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INTERROGATION OF HELMUT GOTTRUP
DIPL. ING.
ELEKTROMECHISCHE WERKE

COMBINED INTELLIGENCE OBJECTIVES
SUB COMMITTEE

INTERROGATION OF HELMUT GOTTRUP

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ELEKTROMECHISCHE WERKE

Reported by

W. HAUSZ, U. S. Ord.

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Rockets & Rocket Fuels

COMBINED INTELLIGENCE OBJECTIVES SUB-COMMITTEE
G-2 Division, SHAEF (Rear) APO 413

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Personnel of Team

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Lt. Hochsmuth, U. S. Ord.
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HELMUT GROTTRUP, DIPL. ING.

I Source:

He graduated from Technische Hochscule Berlin in 1939, was employed by Manfred von Ardenne (private laboratory) for six months then went to Peenemunde in December 1939. Rose from making laboratory measurements to assistant to Kirschstein, then, in December 1943 to assistant of Steinhoff who was in charge of all electrical work under von Braun. His position there was head of the Technischestelle (or Technical Point) a small committee of about five through which the various sections made contact with Steinhoff. He has broad general knowledge of all the sections under Steinhoff. He can not give detailed circuits of any project except those he worked on before 1943.

He is married, has two children aged 4 years and 6 months. Both he and his wife speak English. Both allegedly have strong democratic leanings and were under close arrest for over a year although he continued work. There was allegedly an order for his hanging in Nordhausen just before he left with the train for Munich. He got off the train before Munich, hid, then made his way back to Nordhausen after occupation.

II Work at Manfred von Ardenne:

This laboratory before the war worked on television. In the electron optics field they developed a type of electron microscope which created by means of two magnetic lenses a beam of electrons of diameter 10^{-6} mm at the object. This beam was scanned as in television by a set of deflection plates only a few mm. in size. It scanned an area about 10^{-4} mm. on a side. The intensity modulation in penetration of the object was amplified electrically and projected on a screen of about 10 cm. size, giving about 10^{6} magnification. This very fine beam technique was also useful for very high writing speeds since small deflections (and small deflecting plates) could be used with good resolution and magnified optically. The development was purchased by Siemens and dropped by Ardenne. On the project, Grottrup performed some experiments on the penetration of these fine beams in photo-paper. Beams of various voltages were impinged, the paper was developed, and cross-sections of the emulsion were examined.

III Organization of Group 22 (Steinhoff):

Directly under Steinhoff was the Technischestelle of about 5 persons which functioned as a clearing house for technical matters. Grottrup headed this. Then there were nine sections, 221-9.

221 - Prof. Wierer and 50 persons: Bordnetz and Bodennetz, (cabling and wiring both in rockets and on ground), batteries, MG sets, relays.
222 - Dr. Hoelzer and 90 persons: Azimuth control and stability control (of A1-A9 series), gyros, mischgerät, servos, sequence switches,

Leitstrahl, Messina II (Busch's telemetering system), 500 MC antenna development.

223 - Prof. Kirschstein and 80 persons: Brennschluss control and telemetering, Wolman (Verdoppler) control of Brennschluss, I-gerät types, Messina I, Ib and Ic types of telemetering, 50 MC antenna development.

224 - Dr. Netzer and 120 people: Control of Wasserfall (C-2). In this section was Dr. Slevogt who worked on homing devices and proximity fuses. Since Steinhoff was most interested inthe A series this section partially reported direct to von Braun.

225 - Dr. Brutzil and 300 men: This section consisted of a few engineers, but mostly draftsmen and craftsmen who built the first models of everything invented or developed at Peenemunde for use in the air (contrasted to ground equipment).

Konstruktionsbüro

226 - Bohm and 70 men: Headed what was called the Construction Bureau for Steinhoff, made drawings and the units themselves of mountings, chassis and the plywood compartments for radio (Geräteraum).

227 - Debus and 50 men: In charge of all electrical apparatus during trial shots at Peenemunde. Had specialists on each new apparatus, sometimes drawn from the section developing it. He was evacuated in February 1945 from P. to a place north of Rehden which is near Bremen. Trial shots were to be fired to pass along the west coast of Denmark where they could be observed.

228 - Dr. Gengelbach and 100 men: First models of all ground apparatus. Of some equipment such as Wolman Brennschluss, his group made all production models of the ground equipment.

229 - Neubert and 30 men: (a) Led production of test machines for A-4 (component parts tests). (b) Liaison with Sonderauschuss (the production coordinator for all directed missiles) namely Direktor Kunzer. (c) In charge of diverting from production such parts and complete missiles as were needed for trials.

IV Telemetering:

Messina was the code name for all telemetering apparatus. Section 223 worked on Messina I and its successors, Messina Ib and Ic. Messina II was developed by Section 222 and Prof. Busch of TH Darmstadt.

Messina I consisted of a carrier with up to ten amplitude modulated audio tones carrying the ten channels of information. Messina Ib was similar except that the frequency of the audio tones carried the information instead of their amplitude. Messina Ic was Grottrup's invention and was still in the experimental stage. Each channel consisted of a set of regular pulses, the repetition rate of which was varied to convey the information. Each channel required a 40 KC bandwidth and as many channels could be used with 100 KC separation as the characteristics of the antenna permitted. Messina II used amplitude modulated pulses, with twelve sets of pulses interlaced. One of the twelve channels was used for time and amplitude reference.

