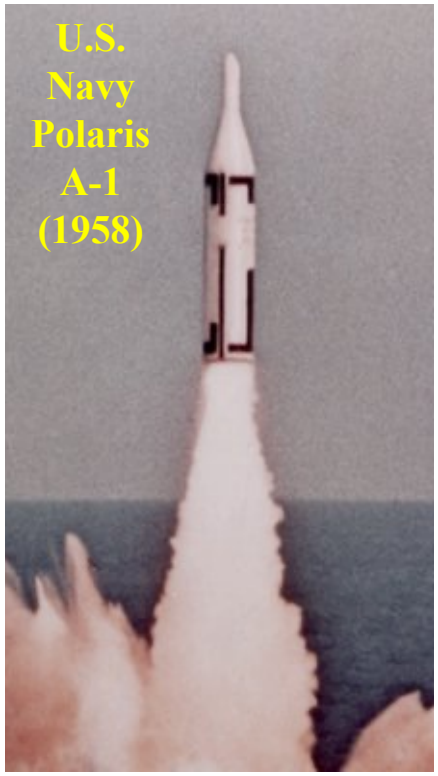
R, the alcohol portion of the dinitroalkanoic acid ester is an alkyl radical. Likewise, the dibasic acids of this invention will react with any organic alcohol to form esters in the usual manner.

The corresponding dibasic acid is prepared by hydrolysis of the alkyl ester with a strong acid which is sulphuric acid, hydrochloric acid, hydrobromic acid, phosphoric acid, trifluoroacetic acid or mixtures thereof in the conventional manner. The reaction of compound (I) with nitric acid produces the hexanitro deriva-

[*Price 4s. 6d.*]

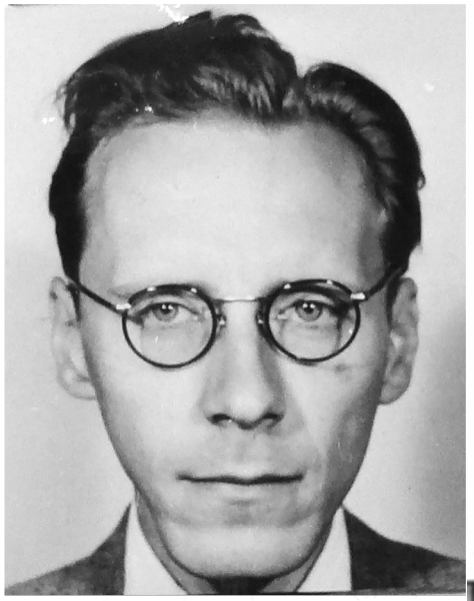
Postwar U.S. Submarine-Launched Missiles

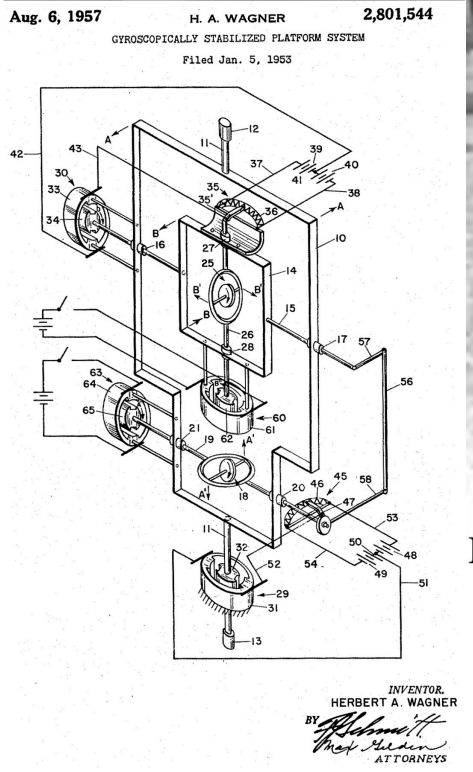
Many other Germans & Austrians



U.S. Navy Polaris A-1 (1958)

Wolfgang Noeggerath (1908–1973)





Aug. 6, 1957 H. A. WAGNER 2,801,544

GYROSCOPICALLY STABILIZED PLATFORM SYSTEM

Filed Jan. 5, 1953

INVENTOR. HERBERT A. WAGNER

BY ATTORNEYS

Naval Air Missile Test Center, Point Mugu, California (ca. 1950)

Wilfried Hell (1914–2010) Herbert Wagner (1900–1982) Werner Hohenner (1907–2000) Edgar Kutzscher (1906–19??)

Reinhard Lahde (1908–1999) Ernst Friedrich (19??–19??) Hans Hollmann (1899–1960) Theodore Sturm (19??–19??)

Not shown: Alexis Dember (1912–2002), Willy Fiedler (1908–1998), Johann Ludloff (19??–19??), Robert Lusser (1899–1969), Otto Schwede (1912–2005), etc.

Postwar Soviet SLBMs Using German Technology

German Wasserfall (1944)

0.86 m diameter

7.77 m length (W-5)

Hydrocarbon (visol) fuel

Nitric acid oxidizer

Soviet R-11FM (1955)

0.88 m diameter

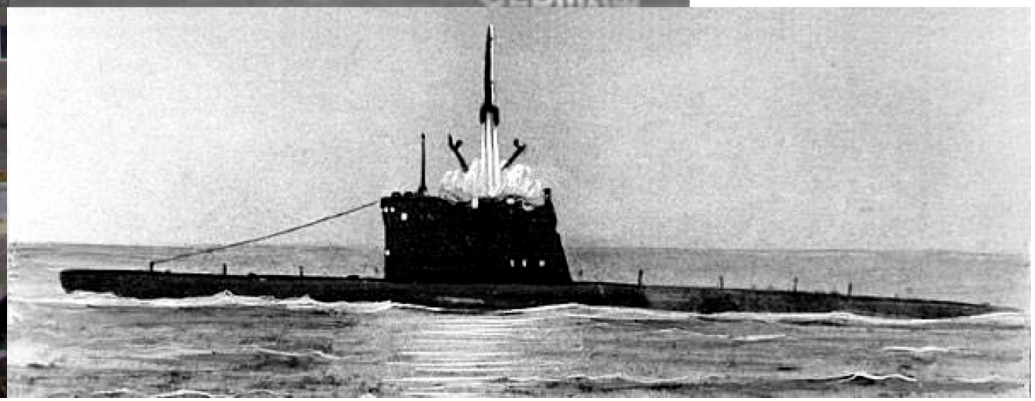
7.40 m length

Hydrocarbon (kerosene) fuel

Nitric acid oxidizer

The Soviet R-11FM Zemlya (SS-1B SCUD-A) SLBM was first launched from a submarine on 16 September 1955

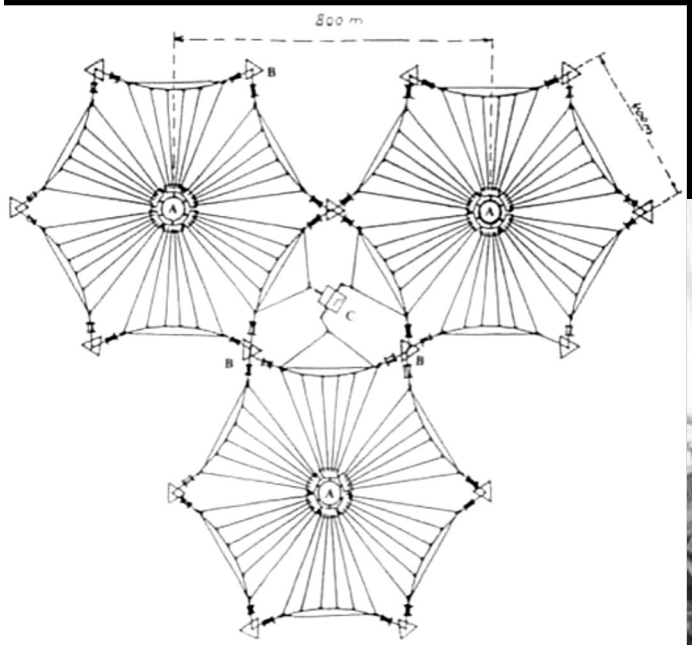
The first Soviet SLBMs were directly based on the German Wasserfall missile and were launched from a Zulu class sub, which was directly based on the German Type XXI submarine

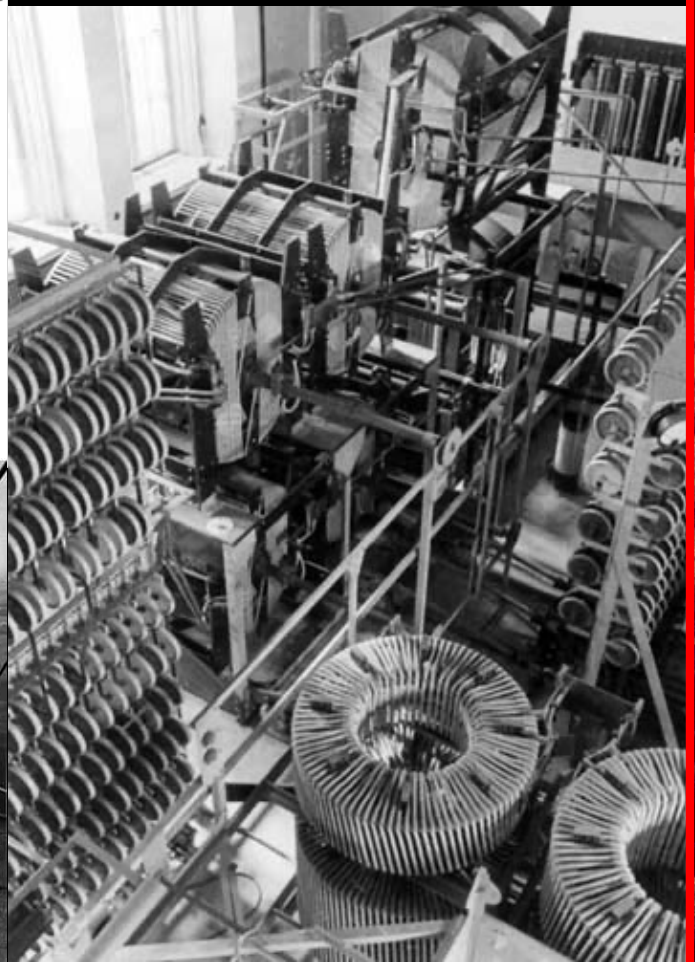


For more information, see *Forgotten Creators* 9.8 and E.4

Communications with Submarines

Goliath low-frequency radio transmitter to communicate with submarines (Kalbe an der Milde, operational in 1943)





U.S. low-frequency radio transmitter to communicate with submarines (U.S. Navy Clam Lake facility, Wisconsin, operational in 1985)

Outline

Nuclear payloads

1. Land-launched intercontinental missiles

    A. Liquid propellant missiles

    B. Liquid propellant space planes

    C. Solid propellant missiles

2. Submarine-launched missiles

    A. Sub-launched cruise missiles

    B. Sub-launched ballistic missiles

3. Intercontinental jet bombers

Examples of Wartime Aircraft and Their Ranges and Payload

(Max range will depend on payload)

