B.I.O.S. FINAL REPORT No. 551.
ITEM No. 7.

GERMAN WIRELESS COMMUNICATION: MAINLY WITH REFERENCE TO Cm, Dm, and PULSE TECHNIQUE

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BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE

LONDON — H.M. STATIONERY OFFICE

German Wireless Communication, Mainly With Reference To Cm, Dm and Pulse Technique.

B.I.O.S. Trip No. 1891.

Reported by:

Mr. E. Coop — M. of S.
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B.I.O.S. Target Numbers :

C7/300,	C7/316,	C7/301,
C7/262,	C7/302,	C7/303,
C7/304,	C7/305,	C7/306,
C7/307,	C7/308,	C7/309,
C7/310,	C7/311,	C7/312,
C 7/313,	C7/244,	C7/315,
C7/211,	C7/314,	C7/214,

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Personnel of Team

Mr. D. Cooke	M. of S.
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Capt. J.R. Guest, R.E.M.E.	M. of S.

Wireless Communication

1. Introduction

1.1. Object of Trip

The primary object of the trip was to investigate German wireless communication technique in the dm and cm bands which had either not been previously reported, or was of direct interest to S.R.D.E. Some other targets of general wireless communication interest were also investigated.

1.2. Nature of Report

It was found that this field of investigation had already been quite well covered; the 19 targets visited yielded little information additional to that already known. This Report, therefore, only covers certain specific points on which full details have not yet been published.

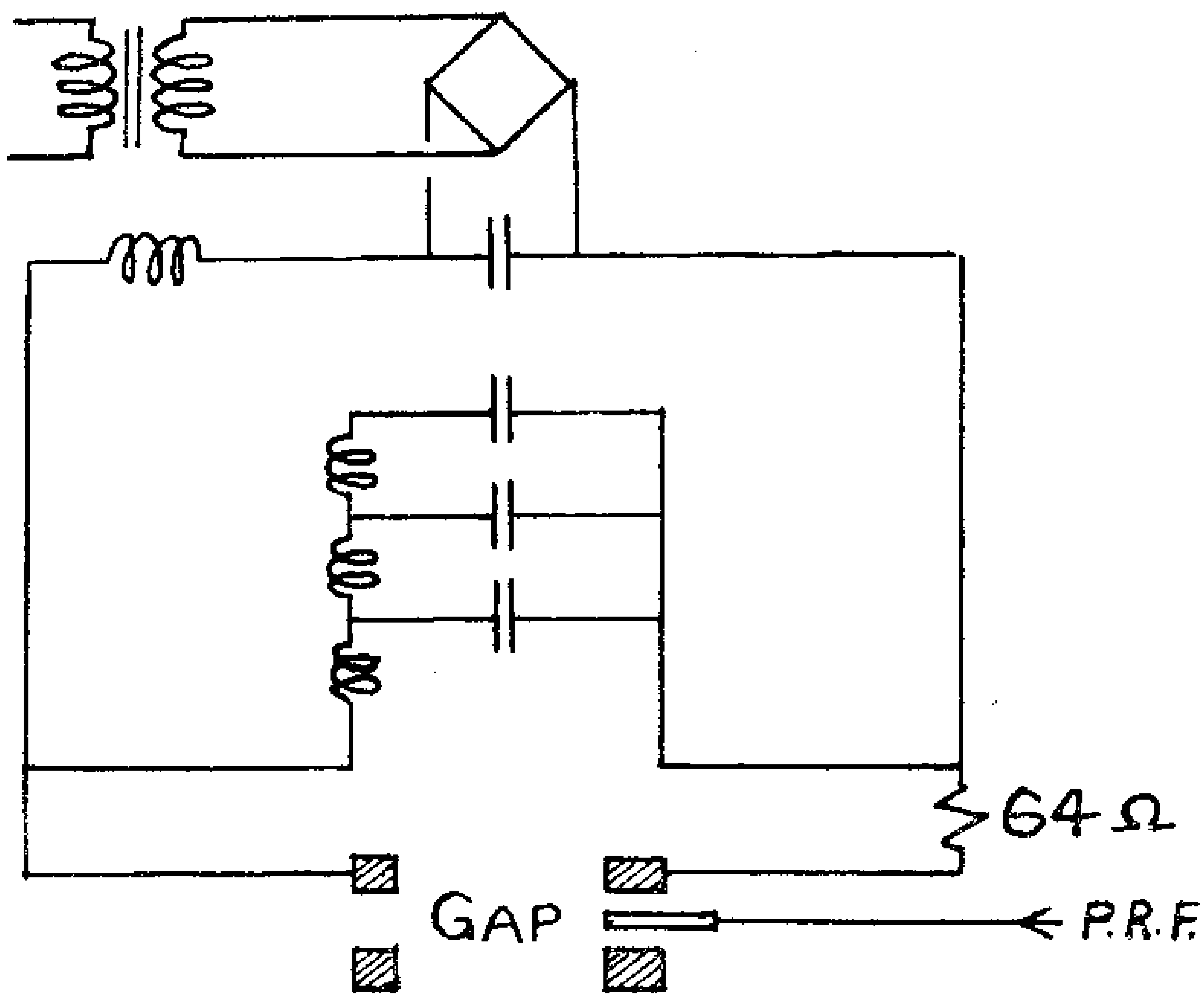
2. Interrogations on Production and Utilisation of Short Pulses