For the purposes of his patent docket on Messina Ic, Grottrup had made the following comparison table.

	Messina I (&Ib)	II	Ic
No. of channels	8	11	10.
No. continuous	4	11	5
No. on-off	4	--	5
Weight-kilograms	27	50	12
Volume - cu. decim.	30	80	15
No. of tubes	24	60	17
Required input watts	240	600	100
Antenna output in watts per continuous channel	0.2	8 peak	12 peak

In Messina I, each audio tone amplitude-modulated the carrier about 15% for its maximum signal. This applied only to the continuous channels which were used to transmit such things as pressures, rudder positions, etc. The on-off channels consisted of quite small modulations of about 1% which were used to give specific time points such as Brennschluss, time of reentry into atmosphere, times when flutter of surfaces exceeded a set limit, times when temperatures exceeded set limits, etc. One on-off channel was used to give turbine speed information by being set to go alternately on and off after each ten revolutions of the turbine wheel.

Messina Ib was sponsored by Prof. Fassbender. Instead of varying the amplitude of the modulating tone, the tone remained always at full amplitude and was varied in frequency over a range of 15% for full range of signals.

The block diagram of Messina Ic is shown in Fig. 1. For each channel, a dc signal voltage (1) obtained from the measuring instrument is fed in at the left to (2) a tube which converts it to an audio frequency between 200 and 300 cycles. Minimum signal give 200 and max. gives 300 cycles. This audio is used to trigger a single tube self-pulsing oscillator (3), which puts out pulses of r-f (50-60 MC.) in synchronism with the audio tone. The pulse lengths are of the order of 20 to 100 microseconds.

The separate transmitting channels are tuned to frequencies about 100 KC apart. The antenna is broad enough in its frequency characteristics to permit use of at least ten. For such channels as are to be used for on-off signals instead of continuous variations, the audio tone tube may be eliminated and the dc input used to cause or stop oscillation or markedly change the repetition rate of the r-f oscillator by means of a relay.

At the receiver end, 4 is a broad band r-f amplifier; 5 is a mixer and 6 a local oscillator. There is thus conventional superheterodyne construction. However, each i-f amplifier is sharply tuned to the frequency for its channel and excludes all the other channels. A 40 Kc. bandwidth is used. When the pulses are detected at the end of the i-f strip, as accurate a means of measuring frequency as is justified may be used. Grottrup planned to use a Wahl frequency meter.

Grottrup's pride in this system was based on its simplicity, its light weight, small volume and small use of tubes and various other critical components such as iron cored filters.

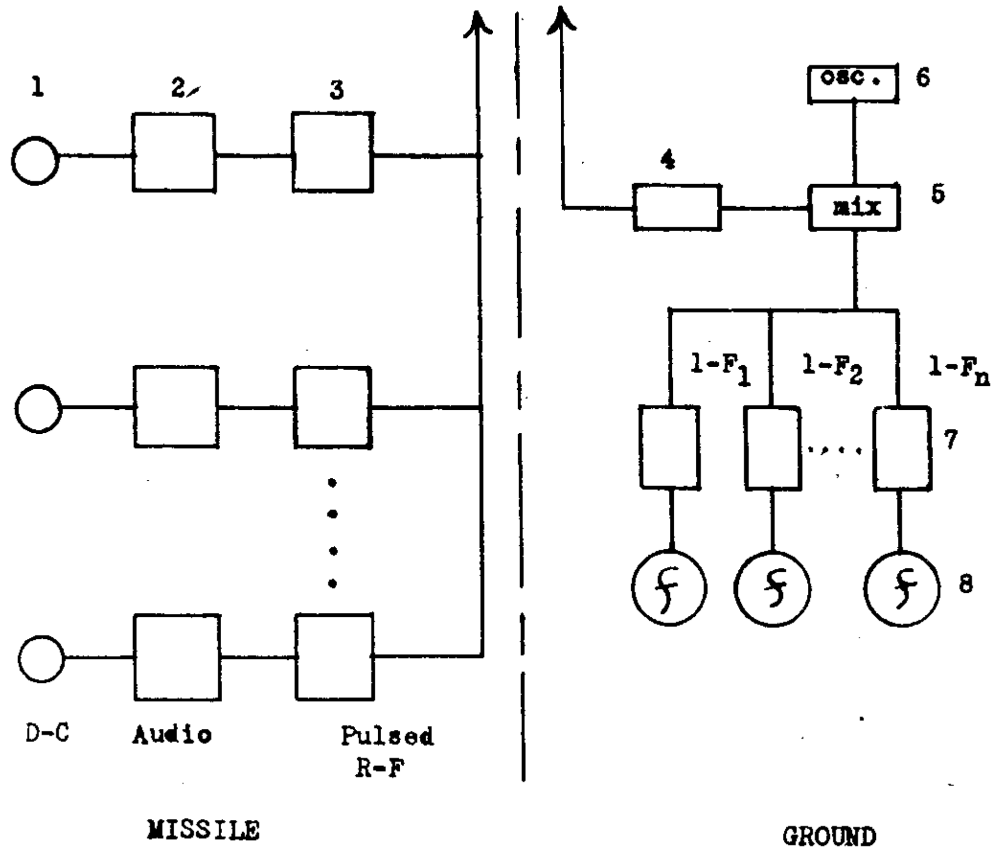

Fig. 1 - **Telemetering System Messina IC**

Messina II was very complicated by comparison. An oscillator fed a phase splitter which put out 12 signals spaced 30^o apart in phase. The individual channels consist of an oscillator, a means for controlling the amplitude of its output by the desired signal, and an electronic switch to feed it to the antenna only during its allotted period. The ground equipment has to either separate the channels or photograph them simultaneously on an oscilloscope. Only several flights were made with this system which was not quite completed and, since other troubles were encountered on these flights, the effectiveness of the system is not known.