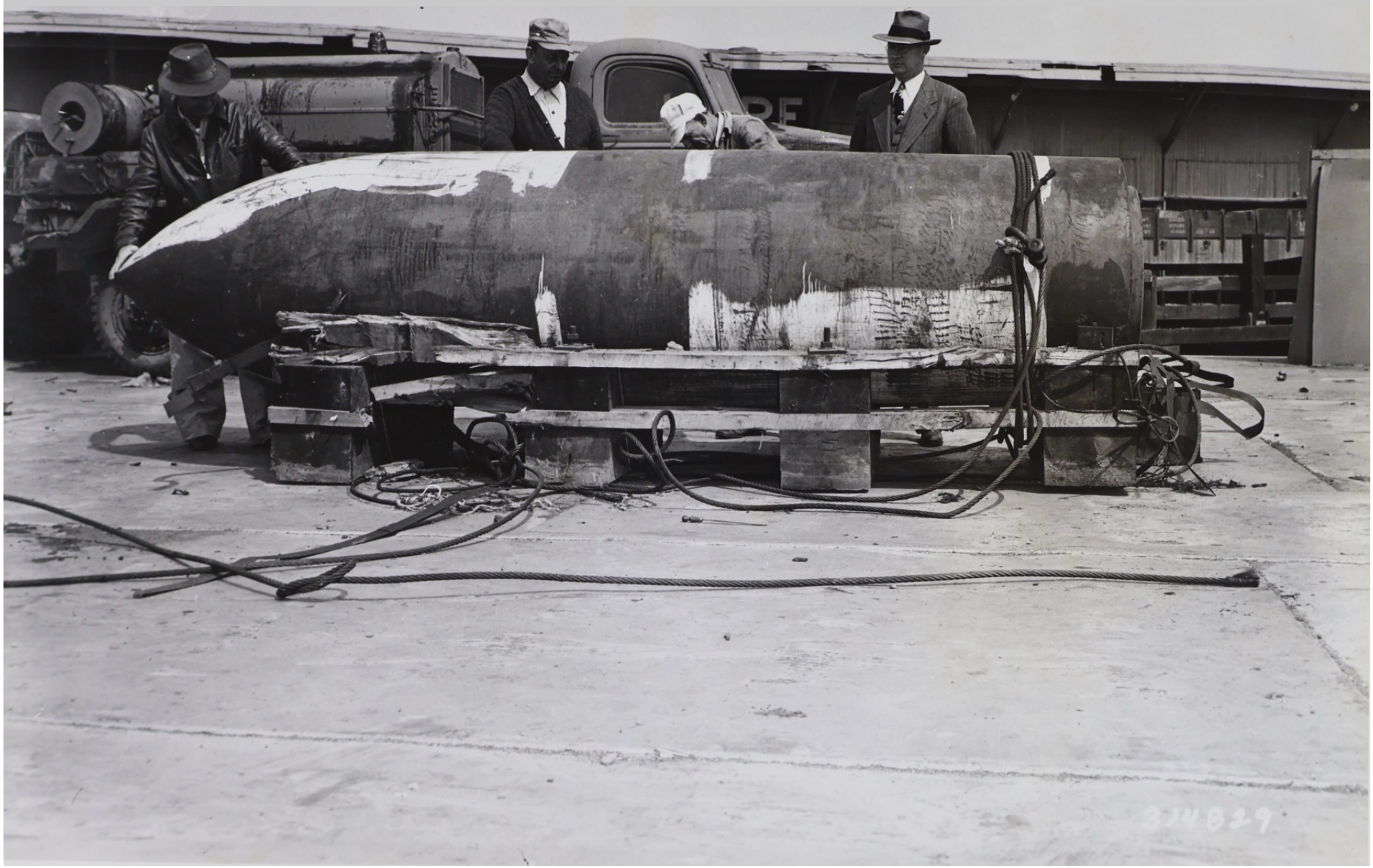
Aircraft	Max range	Max payload
Bf 109	1000 km	0.3 ton
Ar 234	1560 km	0.5 ton
Me 262	1050 km	0.5 ton
Ho 229	1900 km	1 ton
Ju 287	1570 km	1 ton
Me 410	1500 km	1 ton
Ju 88	1800 km	3 tons
Ju 290	6150 km	3 tons
Ar 232	1060 km	4.5 tons
He 177	6000 km	10 tons
Ju 390	8000 km	10 tons
Me 323	800 km	10 tons

Could carry small (0.3 ton) nuclear weapon

Could carry medium (2 tons) nuclear weapon

Could carry large (6 tons) nuclear weapon

Caption on photo: "Ordnance experts examine a 35,000 pound German giant aerial bomb upon its arrival at the New Orleans Port of Embarkation, La., from Germany. 11 March 1948." What wartime German aircraft were intended to carry a 35,000 lb [16 ton] bomb? What did the bomb contain?



NARA Still Pictures, RG 111 SCA—Records of the Chief Signal Officer. Prints: U.S. Army Signal Corps Photographs of Military Activity During WW II and the Korean Conflict, 1941-1954. Captured German Equipment, German, Box 3353, Book 15, SC 314829.

Flying Wing Jet Fighters Were Built

Horten Ho 229 (first flight 1944)

Larger versions were designed as intercontinental jet bombers; see e.g.:

Griehl, Manfred. 2005. *Jet Planes of the Third Reich: The Secret Projects* Vol. 2.

Herwig, Dieter, and Heinz Rode. 2000. *Luftwaffe Secret Projects: Strategic Bombers 1935-1945.* 2nd ed.

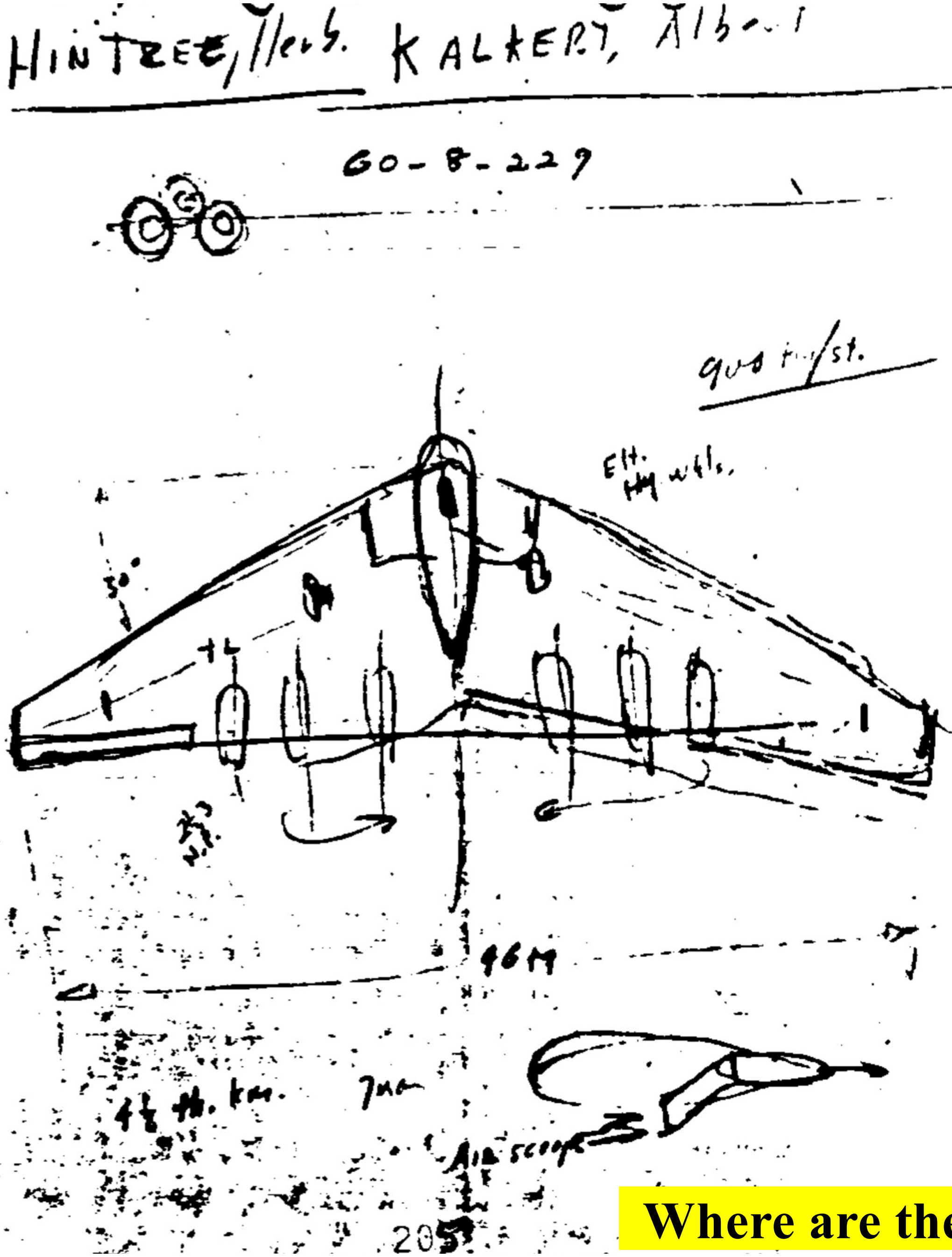
Masters, David. 1982. *German Jet Genesis*, esp. pp. 79-80.

Miranda, Justo. 2015. *The Ultimate Flying Wings of the Luftwaffe.*

Myhra, David. 1998a. *Secret Aircraft Designs of the Third Reich*, esp. pp. 156-160.

Myhra, David. 1998b. *The Horten Brothers and their All-Wing Aircraft.*

After the war, a group of German aerospace engineers offered to immediately begin building the U.S. a 7,000-km-range (14,000-km round trip), 6-jet-engine flying wing bomber. Was their offer based on an aircraft they had already built during the war?



Bericht.

Die Ermittlungen über das Projekt "Horten-Parabel sind abgeschlossen.
Die Ergebnisse können folgendermassen zusammengefasst werden.

1 .

Die Russen sind im Besitz der einschlägigen Pläne und werden von Deutschen Fachleuten unterstützt.
Der Serienbau der sogenannten Horten 13 (Modell mit 2 TL-Triebwerken) soll beim Russen nicht über das Anfangsstadium hinaus gediehen sein. Die Zahl 300 die für den Ausstoss genannt wurde, ist wesentlich zu hoch gegriffen. Die Flugzeit der Horten 13 wird von Fachleuten mit 1 Stunde angegeben. Dieses Modell ist nur zur Verteidigung geeignet.
Die grosse Horten 48 mtr. Spannweite, 6 TL-Triebwerke. 7000 km Aktions-Radius ist beim Russen nicht über das Projekt hinausgediehen, da sich nur ein geringer Teil der einschlägigen Mitarbeiter beim Russen befindet.

2

Zur Entwicklung dieser Angelegenheit wird folgender Vorschlag gemacht:
Wir sind jetzt in der Lage, innerhalb von 4 Wochen den einschlägigen Mitarbeiterstab aufzustellen, der sich mit dem obigen Projekt befasst hat. Der Chef-Konstrukteur hat bereits günstige Angebote aus der Türkei und der Sowjet-Union erhalten, erklärte sich jedoch nach Rücksprache grundsätzlich bereit für die US-Army zu arbeiten. Alle anderen in Frage kommenden Mitarbeiter (etwa 30) sind grundsätzlich zur Zusammenarbeit bereit, bitten jedoch um die Bekanntgabe der finanziellen-u. Existenz-Bedingungen, da die meisten sich nach dem Zusammenbruch eine eigene Existenz gegründet haben und naturgemäss nicht gern bereit sind, Bindungen mit Unsicherheitsfaktoren einzugehen.
Ferner ist zu klären, ob die Versuchsgruppe in Deutschland oder den Verein. Staaten arbeiten soll.
Wenn die US vorgesehen sind, so erscheint Sicherung gegen unvorhergesehene Entlassung angezeigt. (Chef-Konstrukteur macht das zur Bedingung, da bereits mehrere Jahre in US-Flugzeug-Industrie gearbeitet, um sich gegen Eventualit. zu sichern)
Nach seinen Angaben kann nach Aufgabenstellung der konstruktive Teil in allerkürzester Zeit abgeschlossen werden.
Wenn das Projekt anlaufen soll, bitten wir um Zuweisung eines PKW u. Betriebsstoff, um die Aufstellungs-Organisation durchführen zu können.
Weiterhin wird um die Unterstützung der US-Militär-Regierung gebeten, wenn verschiedne Mitarbeiter aus der R. Zone geholt werden müssen.

Zu Beginn der Arbeit bitten wir um genaue Aufgabenstellung seitens der US-Army, z.B.
wird Holzbauweise verlangt, wieviel Triebwerke, Aktionsradius. Zuladung, Besatzungs-Stärke, Waffen-Anordnung etc.

FOIA: Operation Harass and the Horton Brothers. Control Number: FP-10-027542. Activity Number: FA-10-4911. Initial Reception Date: 7/13/2010. Requested by: Jacobsen, Annie. documents.theblackvault.com /documents/foia/4402F-12Greenewald_Redacted.pdf

Where are the reports?

Dated; October 12, 1944.

Intercontinental Bombers Were Built. Where Are the Detailed Reports?

AMEMBASSY

LUMMY.

Hart adds following details on V-3: Capture of Watten and flooding of Walcheren has played out V-2. Atom splitting explosive and frozen blitz considered diversions by industrialists acquainted with German industry. V-3 also known as cistern plane considered the real thing and estimated that a third of Luftwaffe productive capacity devoted to it. Probably two engined long range bomber but some four engined and considerable proportion jet-propelled. Experiments conducted on Leuneberger Heide near Hambrug and is now in mass production. About 2000 to be produced. Also reports that Germans are distributing gasmasks with new energy and putting new filters on old ones.

N.P.

1431-1432

11. Experimental Aircraft

PW heard in 1942 when he was working as a camera man at the aircraft testing field REGHLIN (Mecklenburg) that a new type plane was being designed which could retract its wings during flight and thereby increase its speed considerably.

PW saw the plane in flight in Feb 44 and describes it as a two (4) motor transport plane, similar to the US C47. PW heard from mechanics that the plane was designed to fly bombing missions to the US, it can carry a load of 3,000 to 4,000 kg. The speed is supposed to be 700 to 800 km per hr. The two propellers are connected to two in-line 16 cylinder engines each.

According to PW the experimental flights were very successful but the plane is not being mass-produced as yet.