2.1. Prof. Dr. Ingr. MARX C7/300

MARX was interrogated at the site of his laboratories, at (20) MEINE bei BRAUNSCHWEIG. Apart from a few high voltage transformers and condensers, all apparatus had been removed from the site. MARX, originally at the Brunswick Technical High School, had done a considerable amount of work on high-voltage transmission lines, in connection with which he had produced high-voltage pulse-generating equipment for testing purposes. In 1943 he was instructed to develop his pulse-generator for use with new TELEFUNKEN radar equipment which he thought was never completed. He was given a target of 30,000 V and 300 A, i.e. 9 megawatts, which he never achieved owing to supply limitations, but claimed to have used voltages up to 25,000 V of which one half was apparently developed across a load resistance of 64Ω, giving approximately a 2.5 MW pulse. The pulse width was 1μS.

The system used was the well-known one using an artificial line and spark-gap. The type of line used is shown in the sketch overleaf. The negative electrode was an annular ring around the priming electrode, and a stream of air was directed between these electrodes and thence through the hollow positive electrodes.

Marx had also worked on a rotary system, but stated that the artificial line gave much greater freedom from jitter. A P.R.F. of 1500 c/s was used and photographs of the pulse, taken on an oscillograph, with 1/5 sec. exposure, showed a clearly defined leading edge. Although Marx claimed a build-up time of 10^{-8} sec, the photographs only showed one of about 10^{-7} sec.



2.2. Dr. W. KROEBEL C7/316.

Kroebel was interrogated in the laboratories at Herren House, Schloss Bredeneck, Nr. Preetz (12 Km. S.E. of Kiel).

Kroebel had used a discharge tube and differentiating circuit for the production of very short pulses. The method used consisted of generating a pulse of the order of 1 microsecond duration by any of the well-known methods and applying this pulse to the grid of a gas discharge tube (Type EC.50), the anode circuit of this tube being followed by a differentiating circuit of short time constant. This process was repeated using several discharge tubes and differentiating circuits in cascade until a pulse of the desired duration was obtained. This method was used to obtain pulses down to 10^{-7} seconds duration; to obtain shorter pulses than this the gas discharge tubes were then followed by hard valves and suitable differentiating circuits and by this means, pulses of 2×10^{-8} seconds duration had been obtained.

Further work is still being carried out with these circuits in an endeavour to obtain pulses of 10^{-9} secs. duration.

2.3. Dipl. Ing. RICHARD FILIPOWSKY C7/301.

Filipowsky is at present (March, 1946) at FISCHBACH near BAD AIBLING. Interrogation produced no additional facts to those reporte on (SIGESO 56, Sec. 1.2. AL No. 23, Sheet 23,) except that successful tests had been made using his 2 pulse (start-stop) communication system (Luft Kürier) over normal broadcast radio systems.

He is expecting to move shortly to:-

ROTHIS 99,
Nr. VORARLBERG,
AUSTRIA.

2.4. Dr. ROSENSTEIN C7/302.

Rosenstein was interrogated at MAXSTRASSE 8, SCHÖNBERG, BERLIN. He is at present working for the Russians, but had been brought to Maxstrasse by Dr. RUNGE of Telefunken, for whom he had worked during the war. Rosenstein was born in Holland but had become a naturalised German.

Dr. Rosenstein had been asked to produce a 100 channel frequency modulated communications link to be used on a wavelength of about 50 cms.

After some calculation it was decided that a 100 channel pulse modulated link would be more practicable and work was accordingly started on these lines.

The basic scheme was to produce an interlaced pulse train by means of an electronic switch.

The switch was eventually produced in the form of a cathode ray tube, the beam being rotated electromagnetically. Equally spaced anode segments were arranged in the form of a large circle on the large end of the tube which would normally carry the screen, and modulation from telephone line No. 1 was applied to segment 1, line 2 to segment 2, etc.

In order to obtain more sensitivity from the switch, secondary emission from the segments was collected by an electrode in front of the segment, the pulse amplitude thus obtained was approximately 0.1 volts across 10,000 ohms, the telephone line with peak clipping being fed direct to the segment.