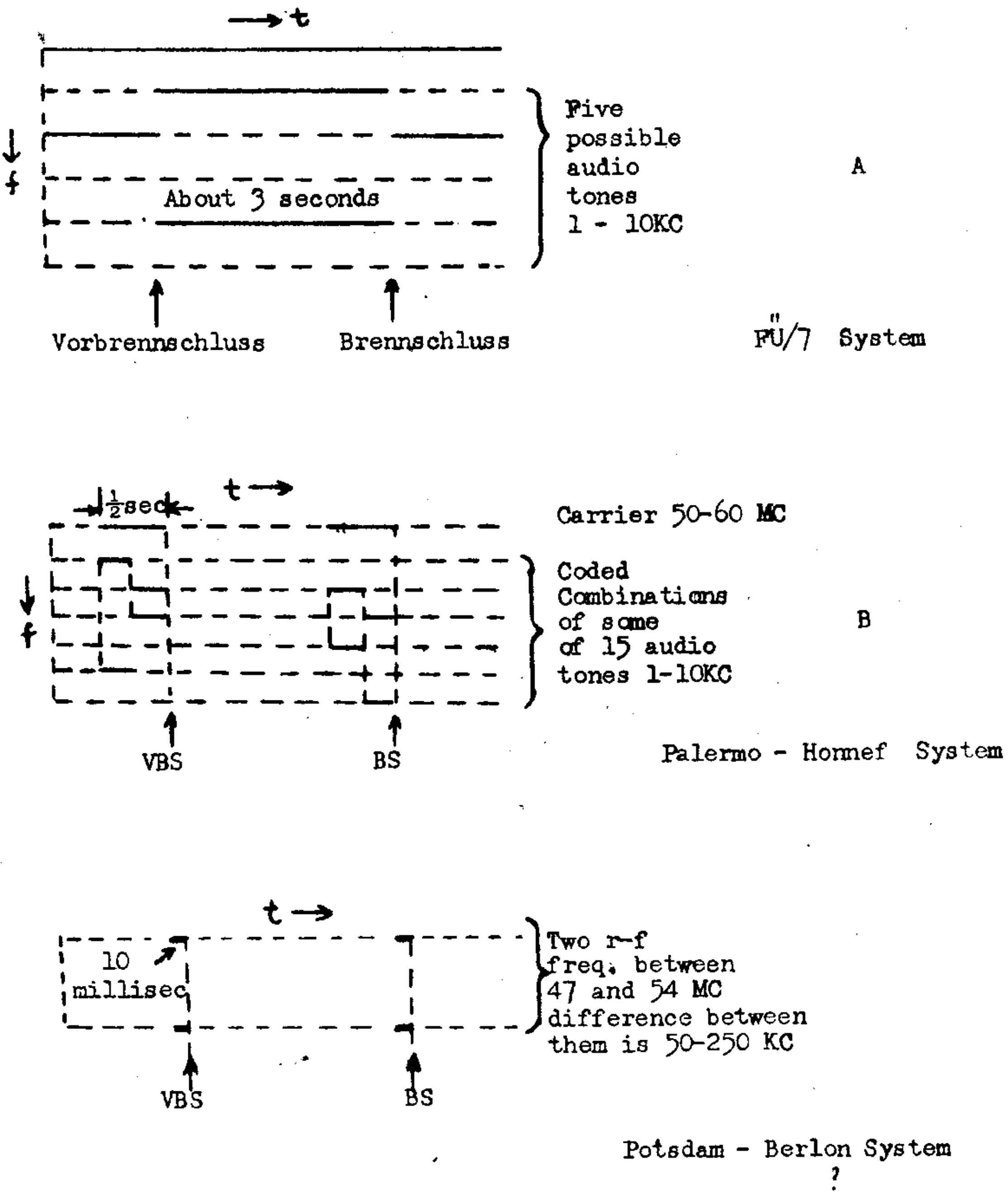

Figure 2. Kommandogerät Systems

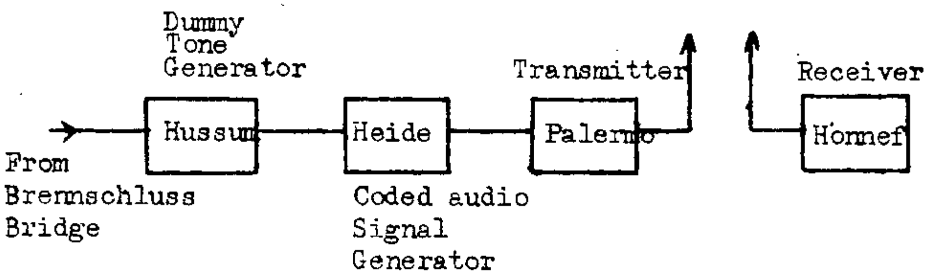

Figure 3. Palermo - Honnel Honnef. System

All of these telemetering systems were expected to have about the same accuracy - namely about 2%.