(Source: S/Gefr Gerd JANNOWSKI, Pz Lehr Div, captured 14 Jan VILLY)

~~S E C R E~~ T

- 16 -

Intercontinental Jet Bombers Were Built—Where Are the Reports?

German 'Flying Wing' Factory Found by Yanks. 718 M.P.H. Claimed; Plane Tailless. ***Chicago Daily Tribune*****, 13 April 1945, p. 9.**

GOETTINGEN, Germany, April 9 [Delayed]--- A factory in which the Germans had been experimenting with a "flying wing," a super-powerful plane without fuselage or tail, has been overrun by American infantry. Both bomber and fighter types had been produced, with one to six engines. Later models were jet propelled.

Eight German technicians who had been left behind said they had flown the flying wings and found them much more maneuverable and of greater stability than conventional type planes.

One model was said to have a speed of 625 miles an hour at an altitude of 3,280 feet and 718 miles an hour at 4,600 feet. The plane's ceiling is about 52,500 feet, with a climbing rate of 65.6 feet a second. Its flying radius was reported at 937 miles.

This plane was designed to carry two bombs under the wings.

New York Bomber Built in Germany. De Seversky Says Principal Bar to Use Was Its High Rate of Fuel Consumption. ***New York Times*****, 8 June 1945.**

The Germans planned to bomb New York and other eastern American ports and, according to Hermann Goering, were within a few months of working out the kinks in a jet-propelled plane that would do it, Maj. Alexander P. de Seversky, airplane designer and airpower advocate, said today.

Major de Seversky, World War I commander of the Russian Navy's Baltic fighter plane force, has been touring Germany as a special air consultant to Secretary of War Henry L. Stimson. He interviewed Goering with Gen. Carl A. Spaatz right after Goering was captured at Augsburg. […]

The Germans' "New York" bomber, a prototype of which was found at an undisclosed place in France, was a Messerschmitt 264. It had four engines with jet propulsion for high altitudes, Major de Seversky said. The Germans started working on it before the war, designing it to cross the Atlantic and return nonstop with two or three tons of bombs. The only obstacle to its introduction was its big fuel consumption, but this, Goering asserted, the Germans had expected to solve in a few months.

40 Intercontinental Bombers in Norway—Where Are the Reports?

Preparing. Behind the Lines. *Flight.* 11 May 1944 p. 503.

Only time will show the real purpose of the new chain of airfields now being established by the *Luftwaffe* in Norway. But whether for defence or offence, reports indicate a feverish activity in the expansion of existing landing facilities and the construction of new ones.

Over 300 acres of forest have been cleared to make room for the big airfield which the Germans are building at Halsemoen, Flisa, about twenty miles from the Swedish border and about fifty miles from the big air base at Gardemoen which has recently been substantially enlarged.

The work on the Haslemoen airfield started in January and large areas have been evacuated, schools and churches requisitioned, and farms devastated. The whole district has been practically destroyed. One thousand Russian prisoners and 800 Norwegian slave labourers are engaged on the work.

Only twelve miles from this airfield another temporary one is being rapidly built, and the construction of a third situated close to the Swedish border, was started at the end of last month.

Both the Fornebu airfield, near Oslo, and the Bardufors, in the county of Troms, are being expanded. […]

In Denmark, too, the *Luftwaffe* is preparing; the Kastrup airfield is being transformed from a training to an operational base; many bombers are reported to have arrived and stocks of bombs are placed around the periphery.

On the Avedore airfield the B.M.W. have installed repair workshops for their engines, while the Heinkel concern has taken over the engine shops of the naval dockyards.

Planes to Bomb N. Y. Uncovered. *Stars and Stripes.* Paris ed., 30 June 1945, p. 8.

21st ARMY GROUP. June 29 (AP).– The Germans had "almost completed" preparations to bomb New York from a "colossal airfield" near Oslo when the war ended, RAF officers disclosed today.

"Forty giant bombers, with a 7000-mile range, were found on this base–the largest Luftwaffe field I have ever seen," a senior officer said. "They were the new type bombers developed by Heinkel. They are now being dismantled for study. German ground crews said the planes were held in readiness for missions to New York."

Hundreds of different type planes were taken intact on the field, cut through a pine forest about five miles from Oslo. Some of the latest model fighters, including the JU88 night fighters, equipped with intricate Radar devices to guide pilots to their target, were found.

RAF officers said they were indications that the Germans had planned a "last-ditch stand" in the area and were hoarding their newest bombers and fighters.

Chlorine Trifluoride (???) Stockpiled at Norway Airfields

SECRET

CHEMICAL WARFARE

15. New Secret Gas

Preamble. PW, an intelligent and sincere youth, was stationed in NORWAY as Ordnance Sgt with Luftgau V until Aug 44, when he was transferred to the paratroops. The transfer was principally in consequence of disparaging remarks PW had made about the Fuehrer in connection with the events of 20 July 44. Only the intervention of his OC, also an anti-Nazi, saved PW from court-martial and a possible concentration camp sentence. PW hates the Nazis bitterly and is eager to do whatever he can to help shorten the war. He believes that the use by the Germans of the weapon described below would "bring the eternal condemnation of humanity down upon us."

Because of large elements of the improbable and the fantastic in PW's story, and because of his abnormally pro-Allied attitude, every effort has been made to discredit him and prove him a plant. These efforts have not been successful. PW appears to be telling what he thinks is the truth.

Fliegerwaffentechnische Schule. At the end of Feb 44, PW and 6 other EM of Luftgau 5 were sent to I Fliegerwaffentechnische Schule, HALLE for a special course, whose nature they did not know until their arrival at the school. The school consisted of eight student coys, with 120-180 men each; one coy (8 Coy) of instructors; and three regular coys (composed of work details), with appr 60 men each.

Purpose of Course. At RECHLIN the trainees studied a new war gas, including its use as an airborne weapon in a spraying device attached to a/c.

The Gas. PW describes the new gas in its liquid state as being comparable in viscosity to egg white. The liquid has a specific gravity of appr 1.3. It has a grayish-brown color, opalescent when seen from an angle, gives off spectral reflections. It has the appearance of Diesel oil, according to PW, who cannot describe its odor because the students always wore complete protective equipment when handling it. It was even referred to as "Kleister" (glue). It has no code name or identifying number.

Students observed experiments conducted at RECHLIN. In one of these, a drop was placed on a rabbit's back, about a third of the distance from its head to its tail. In 2-3 minutes the animal was dead. Its hair bristled slightly. The skin (gray) became darker. The rabbit seemed to die in a convulsion. "Death without blood" it was called by the students.

Effect on Metals. Bronze, gold, silver, zinc, lead, copper, and tin plates, 8-10 mm thick, 8 cm long, and 6 cm wide, were sprayed. Thus sprayed, the metals gave off a white vapor. After a few minutes the plates were worked over with a glass hammer. Impressions were left wherever the hammer struck. The lead plate showed the greatest resistance. PW calls the result of the experiment "Zersetzung des Kerns" (decomposition of the substance).

The barrel of a 2 cm Flak was sprayed, resulting in 60% decomposition. The metal apparently lost its intra-molecular cohesion, and the weapon was rendered useless.

One drop of the substance was dropped on earth, whereupon the substance turned grayish-green and vaporized. After appr 7 minutes it turned grayish-white in color.

In the course of the experiments a drop of the substance fell on a trainee's arm at a point just above the wrist, necessitating the immediate amputation of the arm at a point just above the elbow.

SECRET

15. New Secret Gas (Continued)

Experiments had also been conducted at RECHLIN using this gas with jet-propelled planes and V-weapons, but PW did not witness these experiments.

Storage in NORWAY. On completion of his course, PW returned to his station in NORWAY. (He does not know if other classes followed at HALLE.) On direct orders of Luftflotte 5, PW was put in charge of examining guards and the material they were guarding at secret dumps (Geheimlager) at various Luftparke in NORWAY.

Before his departure end of Feb 44 for the school (previously recounted), large quantities of the gas had arrived at Luftgau 5 by plane. PW would spot-check the stores of the gas. A special certificate issued by Luftflotte 5 permitted him to enter the secret stores. PW claims that not even high-ranking Luftflotte officers were aware of the nature of the stores. PW checked for leakage and dry storage. In only one instance did he find some cases stored in a damp spot. On orders of Luftflotte 5, this was corrected immediately.

When PW left NORWAY in Aug 44, the following was stored at the Luftparke indicated:

OSLO

900-1000 cases, each containing one 50-liter demijohn
300-400, each containing one S 125 spraying unit
15-20 cases of protective clothing

BERGEN, STAVANGER, and TRONDHEIM

At each Luftpark:

150 cases, each containing one 50-liter demijohn
40 cases, each with one S 125 spraying unit
Several cases of protective clothing
There were also "Ueberdruckgranaten" for Do-Gerat stored at STAVANGER-FORUS.

KEVIK, nr KRISTIANSSAND

240 cases, each containing one 50-liter demijohn
150-180 cases, each with one S 125 spraying unit
Several cases of protective clothing
There were a few S 200s mixed in with the S 125's listed abo

The secret stores are very heavily guarded by special 24-man guard details. A relief consists of 6 men, equipped with MGs, automatic rifles, and hand grenades. Minefields have been laid in front of the storage buildings, and the installations are heavily protected by Flak (8.8 cm and 10.5 cm).

According to PW, the Germans consider NORWAY a safe storage place for the gas, since that country has not been subjected to invasion or air attacks.

PW knows of no storage places for this gas outside of NORWAY. However, hi classmates returned to their proper stations (unidentified Fliegerhorste). PW was relieved in OSLO by O/Feuerwerker PETHAN (Luftflotte V, OSLO).

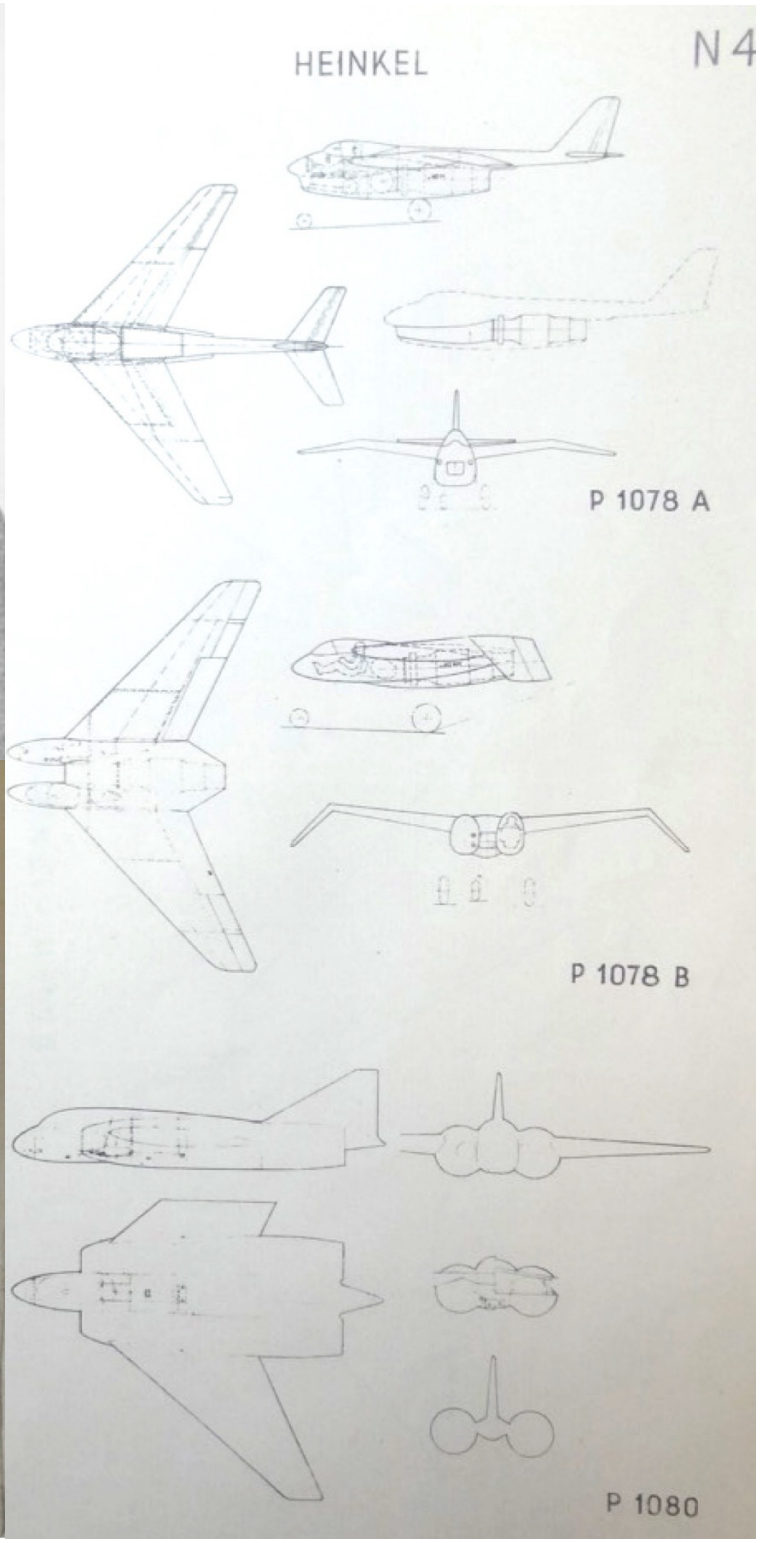
Similar Use of Other Gases. According to PW, experiments have also been co ducted at RECHLIN with spraying units which are made of metal and filled with different substances: Gelbkreuz (yellow-cross gas), Blaukreuz (blue-cross gas), and a phosphorous solution. When the phosphorous solution is released, it begi to glow appr 400 m above the ground. On reaching the ground it attains maximum burning effect.

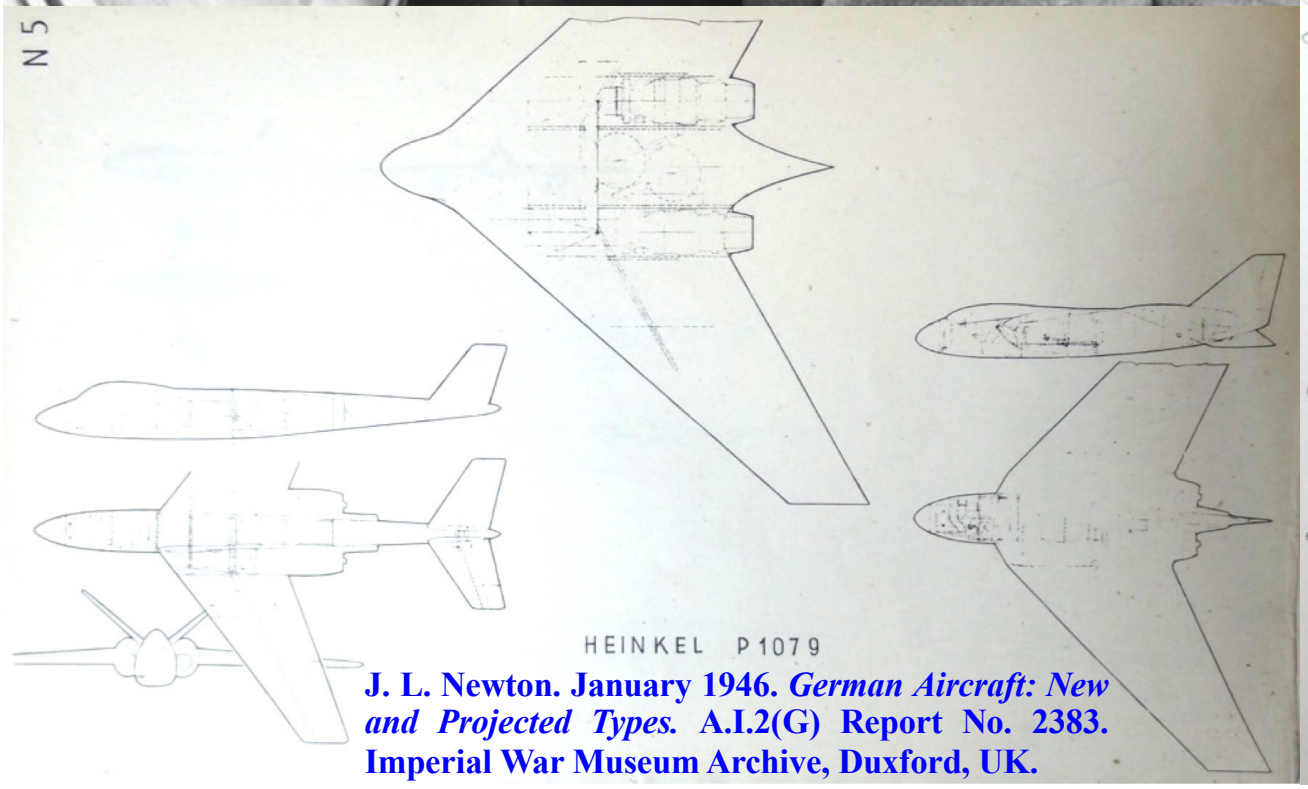
(Source: O/Jg Wilhelm KUNZ, 4 Coy 15 Para Regt.)

SECRET

-y 8-

Siegfried Günter and Ernst Heinkel (1941)





J. L. Newton. January 1946. *German Aircraft: New and Projected Types.* A.I.2(G) Report No. 2383. Imperial War Museum Archive, Duxford, UK.

Ernst Heinkel and Siegfried Günter—Where Are the Reports?

Ernst Heinkel. 1956. *Stormy Life: Memoirs of a Pioneer of the Air Age.* New York: E. P. Dutton. pp. 236-241, 246-247.

After returning home on August 5, 1945, I wanted to see the situation in Jenbach with my own eyes. [...]

Stopping at Landsberg, I searched for Siegfried Günter, who had escaped there in the middle of April, 1945, and had managed to carry on a primitive office with thirty-five other employees from my design office. I found him---the most important expert on airplane structures and aerodynamics that Europe had at that time---living with his wife in a small room. He was working with ten of my people in a technical office that an American, Major Cardenas, had established on the airfield. They had tried in vain to call the attention of the American military authorities to the importance of Günter.

Günter was too modest and shy to blow his own horn. Now he was happy that Cardenas had enabled him to carry on his scientific work. This work embraced everything we had planned for the future in the way of fresh developments in jet propulsion. He was particularly engrossed with new "flying wing" types. I hoped on this visit that Günter would find a permanent outlet for his activities, either in Landsberg or in America.

I knew him. His only happiness was in scientific work and I told this to Cardenas. A few weeks later, however, at the end of September, Cardenas closed his office and flew to England. He informed Günter that a larger office was planned in Wiesbaden and that he would send for him, but he never did.

Günter remained in Landsberg until the spring of 1946, when his money ran out. During the last weeks he constantly repeated that he had no skill for anything else---he had to build airplanes. If the West didn't want him, he might have to work for the East. At that moment, I was empty-handed and could do nothing for the man who for so many years had been my closest collaborator and whose unique abilities no one could appreciate better than myself.

In the spring of 1946 he used the last of his money to go to Berlin to see his father-in-law, who kept a garage. He still hoped the Americans would send for him, and left his address in case some message should arrive, but no message came.

Instead, the Soviet special experimental unit OKB IV, in Berlin, took him on. Günter continued to work on our latest designs and was then taken to Russia, where, I am convinced, he worked on constructions that today have become a problem for the Western world.

Dieter Herwig and Heinz Rode. 2000. *Luftwaffe Secret Projects: Strategic Bombers 1935-1945.* 2nd ed. Hinckley, UK: Midland. p. 68. Heinkel Projects for a Four-Jet Long-Range Bomber

According to a report which Dipl-Ing Siegfried Günter—who had been head of Heinkel's Project and Design Department in Vienna—was required to write for the US Technical Service on 1st October 1945, Heinkel engineers had been engaged on designs for four-jet long-range bombers right up until May 1945. These designs included not only aircraft of standard 'fuselage and tail' configuration, but also of flying-wing layout.

Work was concentrated particularly on one flying-wing bomber which was powered by four HeS 109-011 jet engines, each developing 1,300 kg (2,865 lb) static thrust, and which weighed 26 tons.

Another flying-wing bomber was to have been fitted with either four BMW 109-018s, each of 3,000 kg (6,612 lb) static thrust, or six Junkers Jumo 004 jet engines, each of 1,300 kg (2,865 lb) static thrust. This machine which possessed a very high wing loading, would have weighed 60 tons. [...]

Again according to Günter's report, the 60-ton flying-wing project was to have combined a 3,000 kg (6,612 lb) bomb load with a range of 28,000 km (17,388 miles).

Maximum range $R = v\, I_{sp}\, (C_L/C_D)\, \ln(M_{initial}/M_{final})$ for bombers with piston propeller, turbojet, turbofan, or turboprop engines and a mass ratio $M_{final}/M_{initial} = 0.6$ (best that is likely)

Characteristic	Piston prop	Turbojet	Turbofan	Turboprop
Cruising velocity v	100 m/sec	240 m/sec	240 m/sec	150 m/sec
Specific impulse I_{sp}	6500 sec	3600 sec	6000 sec	12,000 sec
Lift/drag ratio C_L/C_D	20	20	20	20
Mass ratio $M_{\text{final}}/M_{\text{initial}}$	0.6	0.6	0.6	0.6
Maximum range R	6600 km	8800 km	15,000 km	18,000 km

or $M_{final}/M_{initial} = 0.5$ (extremely optimistic)

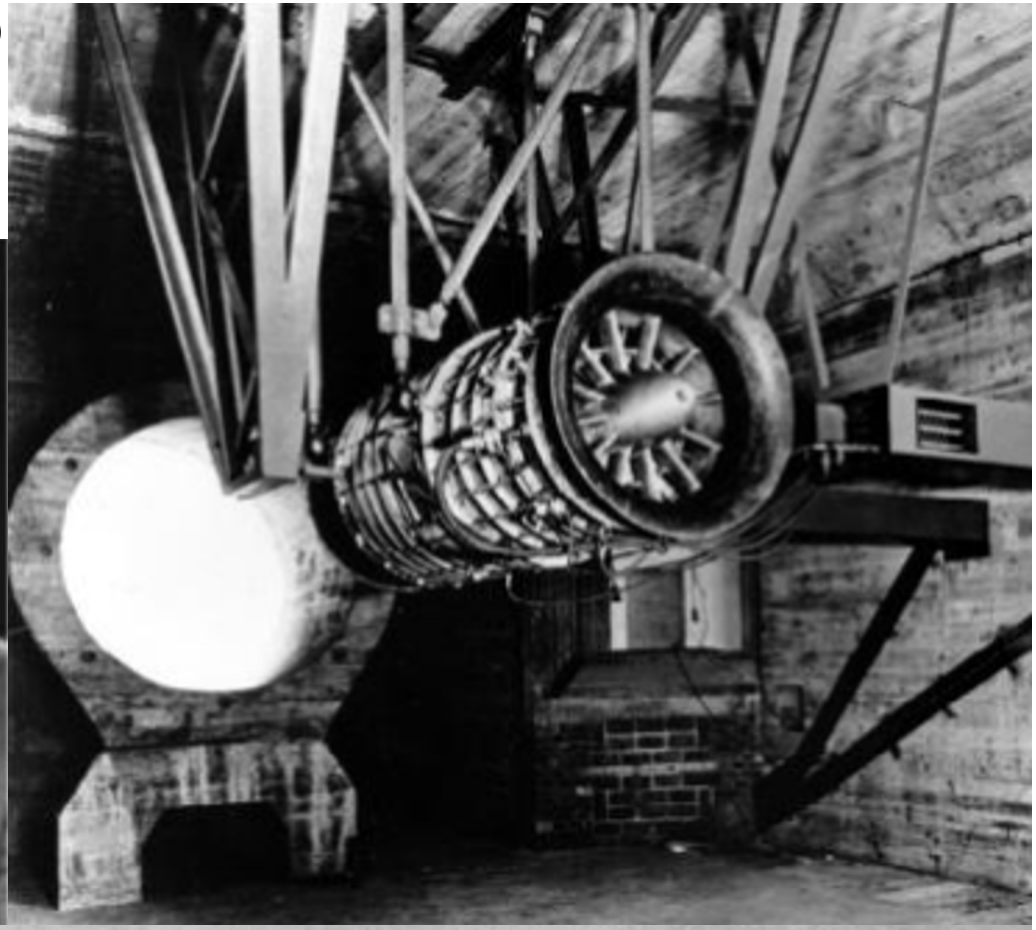
Characteristic	Piston prop	Turbojet	Turbofan	Turboprop
Cruising velocity v	100 m/sec	240 m/sec	240 m/sec	150 m/sec
Specific impulse I_{sp}	6500 sec	3600 sec	6000 sec	12,000 sec
Lift/drag ratio C_L/C_D	20	20	20	20
Mass ratio $M_{\text{final}}/M_{\text{initial}}$	0.5	0.5	0.5	0.5
Maximum range R	9000 km	12,000 km	20,000 km	25,000 km