V Kommando Systems:

To give a command to a missile at an accurately determined time while taking all possible precautions to prevent the enemy from stealing control or preventing control was the function of several systems called Kommandogerät.

One of the early systems called the Fü/7 had a transmitter capable of modulation with any combination of five audio tones. The time sequence of operation as this was applied to A-4 is shown in Fig. 2a. One tone was normally on. At the moment of stopping this tone and thus actuating one relay in the receiver, a pair of different tones would be sent. Unless the first tone stopped and the proper two additional tones began no action would occur, but when these events happened Vorbrennschluss or reduction of thrust took place. Complete Brennschluss took place about three seconds later at a time determined by shutting off the two tones and reverting to the original one. This system has the disadvantages of few coding possibilities, continuous transmission of carrier and one tone giving ample opportunity for jamming and putting large power requirements on the transmitter. At first a 200 watt transmitter was used, but results were not reliable enough so 2,000 watt transmitters were made.

The next system was developed by Siemens for the HS293 and was adapted for A-4. Its sequence of operations is shown in Fig. 2b and a block diagram is shown in Fig. 3. For any particular signal, the transmitter, which to this moment has transmitted no power, sends out a carrier modulated by two audio tones which after about 1/4 second changes to a different pair of tones. The transmitter is on the air for only about 1/2 second and no enemy signal will take control unless it has the right carrier frequency, the right pairs of tones and the right time sequence between them. About fifteen audio tones are available at the transmitter, but each receiver can only utilize several combinations of five of these. As an additional precaution a dummy tone generator was developed (Hussum) which would mix in as many as fifteen tones which were not useful, but would confuse the enemy. This device was found not to be necessary. This system was called the Palermo-Honnef.

A third type of system, developed and invented by Grottrup, was planned, but not yet in use. It was called the Potsdam-Berlon (not Berlin because some other device had that code name). Its merit was simplicity and reduction of tubes, relays, iron cored chokes and other critical items. As indicated in Fig. 2c its sequence was just a 10 millisecond pulse simultaneously on each of two r-f frequencies. The block diagram of operation is shown in Fig. 4.

In the transmitter for this system, two oscillators are used, one of the order of 5 megacycles and the other of the order of 100 kilocycles. They are mixed and triplers provide thrice the first frequency and thrice the sum of the two frequencies. These areagain tripled to give frequencies of the order of 50 MC. Two power amplifiers are energised simultaneously by the signal it is desired to transmit and a ten millisecond pulse is sent simultaneously at the two frequencies.

At the missile, the receiver antenna has resonant coupling circuits for the two frequencies chosen and for none other. All that follows this is a non-linear tube, or mixer, and several high gain i-f amplifiers which respond to the difference between the two frequencies.