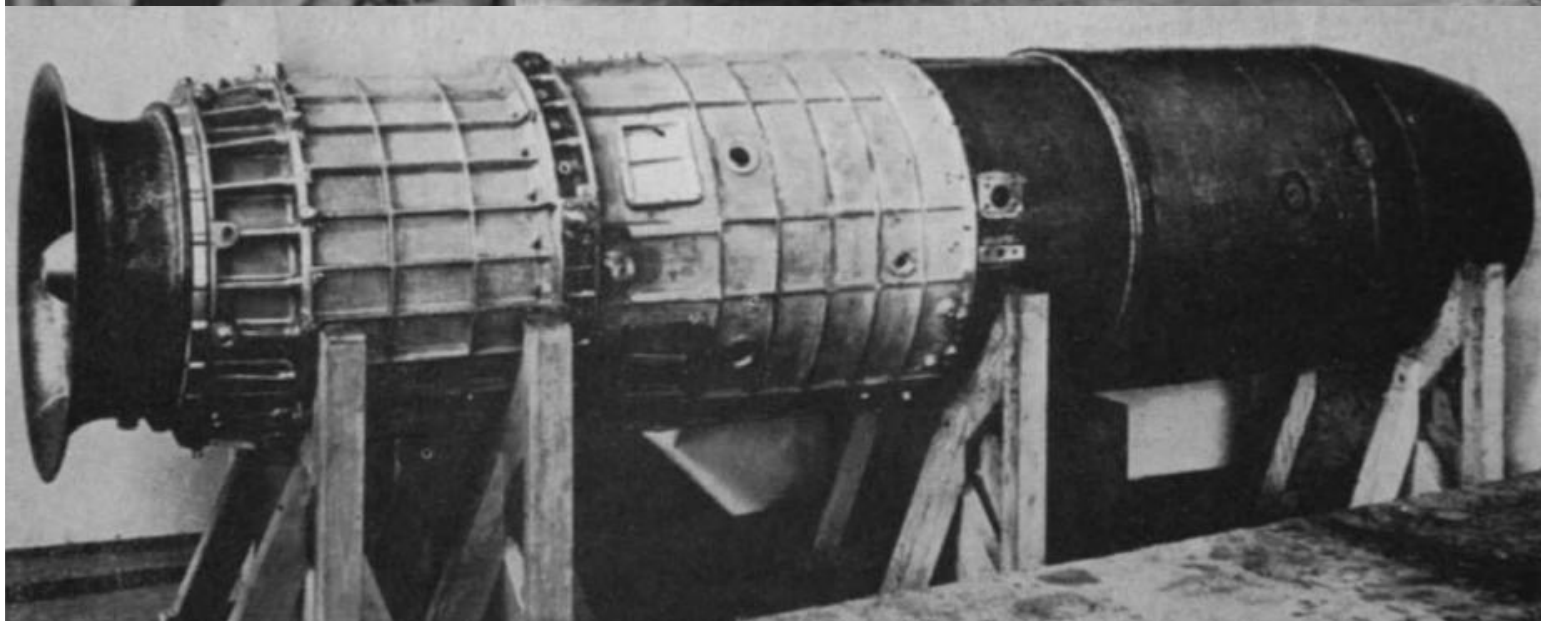
For U.S. B-29: R = (100 m/s) (6500 s) (16.8) ln(1/0.62) = 5200 km (correct)

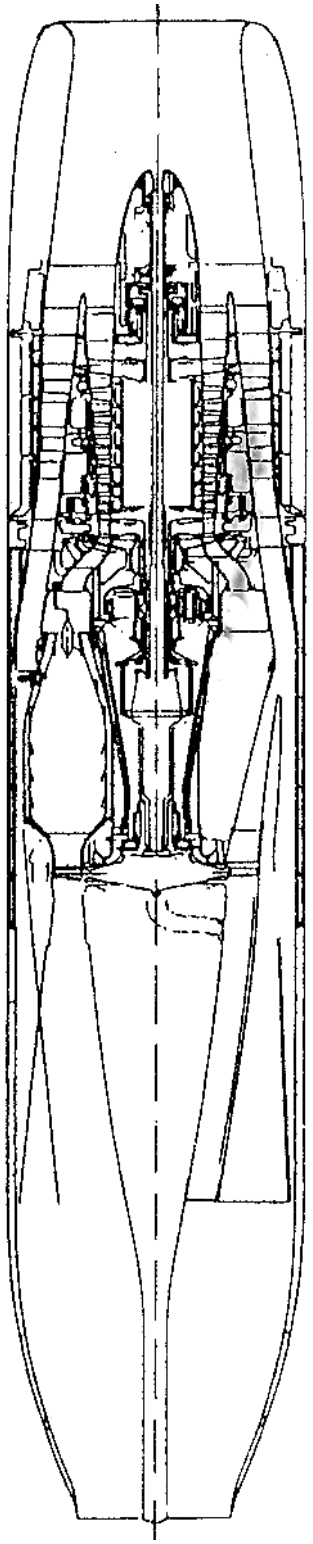
Round trip: Oslo–NY 12,000 km, Oslo–DC 12,500 km, Oslo–Chicago 13,000 km

See Forgotten Creators E.6 for more details

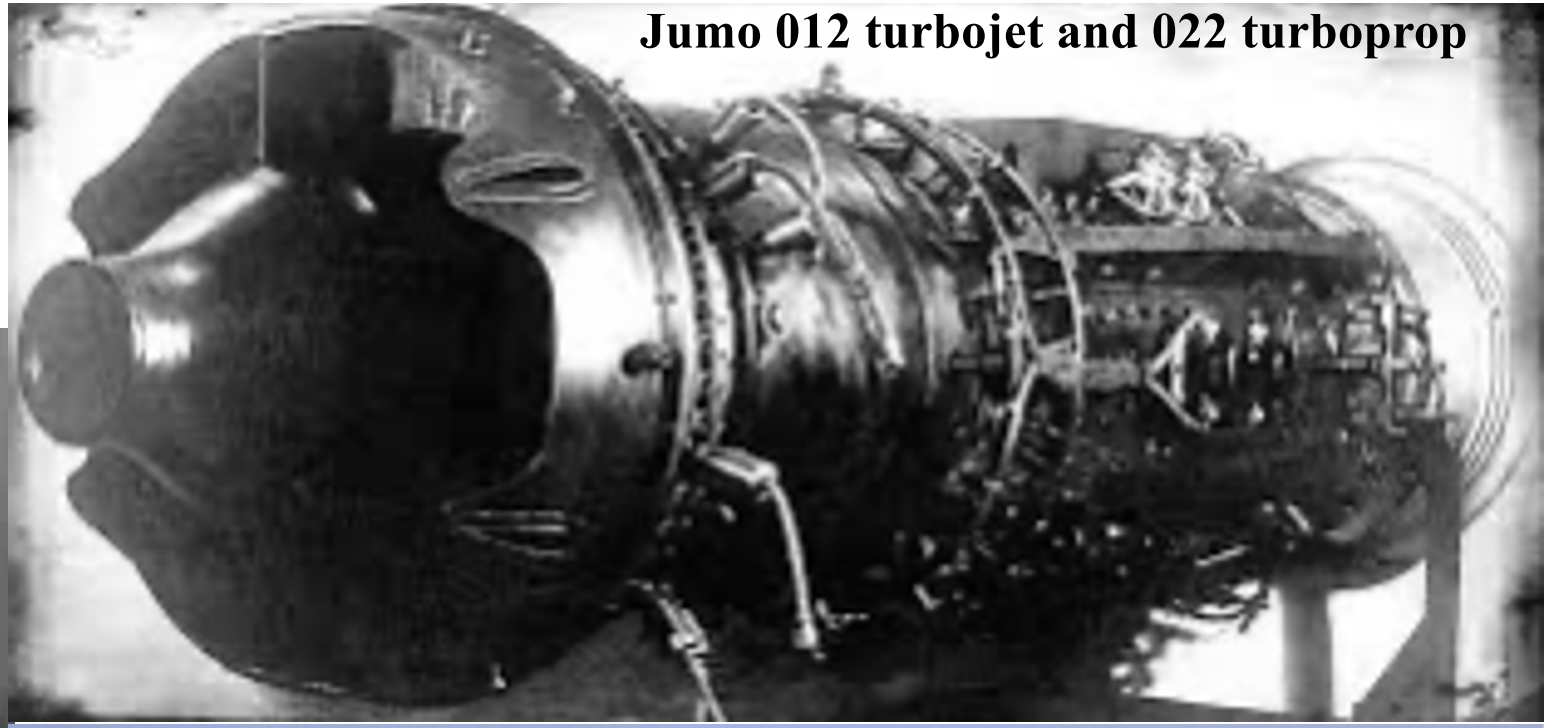
Karl Leist (1901–1960)
First turbofan engine
Daimler-Benz DB 007
(demonstrated 1943)







Ferdinand Brandner (1903–1986) Turboprop engine Junkers Jumo 022



Jumo 012 turbojet and 022 turboprop

Jumo 022, a.k.a. NK-12, turboprop engine is still in service on the Russian Tupolev Tu-95

Other wartime turboprop engines:

- **Jendrassik Cs-1**
- **BMW 028**
- **Heinkel He S 021**

Intercontinental Jet Bombers and Rockets Were Built

ELIMINATION OF GERMAN RESOURCES FOR WAR

HEARINGS

BEFORE A

SUBCOMMITTEE OF THE

COMMITTEE ON MILITARY AFFAIRS

UNITED STATES SENATE

SEVENTY-NINTH CONGRESS

FIRST SESSION

PURSUANT TO

S. Res. 107

(78th Congress)

AND

S. Res. 46

(79th Congress)

AUTHORIZING A STUDY OF WAR MOBILIZATION PROBLEMS

PART 3

TESTIMONY OF

FOREIGN ECONOMIC ADMINISTRATION

AND MATERIALS ON

GERMAN PENETRATION OF EUROPEAN INDUSTRY

JUNE 26, 1945

Where are the reports?

www.economicsvoodoo.com/wp-content/uploads/Elimination-of-German-Resources-for-War-Hearing-1945-Part-3-German-Infiltration-of-European-Industry-mas-0015.pdf

STATEMENT OF HENRY H. FOWLER, DIRECTOR, ENEMY BRANCH, FOREIGN ECONOMIC ADMINISTRATION

In assessing these bare bones of Germany's industrial war potential certain other less tangible, but none the less important, aspects of her economic base for aggression should be appraised. These include her amazing technical ability to produce new weapons as a result of technological invention, her vast pool of skilled workmen and highly trained scientists, the existence abroad of extensive economic assets and activities, and finally, a highly integrated organization and control of her economy. Each of these aspects of Germany's base for aggression deserves a brief reappraisal as of today.

Ability to produce new weapons and products.—According to recent reports from Germany, it appears that if the Germans could have held out only 6 months longer they would have been able to smash New York City with improved V–2 bombs.

Only a little longer period would have been needed to bring into production the jet-propelled planes that could have reached Washington.

It is not necessary here to elaborate upon the terrifying scientific discoveries which our economic and industrial intelligence is gradually uncovering as we work beneath the lid in Germany. With the memories of her new V-weapons fresh in our minds, little needs to be added except to point out that they just didn't appear out of thin air. They were the fruit of carefully organized and adequately financed research institutions in which large numbers of highly trained and specialized scientists went about their business of inventing and developing the weapons that would establish German world supremacy. The results they achieved and would still achieve if opportunities are provided, spring from the existence of a laboratory here and pilot plant there and a research institution in another place. These institutions and these scientists are still on hand ready to do business for a new Germany when the break comes. Nor will their ideas and inventions be fruitless because of a lack of German capacity to translate them into mass production.

Germany could rapidly set up plants for such new products because of its enormous capacity to produce machines and machine tools, and the huge supplies of machine tools that were built up in advance of need. The plants the victors so innocently permitted to operate after the last war to turn out agricultural, construction, and textile machinery for the devastated regions of Europe were expanded and re-equipped to supply German factories to meet the needs of the war of 1939—already being planned when the armistice of 1918 was signed.[7]

...by the Skin of our Teeth

SEVERAL TIMES during the European phase of this war, victory was almost within Germany's grasp . . . on land, on the sea, or in the air.

Above all, knowing the vital importance of air supremacy, the Nazis tried time and again to wrest it back from the Allies.

And they almost succeeded.

Time ran out

Especially in the last months of the war, our margin of safety was slimmer than most of us suspected.

Just how slim it was is known best to certain American military experts **who have since inspected some of Germany's underground research laboratories and** war **plants.**

Here they saw secret weapons in various stages of development . . . **weapons which might conceivably have turned the trick for the Nazis if they could have used** them **boldly in a last desperate gamble.**

Some of these things can now be revealed. **Others cannot—yet.**

In one plant, the U. S. Army officers found partially assembled jet fighter planes of radical new design. There were planes potentially better than anything the Allies had in combat at that time.

If time hadn't run out on the Germans, **quantities** of these **jet planes might have changed the balance of air power** in their **favor.**

In a V rocket plant, burrowed 800 feet deep in limestone rock, our technicians found blueprints for a fearful V bomb with an estimated range of 3000 miles.

"We planned to destroy New York and other American cities starting in November," said a German rocket engineer.