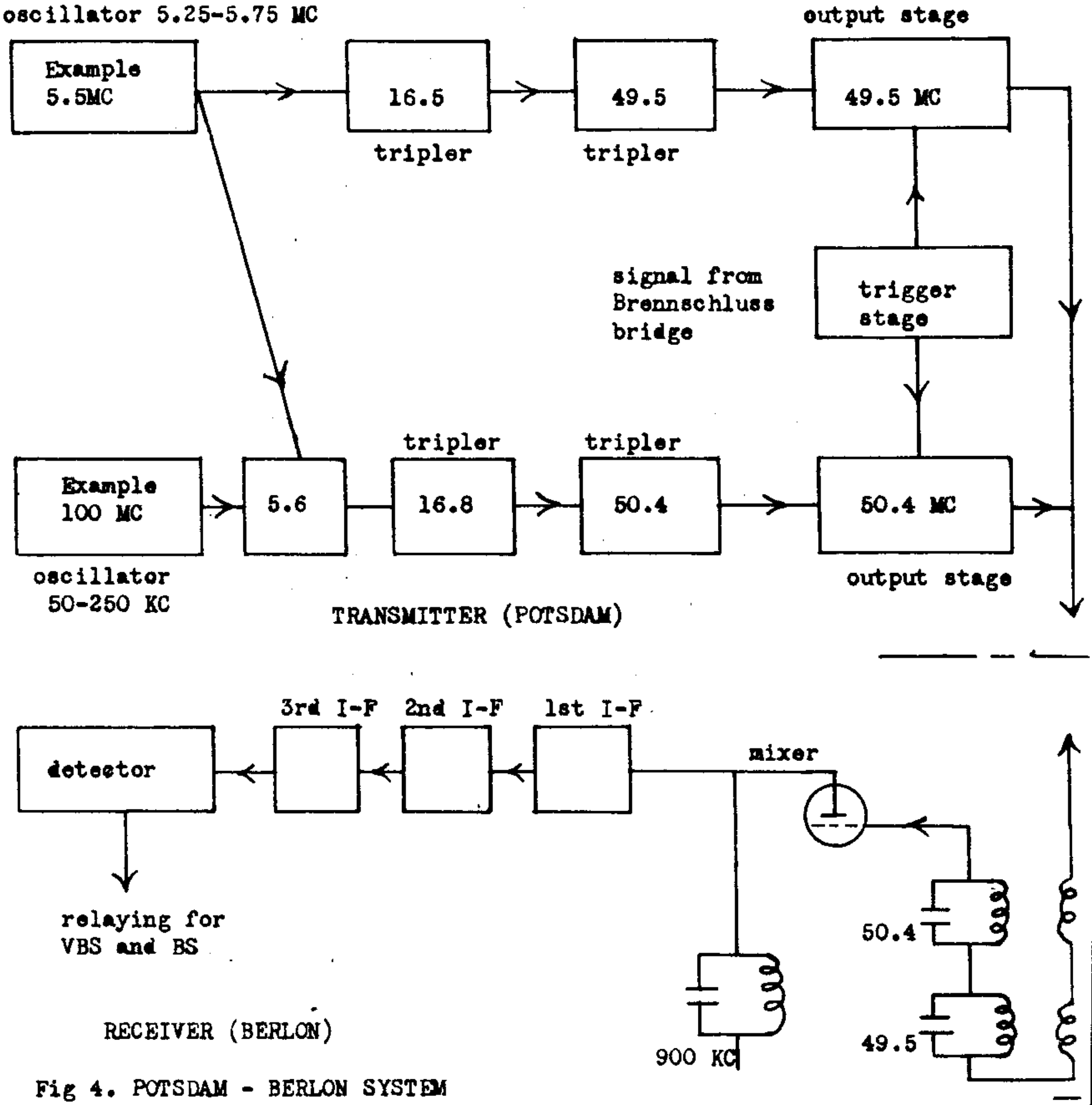

Fig 4. POTSDAM - BERLON SYSTEM

Relaying at the output of the i-f strip is so arranged that the first signal only operates the thrust reduction relay, but enables the second signal to operate the complete Brennschluss relay.

It will be seen that no superheterodyne receiver is needed because the i-f is inherent in the received pair of frequencies.

In operation each receiver would be adjusted differently in random fashion at the factory and marked for its particular i-f frequency and lower r-f frequency. The troops would then set the dial on the two oscillators in the transmitter and then shoot. Lorentz in Berlin had manufactured two transmitters and about a dozen receivers for development, but these were on 1500 MC., using already developed transmitter circuits.

The accuracy of a command system depends on the variables in its operation such as differences in relay action times and on the length of time that it must be activated before the signal since this requires anticipation of the missile behaviour. In the Potsdam-Berlon system all components are fast acting except a single relay and variations in its action time can be made very small. In comparison, the Palermo-Honnef system requires that the time of Brennschluss be anticipated by about 1/2 second to permit the proper coded sequence of pulses to be given and the action time of several relays in series is involved. Errors in range due to the command system alone were estimated to compare as follows - Fü/7 - 0.02%; Honnef - 0.10%; Berlon - 0.002%!

VI <u>The A Series of Missiles and Their Control</u>:

A. The general aspects of missiles A-1 to A-10 have been described in more detail in other reports. Grottrup was able to supplement this only on control aspects, but for summary purposes the following table is presented:

A-1 to A-4 Old missiles now discarded

A-4 The V-2

A-5 A missile half the size of V-2 that was used for development of control while the full scale motor and other details of V-2 were being developed. It could descend by parachute to preserve records of built in cameras. From 1939 to 1942 all control methods were first tried in A-5. After that time A-4 could be used directly.

A-6 Same size as V-2, but was to use Solbei (nitric acid) instead of liquid oxygen.

A-7 Similar to A-5, but with little wings. It was only for development and only a few shots were made.

A-8 Same size as V-2, and same oxidant (LOX) but with little wings. This unit did not pass the project stage.

A-9 Same size as V-2, oxidant was Solbei and was to have little wings. Its range was to be 600 km.

A-10 A very large missile for trans-Atlantic shots that was still in the project stage.

In addition to these there was a project known as the A-4b. The A-9 as originally planned used a body construction considerably different from V-2 to give wing support. Since the V-2 was in production and was all tooled. The A-4b project was started to add wings to the V-2 body. Due to the lower strength and improper utilization of weight, a maximum range of only 450 km was expected.

B. Brennschluss control ... The three methods of Brennschluss control mentioned were all previously known. The interrogation was confined to details not known to the writer from earlier reports. There were two methods of Brennschluss control by different types of integrating accelerometers. These were the gyroscopic type for which the code name was ILLER and the electrolytic current-integrator type whose code name was ISAR. Also there was a radio method developed by Prof. Wolman. Its code name was CAMPANIA.

Wolman's apparatus measures the missile velocity through the Doppler effect. A doubler and relay transmitter are included in the missile to make the system not depend on weak reflected signals. The receiving apparatus on the ground must terminate in a frequency measuring bridge. This bridge feeds an amplifier (and limiter) and a detector. The bridge balance point is somewhere around 400 cycles. The amplification is so high that the detector output goes from saturation in one direction to saturation in the other direction for a change in frequency of only 0.1 cycle per second. At the null point or at a specified value close to it a relay operates. The circuit is so arranged that for Vorbrennschluss a relay reduces the thrust and simultaneously connects an extra capacitor across one arm of the bridge to change its balance frequency to the full Brennschluss value. The output immediately becomes saturated again and only about three seconds later when it goes through the new null point, does the Brennschluss relay act.