Target: U. S. A.

In a converted salt mine, our ordnance officers examined nearly completed jet-propelled heavy bombers . . . bombers **claimed by the Germans to be capable of crashing high** explosives **into the industrial cities of the eastern United States and** flying **back again across the Atlantic.**

Goering himself said the planes had been successfully test-flown and would have been in operation if Germany could have held out 3 months longer.

But those catastrophes, and others, never quite came to pass on the German timetable of war. **We managed,** right to

Intercontinental Jet Bombers and Rockets Were Built

Where are the reports?

Consolidated Vultee Aircraft Corporation (Convair). *Life*, 27 August 1945, 19:9:2-3.

For more information, see *Forgotten Creators* E.1

Intercontinental Jet Bombers and Rockets Were Built

George C. Marshall, 1 Sept. 1945

history.army.mil/html/books/070/70-57/CMH_Pub_70-57.pdf p. 132:

Victory in this global war depended on the successful execution of OVERLORD. That must not fail. Yet the Japanese could not be permitted meanwhile to entrench in their stolen empire, and China must not be allowed to fall victim to further Japanese assaults. Allied resources were searched through again and again, and strategy reconsidered in the light of the deficiencies. These conclusions seemed inescapable: France must be invaded in 1944, to shorten the war by facilitating the advance westward of the Soviet forces. At the same time German technological advances such as in the development of atomic explosives made it imperative that we attack before these terrible weapons could be turned against us. In addition, the pressure on the Japanese in the Pacific must not be relaxed. Communications with China must be reopened. Resources were allocated accordingly. The balance was extremely delicate but we had to go ahead.

Where are the reports?

Between Germany and America in 1914 and again in 1939 stood Great Britain and the USSR, France, Poland, and the other countries of Europe. Because the technique of destruction had not progressed to its present peak, these nations had to be eliminated and the Atlantic Ocean crossed by ships before our factories could be brought within the range of the enemy guns. At the close of the German war in Europe they were just on the outer fringes of the range of fire from an enemy in Europe. Goering stated after his capture that it was a certainty the eastern American cities would have been under rocket bombardment had Germany remained undefeated for two more years. The first attacks would have started much sooner. The technique of war has brought the United States, its homes and factories into the front line of world conflict. They escaped destructive bombardment in the second World War. They would not in a third.

It no longer appears practical to continue what we once conceived as hemispheric defense as a satisfactory basis for our security. We are now concerned with the peace of the entire world. And the peace can only be maintained by the strong.

Intercontinental Jet Bombers and Rockets Were Built

Aleksei Sidnev to Ivan Serov. NKVD interrogation of Werner Wächter. September 1945. [FSB Archive, Moscow]

In the same year of 1944, projects were developed for very long-range bombers capable of bombing military manufacturing centers of the Soviet Union in the Urals and industrial facilities in North America. These bombers were supposed to be used to transport atomic bombs. […]

Heylandt informed WÄCHTER that work was being done as a result of which the V-2 missile would be able to rise to 120 km in altitude and hit industrial targets in North America. […]

The head of the production department of the armament ministry, [Karl-Otto] Saur, and his deputy, Feldmann, were personally responsible for the production of atomic bombs.

The most knowledgeable people in this regard should be General Dornberger and Dr. Erich Schumann, who worked specifically on scientific research questions related to the production of the atomic bomb.

Transcript of NKVD interrogation of Werner Wächter by Ivan Serov. 10 October 1945. [FSB Archive, Moscow]

I knew that the Ministry of Armaments was carrying out practical work to prepare for the use of the atomic bomb. I learned about this from my friend, the editor of the secret government bulletin, Hans HERTEL.

As HERTEL told me, in February 1945, on behalf of the Minister of Propaganda GOEBBELS, he went on a business trip to the city of Celle and met there with his acquaintance, the head of the military air force school for special purposes, Colonel Hajo HERMANN, who told him in a private conversation that the school was armed with aircraft of the latest design. These aircraft have a long range and will be armed with this bomb. As Colonel Hajo [HERMANN] stated to HERTEL---the new aircraft were intended for bombing industrial centers of the Soviet Union, located in the Urals and Central Asia, with atomic bombs.

From HERTEL, I know that at the airfield in the city of Celle there were both bombers of the latest design and fighters intended to protect them during flights. In addition, HERTEL reported that aircraft of this design were concentrated at other airfields.

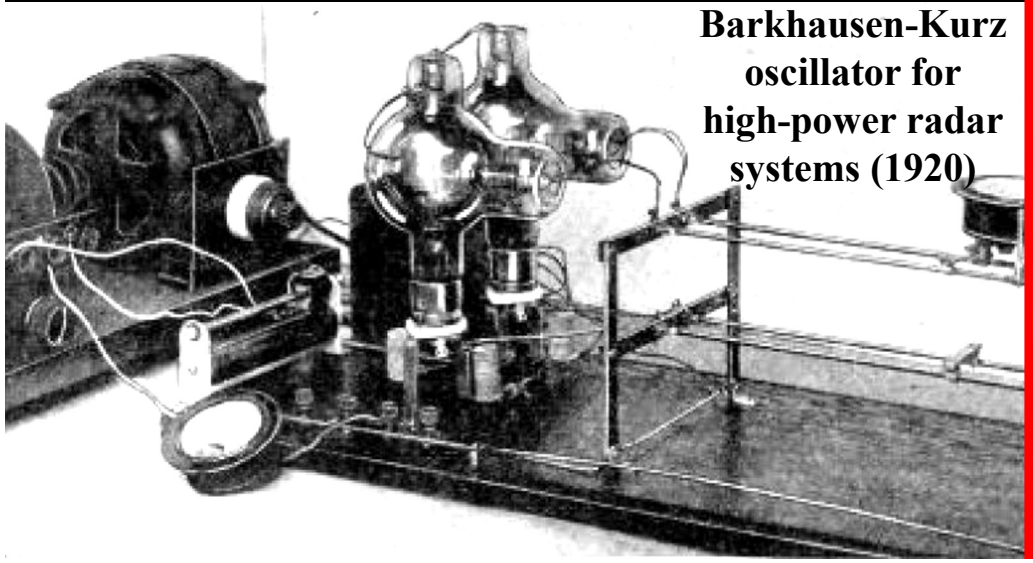
Based on conversations with DOMINIK and HERTEL, I came to the conclusion that the German Ministry of Armaments was preparing to use atomic bombs in 1945. I could also judge this from other facts that were known to me as a leading official of the German Ministry of Propaganda.

Radar

Christian Hülsmeyer (1881–1957) invented radar (1903)

Heinrich Barkhausen (1881–1956)

Karl Kurz (1881–1960)

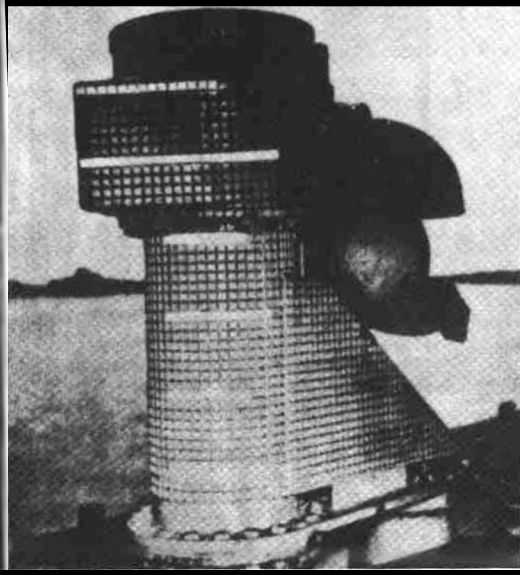


Barkhausen-Kurz oscillator for high-power radar systems (1920)

Anti-Radar

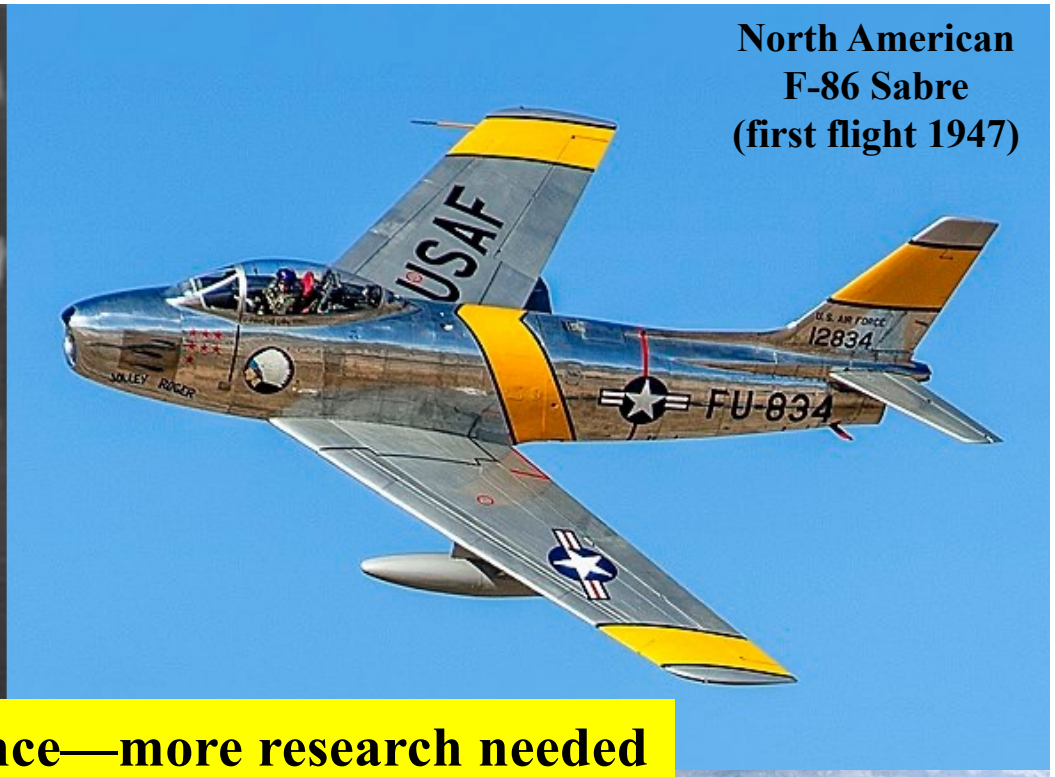
Gustav Franz Hüttig (1890–1957)

Ludwig Wesch (19??–19??) and many others
Radar-absorbing coatings



Structural materials and surface shapes that minimize radar reflections

Hans Multhopp
(1913–1972)



North American
F-86 Sabre
(first flight 1947)

Postwar influence—more research needed

Alexander
Lippisch
(1894–1976)
Building flying
wings since 1930

Northrop Grumman
B-2 Spirit bomber
(first flight 1989)

Dietrich Küchemann
(1911–1976)

Avro Vulcan
(first flight 1952)

Postwar influence—more research needed

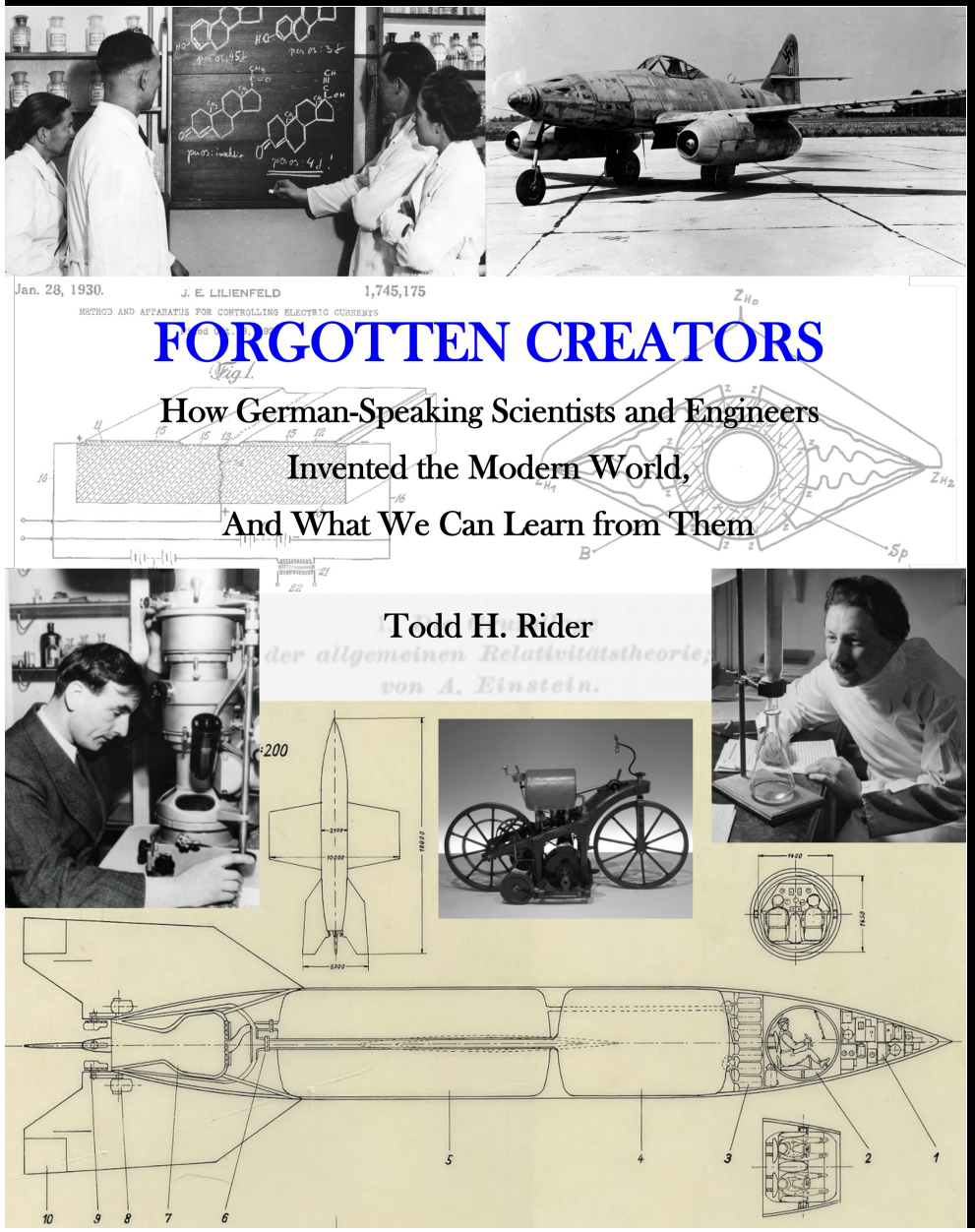
Johanna Weber
(1910–2014)

BAC Concorde
(first flight 1969)

All Relevant Archival Documents Should Be Declassified and Studied!	How far did German work get during the war?	How much did other countries use that after the war?
Nuclear payloads	???	???
1. Land-launched missiles		
A. Liquid propellant missiles	???	???
B. Liquid propellant space planes	???	???
C. Solid propellant missiles	???	???
2. Submarine-launched missiles		
A. Sub-launched cruise missiles	???	???
B. Sub-launched ballistic missiles	???	???
3. Intercontinental jet bombers	???	???

We want you…
to dig!

Modern society runs on revolutionary innovations from the predominantly German-speaking scientific world ~1800–1945



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- Technology transfer out of the German-speaking world
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- >2000 pages of primary sources/analysis on WWII German programs to develop weapons of mass destruction as well as delivery vehicles for them
- >400 pages of bibliography

Reviewed by European and American historians and scientists

Updated as new information is found

Short version—but click the links!

Chapter 9

Creators and Creations in Aerospace Engineering

Dieses merkt Euch, Ihr stolzen Männer der Tat. Ihr seid nichts als unbewußte Handlanger der Gedankenmänner, die oft in demütigster Stille Euch all Euer Tun aufs Bestimmteste vorgezeichnet haben.

Mark this well, you proud men of action. You are nothing but the unconscious hands of the men of thought, who have often, in the most humble silence, directed all your actions in advance.

Heinrich Heine. 1834. *Zur Geschichte der Religion und Philosophie in Deutschland* [*History of Religion and Philosophy in Germany*] Book III, paragraph 3.

This chapter gives an overview of some innovations in aerospace engineering that have played major roles in the modern world and that were invented or discovered by scientists and engineers who were trained in the predominantly German-speaking central European research world in the nineteenth and early twentieth centuries.[1]

[1]In addition to specific references that are cited in different areas throughout this chapter, this chapter makes use of general biographical and project information from: ACLS 2000; Albrecht et al. 1992; Ash and Söllner 1996; Bar-Zohar 1967; Bower 1987; Bunch and Hellemans 2004; Challoner 2009; Cornwell 2003; Crim 2018; EB 1911, 2010; Gillispie 1970–1990; Gimbel 1990a; Glatt 1994; Hall 2019a; István Hargittai 2006, 2011; Linda Hunt 1991; Impey et al. 2008; Jacobsen 2014; Koertge 2007; Kurowski 1982; Lasby 1971; Lusar 1956, 1971; Medawar and Pyke 2000; Mick 2000; Murray 2003; Nachmansohn 1979; NDB 1953–2020; Neufeld 2012; Nouzille and Huwart 1999; O'Reagan 2014, 2019; Porter 1994; Charles Walker 1946; Peter Watson 2010; Weitensfelder 2009.

For general overviews of large portions of the history of aerospace engineering in the German-speaking world, see: Benecke and Quick 1957; von Braun et al. 1985; Coats and Carbonel 2002; Freeman 1993, 2008; Griehl 1990, 2003, 2004, 2005, 2015; Hirschel et al. 2004; Kay 2002; Lommel 2000, 2002, 2005; Jürgen Michels 1997; Myhra 1998a, 1998b, 2000a, 2000b, 2001, 2002, 2003; Michael Neufeld 1995, 2002, 2003, 2004, 2007, 2012; Ordway and Sharpe 1979; Samuel 2004, 2010; Smith and Creek 1982, 1992, 2001; Smith and Kay 2002; Stüwe 1999, 2014, 2015; Trischler 1992a, 1992b; Trischler and Schrogl 2007; Frank Winter 1983, 1990.

Long version of aerospace programs

Available for free at:
riderinstitute.org/revolutionary-innovation

Appendix E

Advanced Creations in Aerospace Engineering

Für den Ring nimm nun auch mein Roß!
Ging sein Lauf mit mir
einst kühn durch die Lüfte,
mit mir
verlor es die mächt'ge Art;
über Wolken hin
auf blitzenden Wettern
nicht mehr
schwingt es sich mutig des Wegs.

For the Ring take now my horse!
Though he once carried me
boldly through the air—
with me
he lost all his magic powers;
above the clouds
through lightning and thunder
no more
will he brave the way.

Richard Wagner. 1874. *Götterdämmerung* [*Twilight of the Gods*]. Prologue. Brünnhilde.

As discussed in Chapter 9, a tremendous number of aerospace technologies were invented by German-speaking creators, especially shortly before and during World War II: helicopters, guided missiles, smart bombs, jet engines and jet aircraft, ejection seats, ramjets, the V-1 cruise missile, the A-4 or V-2 single-stage rocket, supersonic wind tunnels, radar stealth technology, etc. There is also thorough documentation (though regrettably too little modern public recognition) that German-speaking creators personally carried those aerospace technologies to their limits during the postwar era, with funding and support from the United States, United Kingdom, France, Soviet Union, and other countries.

However, archival documents strongly suggest that there are several areas in which aerospace technologies may have advanced significantly further in wartime Germany than has been officially acknowledged in the conventional historical narrative.

Short version—but click the links!

8.8 Nuclear Engineering in the Third Reich

This section presents evidence which suggests that the World War II German nuclear program was much larger and much more advanced than has previously been generally understood. While this claim may seem controversial, much of the relevant archival evidence has only been declassified and rediscovered in recent years, and was not publicly available when earlier historical assessments were made. The evidence presented here covers:

For a far more detailed presentation of the currently available evidence, see Appendix D. As explained in Section 8.8.15, much more work is needed to uncover and evaluate evidence regarding the true history and extent of the wartime nuclear program.

8.8.1 Flaws in the Conventional Historical View of the German Program

The conventional historical view that has been held from 1945 to the present is that the World War II German nuclear program was very small and poorly funded, that Germany was still trying to complete its first prototype fission reactor when the war ended, and that Germany never even made a serious attempt to develop nuclear weapons.[6] This view is based on three categories of evidence, although each category has its own limitations as summarized below and in Section D.1:

[6] E.g., Goudsmit 1945; Goudsmit 1947; Groves 1962; Hentschel and Hentschel 1996; Hoffmann 2023; Irving 1967; Pash 1969; Popp 2016, 2021; Powers 1993; Rhodes 1986; Rose 1998; Walker 1989, 1995, 2020, 2024a, 2024b.

Long version of nuclear program

Available for free at:
riderinstitute.org/revolutionary-innovation

Appendix D

Advanced Creations in Nuclear Engineering

Der Welt Erbe gewänne zu eigen,
wer aus dem Rheingold schüfe den Ring,
der maßlose Macht ihm verlieh'.

The whole world can be possessed by one
who from the Rhinegold forges the Ring,
which can bestow immeasurable power.

Richard Wagner. 1854. *Das Rheingold.* Scene I. Wellgunde.

As discussed in Chapter 8, contributions by the German-speaking research world to fundamental nuclear science are very well documented.[1] Wilhelm Röntgen discovered X-rays in 1895, and Ludwig Zehnder was making detailed whole-body X-ray photos of humans by 1896. Hans Geiger and Walther Müller developed accurate radiation meter designs (Geiger counters or Geiger-Müller tubes) during the period 1908–1928 that are still in use today. Nuclear fission reactions were first proposed by Ida Tacke Noddack in 1934, and demonstrated and explained by Otto Hahn, Fritz Strassmann, Lise Meitner, and Otto Frisch in 1938–1939. Nuclear fusion reactions were proposed by Fritz Houtermans and his student Robert Atkinson in 1928–1929, and refined by Carl Friedrich von Weizsäcker and Hans Bethe in 1938. Detailed mathematical models of the nucleus, essential for accurately predicting nuclear decays and reactions, were first developed by von Weizsäcker in 1935 and ultimately finalized by Otto Haxel, Johannes Hans Jensen, Maria Goeppert Mayer, Hans Suess, and Eugene Wigner by 1949.

[1] See for example: Bethe 1991, 1997; Blatt and Weisskopf 1952; Brown and Lee 2006; Otto Hahn 1968; Irving 1967; L'Annunziata 2016; Nachmansohn 1979; Rife 1999; Schweber 2012; Sime 1996; Szanton 1992; Wigner 1967.

Some Reviewers' Comments on *Forgotten Creators*

"Todd H. Rider's *Forgotten Creators* is an encyclopedic consideration of Germany's central place in the advancement of science and technology between 1800 and 1945. Drawing upon a wide range of sources, Rider has summarized that effort in a survey that will impress the reader just as much for the breadth of German intellectual achievement as for the influence that achievement has had upon the modern world."

George W. Cully, retired Director, Office of History at Air University, Maxwell Air Force Base, Alabama

"Todd H. Rider's *Forgotten Creators* is a monumental treatise about and an exciting intellectual journey through the contributions of scientists and technologists in Germany and other Central European countries and German-speaking areas to universal progress. It is thoroughly researched, meticulously documented, and presented in an easy-to-perceive way. The pre-war and pre-Nazi German system of science support has lessons that would be difficult to emulate but worthy to ponder about even today. The long-range tragic consequences in science caused by National Socialism are well demonstrated as are the benefits in the West and in the East from the exodus of Jewish scientists before and the importation of others from Germany following World War II. The book is a virtually bottomless well for mining reliable information in the history of science and technology. The 'forgotten creators' are no longer forgotten. Todd is to be congratulated for his accomplishment and thanked for sharing it so generously with the international community."

István Hargittai, Professor Emeritus of Chemistry, Budapest University of Technology and Economics, author of *Buried Glory, Candid Science, Drive and Curiosity, Great Minds, Judging Edward Teller, Martians of Science,* and *The Road to Stockholm*

"The book *Forgotten Creators* is a really impressive book, as Todd H. Rider tries to mention all relevant German-speaking scientists and engineers and their scientific fields up to 1945 in this mammoth project. In this form, nobody has dared to do this before. The author deserves my full respect for this. I am pleased that we were able to support him in his research."

Thomas Köhler, Peenemünde Historical-Technical Museum historian and head of the archive

"*Forgotten Creators* is an examination of mid-twentieth-century German science and technology, studying the question of how this era came to be so productive. Using extensive reproduction of original materials and source accounts, the author is not only able to provide an overview of what is known about wartime activities, but is also able to indicate avenues for future historical research. The careful and comprehensive referencing permits the materials presented to be used in academic studies. A notable feature of this work is the fluid format provided by online publication, allowing revisions and new materials to be added. An especially important emphasis of the book is what can be learned from both the German-speaking scientists and the World War II era in general that could improve scientific productivity and creativity now."

Thomas Kunkle, Los Alamos National Laboratory, retired

"With his work, based on very comprehensive, thoroughly researched sources, Todd Rider has presented an astonishing study of the history of German science, especially in the first half of the twentieth century, which also reveals many connections that have been unjustly forgotten or little noticed. This also applies to numerous persons whose achievements are hardly known."