For accurate range control either knowledge or control of both velocity and position is necessary. For the latter double integration of some kind in the missile was considered. One means considered and not previously seen reported used two rate gyros. The first precessed at a rate determined by the acceleration. Its angular position was converted into a force by some such means as a screw and a spring and this force caused a second rate gyro to precess. The angular position of the second gyro then gave distance travelled.

Prof. Wolman had been supervising a series of 200 shots at Tuchelerheide to find the comparitive accuracies of the three methods of Brennschluss control. They expected the ultimate limits to be:

	50% of shots in a bracket of
ILLER	8-10 km
ISAR	4-5 km
Radio	2-3 km

but Grottrup did not think the latter would be achieved yet because most of the error would be in other than the integration - in valves, relays, variations in pressure fall in the chamber, etc.

To reduce other errors in Brennschluss various means were being considered. The fall of pressure in the chamber is not instantaneous, but can be allowed for if reproducible. However, variations

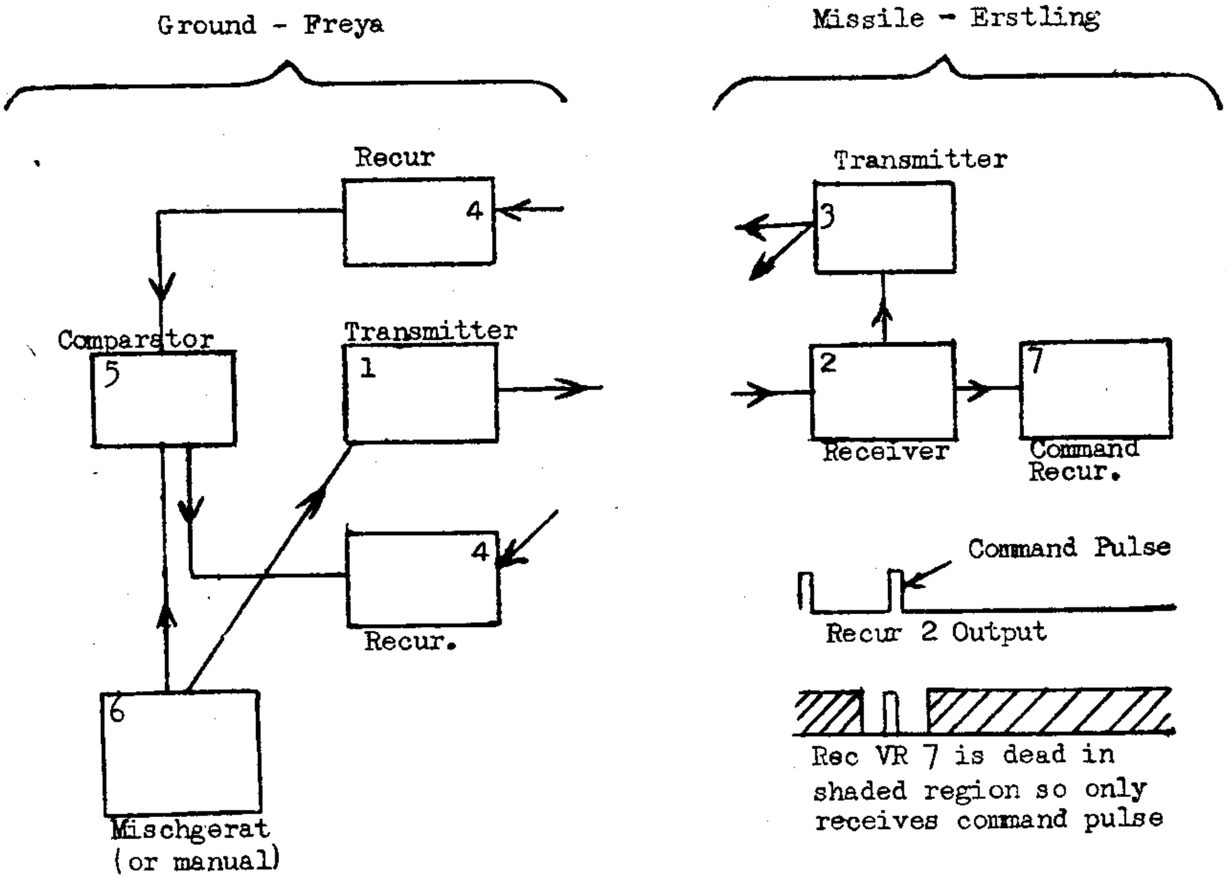

Figure 5. Freya - Erstling Line Control System

are caused by varying degrees of incomplete combustion etc. To reduce these, flushing of the chamber with nitrogen gas from bottles at Brennschluss was considered. Also the alcohol bypass valve, used partly to prevent water hammer at Brennschluss, gave some errors. It was found that the water hammer effect was not serious so they considered eliminating this valve action at Brennschluss.