Günter Nagel, author of *Wissenschaft für den Krieg, Himmlers Waffenforscher, Atomversuche in Deutschland,* and *Das geheime deutsche Uranprojekt 1939-1945*

"A very valuable part of the book is devoted to the development of nuclear weapons in Germany during WWII, 1939-1945. While the histories of both the US/British Manhattan Project and the Soviet atomic project have been to a large extent declassified, little is actually known about the German work. Rider has done historians a favor by marshalling all of the evidence he could find in US, German, and Russian archives regarding the German atomic project. The inescapable conclusion is that the Germans were much farther advanced in nuclear weapons development than is generally thought."

Lee Pondrom, Professor Emeritus of Physics, University of Wisconsin-Madison, author of *The Soviet Atomic Project: How the Soviet Union Obtained the Atomic Bomb*

"*Forgotten Creators* by Todd Rider is an extraordinary work of detailed research and new insights into the technological advances contributed by German-speaking scientists. His lengthy and in-depth study of history often overlooked or not even seen in more cursory reviews is a refreshing read. His attempt to create the fullest account possible has resulted in a fine reference book that also serves to introduce new research for the reader. Rider's contention, right up front in the Executive Summary—that inventions and discoveries had their highest concentration of revolutionary innovations from scientists and engineers from the German-speaking central European research world in the nineteenth and early twentieth centuries—demands the reader's attention. He then fills an enormous amount of over 4,000 pages with supporting details. Amazing subject matter and new revolutionary insights dug up through meticulous research make *Forgotten Creators* a 'must read' for serious historians and curious researchers alike."

D. Ray Smith, Oak Ridge National Lab Historian, retired

"This truly voluminous study provides an in-depth overview of techno-scientific achievements and innovations which originated from the German-speaking world. It is a rich and fascinating history of the transnational circulation of knowledge over a period of no less than two centuries."

Helmuth Trischler, Head of Research, Deutsches Museum, Munich

"A most important and deserving book. Todd Rider's research on the German rocket and nuclear programs in World War II is especially impressive because of the number and depth of the sources cited and the meticulousness of their evaluation. Really pioneering work has been done here!"

Matthias Uhl, Deutsches Historisches Institut, Moscow, author of *Stalins V-2: Der Technologietransfer der deutschen Fernlenkwaffentechnik* and *Die Organisation des Terrors: Der Dienstkalender Heinrich Himmlers 1943-1945*

"Todd Rider has produced a meticulously researched and cogently argued *tour de force* on the men and the circumstances that drove the modern German Renaissance in science and technology. Brought out of the long shadow of the Third Reich, the story of this Golden Age of human enquiry is convincingly shown to have as much relevance to our present times as it did then. A remarkable achievement."

Stephen Walton, Senior Curator, U.K. Imperial War Museum

Dr. Todd H. Rider riderinstitute.org

Fundamental Limitations on Plasma Fusion Systems Not in Thermodynamic Equilibrium

by

Todd Harrison Rider

S.M., Nuclear Engineering, MIT, 1994
S.M., Electrical Engineering and Computer Science, MIT, 1991
S.B., Electrical Engineering, MIT, 1991

Submitted to the Department of Electrical Engineering and Computer Science in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June 1995

Signature of Author ____________________
Department of Electrical Engineering and Computer Science
May 19, 1995

Certified by ____________________
Lawrence M. Lidsky
Professor of Nuclear Engineering
Thesis Supervisor

Accepted by ____________________
Frederic R. Morgenthaler
Chairman, Department Committee on Graduate Students

Fundamental Constraints on Large-Scale Antimatter Rocket Propulsion

Journal of Propulsion and Power
Vol. 13, No. 3, May–June 1997

Todd H. Rider
Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

Nomenclature

I. Introduction

A B Cell–Based Sensor for Rapid Identification of Pathogens

www.sciencemag.org SCIENCE VOL 301 11 JULY 2003

Broad-Spectrum Antiviral Therapeutics

Todd H. Rider, Christina E. Zook, Tara L. Boettcher, Scott T. Wick, Jennifer S. Pancoast, Benjamin D. Zusman

Abstract

Introduction

PLoS ONE | www.plosone.org July 2011 | Volume 6 | Issue 7 | e22572

Fundamental limitations on plasma fusion systems not in thermodynamic equilibrium

Todd H. Rider
Massachusetts Institute of Technology, Department of Electrical Engineering and Computer Science, Cambridge, Massachusetts 02139

I. INTRODUCTION

Phys. Plasmas 4 (4), April 1997 © 1997 American Institute of Physics 1039

United States Patent [19] Rider

[11] Patent Number: 4,723,736
[45] Date of Patent: Feb. 9, 1988

[54] ROCKET STAGING SYSTEM

[76] Inventor: Todd H. Rider, 501 W. "A" St., North Little Rock, Ark. 72116

[21] Appl. No.: 898,010

[22] Filed: Aug. 18, 1986

References Cited

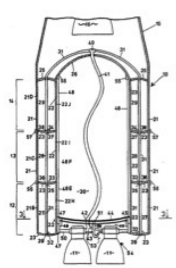
U.S. PATENT DOCUMENTS

Primary Examiner—Galen Barefoot
Attorney, Agent, or Firm—Stephen D. Carver

[57] ABSTRACT

An improved rocket staging system for missiles and the

15 Claims, 9 Drawing Figures



United States Patent [19] Rider

[11] Patent Number: 6,087,114
[45] Date of Patent: Jul. 11, 2000

[54] OPTOELECTRONIC SENSOR

[75] Inventor: Todd H. Rider, Acton, Mass.

[73] Assignee: Massachusetts Institute of Technology, Cambridge, Mass.

[21] Appl. No.: 08/987,410

[22] Filed: Dec. 9, 1997

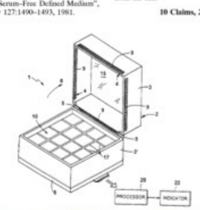
References Cited

U.S. PATENT DOCUMENTS

OTHER PUBLICATIONS

[57] ABSTRACT

10 Claims, 2 Drawing Sheets



United States Patent Rider

(10) Patent No.: US 7,566,694 B2
(45) Date of Patent: *Jul. 28, 2009

(54) ANTI-PATHOGEN TREATMENTS

(75) Inventor: Todd H. Rider, Littleton, MA (US)

(73) Assignee: Massachusetts Institute of Technology, Cambridge, MA (US)

(21) Appl. No.: 11/503,416

(22) Filed: Aug. 11, 2006

Prior Publication Data

Related U.S. Application Data

References Cited

U.S. PATENT DOCUMENTS

OTHER PUBLICATIONS

(57) ABSTRACT

6 Claims, 86 Drawing Sheets

Relativistic Quantum Field Theory

Todd H. Rider thor@riderinstitute.org 13 November 2019

Any suggestions for improvements would be greatly appreciated.

Three quarks for Muster Mark!

–James Joyce, *Finnegans Wake (1939)*

I think I can safely say that nobody understands quantum mechanics.

–Richard Feynman, *The Character of Physical Law* (1965)

Overview

Relativistic quantum field theory (or field theory, for short) combines special relativity, which describes very fast things, and quantum mechanics, which describes very small things. The resulting theory correctly predicts the behavior of fundamental particles, which are small and often move at high speeds (or are in bound states with relativistic energies). A "toy theory" of spinless particles will be used to first introduce some of the basic techniques and results of field theory, since the spin of real particles makes calculations more complicated. Field theory will then be applied in succession to each of the four fundamental forces. Quantum electrodynamics is a field theory describing the electromagnetic force; it is relevant to phenomena such as Compton scattering and electron-positron annihilation. The field theory of the weak nuclear force describes phenomena such as the decay of neutrons (beta decay) and muons. Quantum chromodynamics describes the strong nuclear force and thus is relevant to the behavior of the quarks that compose particles like protons, neutrons, and pions. Finally, it will be shown that general relativity is equivalent to applying field theory to gravitation, although there remain obstacles to developing a complete quantum theory of gravity.

Biochemistry

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Any suggestions for improvements would be greatly appreciated.

Near the further end a low arched passage branched away from it and led to the chemical laboratory. This was a lofty chamber, lined and littered with countless bottles. Broad, low tables were scattered about, which bristled with retorts, test-tubes, and little Bunsen lamps, with their blue flickering flames. There was only one student in the room, who was bending over a distant table absorbed in his work. At the sound of our steps he glanced round and sprang to his feet with a cry of pleasure. "I've found it! I've found it," he shouted to my companion, running towards us with a test-tube in his hand. "I have found a re-agent which is precipitated by hoemoglobin, and by nothing else." Had he discovered a gold mine, greater delight could not have shone upon his features.

"Dr. Watson, Mr. Sherlock Holmes," said Stamford, introducing us.

–Arthur Conan Doyle, *A Study in Scarlet* (1887)

"It was all done that evening and night. While I was still sitting under the sickly, drowsy influence of the drugs that decolourise blood, there came a repeated knocking at the door... It was my landlord, with a notice of ejectment or something... For a moment he gaped. Then he gave a sort of inarticulate cry, dropped candle and writ together, and went blundering down the dark passage to the stairs... I shall never forget that dawn, and the strange horror of seeing that my hands had become as clouded glass, and watching them grow clearer and thinner as the day went by, until at last I could see the sickly disorder of my room through them, though I closed my transparent eyelids. My limbs became glassy, the bones and arteries faded, vanished, and the little white nerves went last. I gritted my teeth and stayed there to the end. At last only the dead tips of the fingernails remained, pallid and white, and the brown stain of some acid upon my fingers... I went and stared at nothing in my shaving-glass, at nothing save where an attenuated pigment still remained behind the retina of my eyes, fainter than mist. I had to hang on to the table and press my forehead against the glass. It was only by a frantic effort of will that I dragged myself back to the apparatus and completed the process."

–Griffin, in H. G. Wells' *The Invisible Man* (1897)

Overview

Biochemistry covers the chemical molecules and reactions that are important in biology. Most biological molecules fall into five categories: (1) nucleic acids such as deoxyribonucleic acid (DNA), ribonucleic acid (RNA), and their component nucleotides; (2) proteins and their component amino acids; (3) lipids such as fatty acids, triglycerides, and cholesterol; (4) carbohydrates such as simple sugars and various polymers composed of them; and (5) iron- or magnesium-containing porphyrins in hemoglobin, chlorophyll, etc. Most biochemical reactions have many steps, each of which is catalyzed by different enzymes, proteins that act as specialized molecular machines to greatly speed up and control reactions. Some major types of biochemical reactions include the synthesis (production) or catabolism (degradation) of proteins, nucleic acids, lipids, carbohydrates, and porphyrins. Other important biochemical reactions include respiration, in which energy is produced by combining hydrogen from biomolecules with oxygen from the air to form water; fermentation, in which smaller amounts of energy are extracted from biomolecules without oxygen; and photosynthesis, basically respiration run in reverse so that light energy is absorbed and stored by splitting water into more oxygen for the air and more hydrogen in biomolecules.

Fluid Mechanics and Aerodynamics

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Any suggestions for improvements would be greatly appreciated.

On aircraft:

"There is as much pressure exerted by a substance against the air as by the air against the substance.

"Observe how the beating of its wings against the air suffices to bear up the weight of the eagle in the highly rarefied air which borders on the fiery element! Observe also how the air moving over the sea, beaten back by the bellying sails, causes the heavily laden ship to glide onwards!

"So that by adducing and expounding the reasons of these things you may be able to realize that man when he has great wings attached to him, by exerting his strength against the resistance of the air and conquering it, is enabled to subdue it and to raise himself upon it."

On parachutes:

"If a man have a tent made of linen of which the apertures have all been stopped up, and it be twelve braccia across and twelve in depth, he will be able to throw himself down from any great height without sustaining any injury."

On helicopters:

"I find that if this instrument made with a screw be well made–that is to say, made of linen of which the pores are stopped up with starch–and be turned swiftly, the said screw will make its spiral in the air and it will rise high."

Advice for test pilots:

"This machine should be tried over a lake, and you should carry a long wineskin as a girdle so that in case you fall you will not be drowned."

–Leonardo da Vinci, *The Notebooks* (ca. 1500)

Overview

Fluid mechanics and aerodynamics concerns the motion of liquids and gases or their interactions with objects such as pipes or aircraft. One fundamental factor affecting how to model the behavior of a fluid is whether the fluid is compressible, or in other words whether its density changes significantly when its pressure its increased. Another fundamental factor is viscosity, or whether the particles of the fluid seem to stick to each other and pull on each other. Therefore, it is most convenient to divide models of fluid behavior into four categories: (1) incompressible, inviscid fluids, (2) incompressible viscous fluids, (3) compressible inviscid fluids, and (4) compressible viscous fluids. Important applications of fluid mechanics include the design of ships and submarines, as well as helicopters, airplanes, parachutes, and spacecraft reentering the atmosphere. Other applications include fluids in pipes and lubricants in machinery, pressure and circulation in the ocean and atmosphere, and sound waves and shock waves.