C. Line control.. A lateral accelerometer had been developed by Prof. Hueter of TH Darmstadt. Dr. Schlidt was the EW man who worked with him. The device consisted of a coil suspended in a magnetic field and used their principle of a vibrating contact to get good characteristics without backlash. The coil would alternately make contact to the right and left and each action would cause a current in the coil in the direction to make it move to the other contact. For no lateral acceleration there was equal dwell, but any lateral acceleration gave unequal dwell, hence a net output signal. First suspension used was a pivot bearing, but the coil then moved in the arc of a circle which would lead to errors from longitudinal acceleration at other than the mid position, so a sliding suspension using air for bearing flotation was being developed. AEG was to produce this accelerometer; specification sensitivity was to 0.001 g.

A line control system that was to be used for tracking the A-4 and later for controlling the A-4b and A-9 was based on the Freya ground radar. A beacon used in the missile was called Erstling (and later Neuling). For control, the command signal would also be given by the Freya ground station. The control system planned is shown in block form in Fig. 5. Transmitter 1 broadcasts a pulse at about 2 meters. Receiver 2 in the missile receives it and causes transmitter 3 to immediately reply on the same frequency. It is received back at the ground station by two antennas. Grottrup was not able to be positive as to whether the phase of reception at the two antennas was compared or whether they were phased relative to each other to give lobe switching on alternate pulses. In any case, a comparison is made, either manually or by a Mischgerät and a command signal delivered to the transmitter 1. This command is transmitted as an auxiliary pulse a short time after the ranging pulse. A second chassis in the missile, 7, is normally cut off, but is activated by the main pulse to be able to receive command pulses at specific times after the main pulse. The antenna used for the Freya was first standard with the receiving antennas several meters apart. A rotatable mount was planned on which they could be 20 meters apart. Although there would be many side lobes, the basic control was expected to be good enough to keep it on the center lobe. An error of $1/10^{\circ}$ was expected to cause about 1/3 the max. receiver signal. GEMA built one station.

D. Range program of A-9 and A-4b ... Both these missiles were to have stabilised platforms with three gyros to control stability and mount control accelerometers. The trajectory expected is shown in Fig. 6. Up to Brennschluss it behaves like the V-2, reaching a velocity of 1500 meters per sec. Accurate control is not necessary because the missile is still controllable at certain times after Brennschluss.

Therefore, the Iller control was planned. Up to A, the point of re-entry into the atmosphere it must behave as a free body. A time program precesses the gyro pickoff up to A. From A to B it is controlled in height by attitude angle, or "wind". It is desired to make best use of the velocity energy in obtaining range so the attitude angle is controlled for the best glide, which should be a known function of the virtual velocity or "wind". The final velocity at B is 100-200 meters per second and the height 5-10 km. From here it goes into a dive that is a time program.

The missile is tracked in range and controlled in line by the Freya-Erstling system until the curvature of the earth prevents. Shortly before this at point D, a lateral accelerometer takes over control of line and a double integration in the range direction was being considered for range control.

E. Antennas used on Missiles... Information concerning various types of antennas used or tried and their performance was received.

On the A-5, which had no warhead, a nose antenna, insulated from the body, and sticking straight forward, was tried.

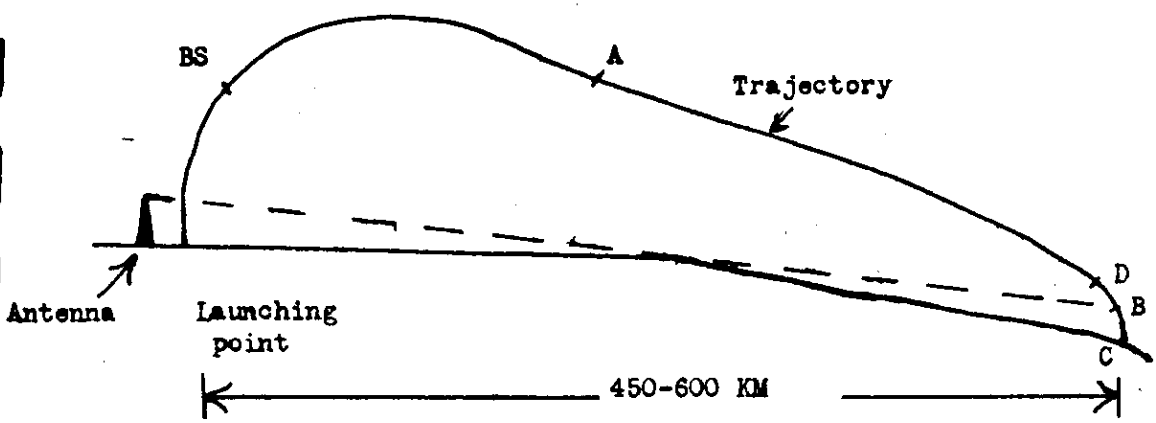

Fig 6. PROPOSED TRAJECTORY OF A-9 AND A-46

On the V-2, three types were used for various purposes. These are sketched in Fig. 7 a, b and c. A is on the tail. A section of the skin and supporting structure is replaced by hard paper or fibre insulation. A strip at the edge that is about 80 cm. long functions as the antenna. Two on opposite tail fins are connected together by coaxial cable of an odd number of half wave lengths. The feed is to the end of one. In little panel inserts in the fibre panel

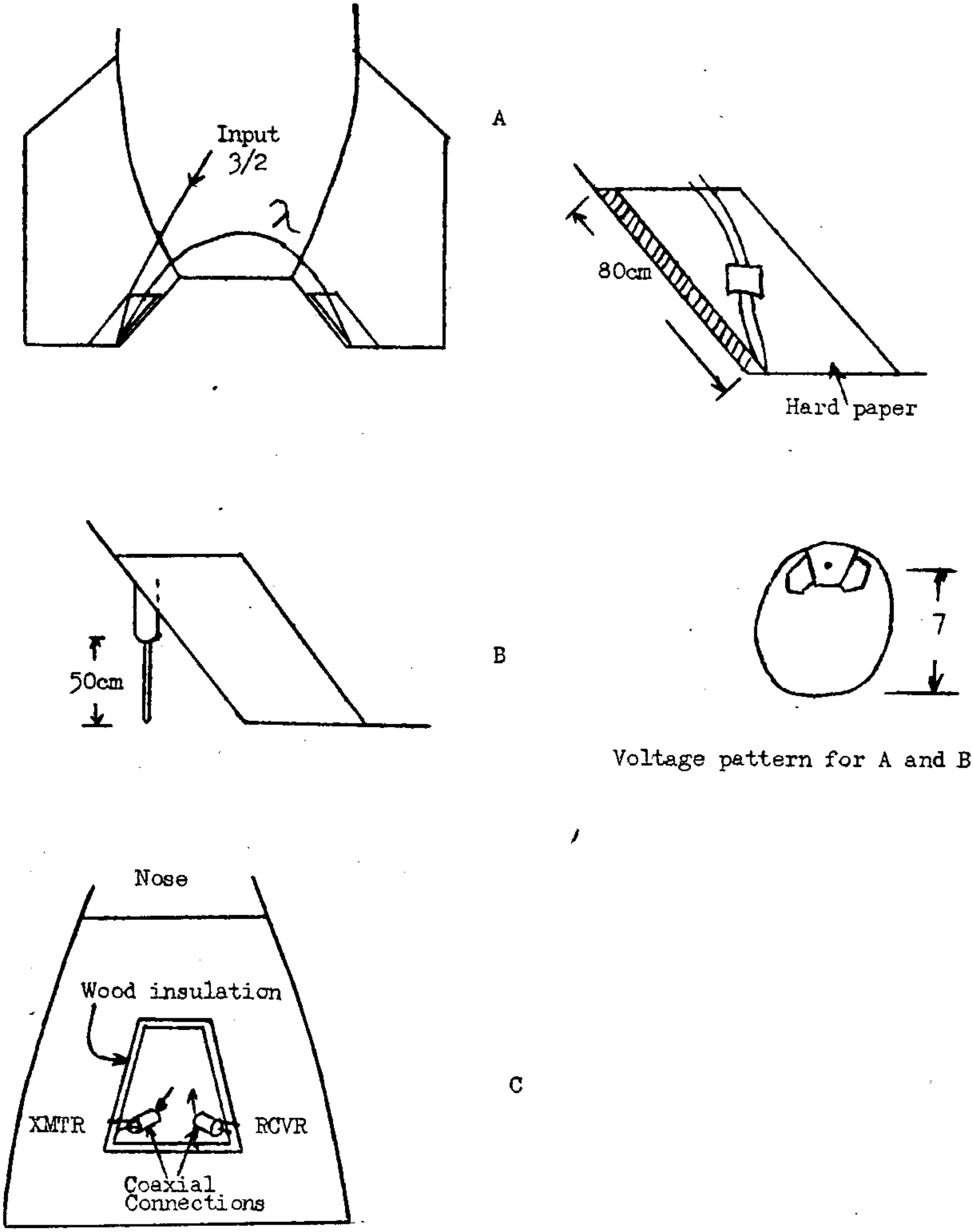

Figure 7. Antenna Types Used on A-4

are the antenna tuning impedances. These cannot be considered strictly as quarter wave dipoles for the whole missile plays a part in the tuning and the pattern. The pattern gives about seven times as much voltage gradient at a given distance to the rear as at the same distance in front. This antenna is used particularly for the Kommando receiver.

Developed particularly for the Leitstrahl is the antenna shown at b. The same type of paper panel is used, the two halves are interconnected by a 3/2 wave line as before, but the antenna is a coaxial line terminated in a rod 50 cm long that points rearward. The pattern is about the same.

The Türantenna shown at c is for the Verdoppler and Wolman's idea. Two doors, one on the right and one on the left side of the missile, in the radio compartment, are insulated from the rest of the body by a strip of wood. This leaves a Lecher line or two-wire line all around the panel. Coaxial lines are attached to this line as shown, one for receiving at 30 MC. and the other for transmitting at 60 MC. The connection points are chosen to secure considerable isolation between transmitter and receiver due to nodal points. The standing wave pattern set up on the metal near the slot radiates a good pattern into space. Transmitting with 6 watts, they are able to receive 6-10 millivolts just before Brennschluss when the missile is 40 km from the receiver.

Concerning effect of the jet on radio, Grottrup said that the voltage at the ground receiver increased 5-10 fold immediately after Brennschluss. There was a troublesome fading with a period of about one per second that they never solved completely. They thought it might be earth reflections, but tests on this proved negative.

VII <u>Conclusion:</u>

The information this man could give on many subjects was sketchy and care must be taken to separate his knowledge from his beliefs. The things recorded should, however, provide numerous lines for further interrogation.