With no modulation on any segment, a train of equally spaced pulses of constant amplitude would be produced from the segments.

When a particular segment had modulation applied to it, the pulses corresponding to that segment were amplitude modulated.

The pulse train was then integrated and the resultant waveform used to trigger off a multivibrator circuit; in this way the amplitude modulated pulses were converted to phase modulated pulses of constant amplitude. These pulses were then passed through a filter network which altered the pulse shape to that of a Gaussian distribution curve.

At the receiving end an exactly similar electronic switch was used for separation of the channels, the phase modulated channel pulses being converted to width modulated pulses after which the elimination of the pulse recurrence frequency was effected by a low-pass filter.

The first experiments had been carried out with a switch designed to give 8 channel pulses and one synchronising pulse. The chief difficulty encountered was that of obtaining a sufficiently sharply focussed electron beam.

A switch for a 32 channel system had been designed and tested and cross-talk between adjacent channels had been shown to be better than 60 db.

No work had been carried out on the 100 channel system but the intention was to use a recurrence frequency of 10 Kc/s, channel pulses of 1/3 microsecond or less if possible, and a one microsecond synchronising pulse.

The electron switches were designed by DR. GUNDERT who is now in Göttingen. No samples or circuit diagrams were available from Telefunken.

2.5. Dipl. Ing. ALFRED VOLLMEYER C7/262.

Vollmeyer, an ex S.S. man, was interrogated at No. 1 Civil Internment Camp, NEUMUNSTER, SCHLESWIG HOLSTEIN.

He had worked at NVK, at HOERUPHAFF, SONDERBORG, DENMARK. From 1942, he had been working with PAWLOVSKI (now believed with the Russians) on a multi-channel speech secrecy system.

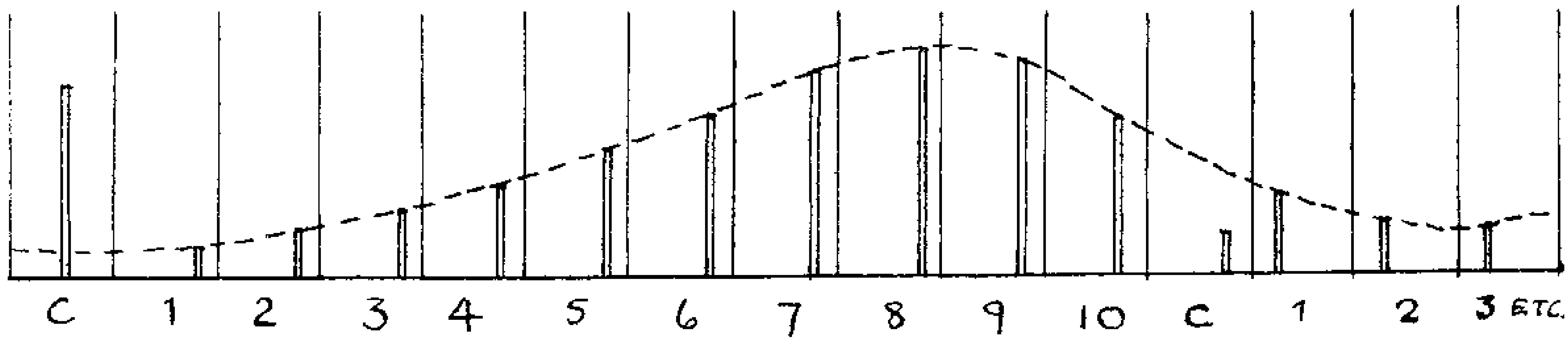
Pulse amplitude modulation was employed, although this was not essential, any form of pulse modulation could have been used. 20 speech channels were used in Vollmeyer's system, these channels being used to amplitude modulate 20 pulse trains which were subsequently interlaced in a predetermined order to form groups of 20 pulses, (one per channel). The relative positions of the channels within the groups remained unchanged for 10 successive groups, their positions being established at the receiver by a coding group of 20 pulses, (similar in formation to a speech group), sent immediately prior to the 10 speech-modulated groups. The coding group (and hence channel order) was selected at the sender by a tape. The next 10 speech groups had their channel order changed, but were again preceded by a coding group giving the new order for selection at the receiver.

Briefly, the order of events was:- a coding group of 20 pulses followed by 10 speech groups each of 20 pulses, then another coding group followed by 10 speech groups, and so on. The diagram shows this sequence diagrammatically.

Any number of channels may be modulated with real or camouflage messages.

This system has never been used in practice, Vollmeyer and Pawlovski only having made one model, which along with their records was destroyed. Vollmeyer had a very high opinion of the degree of secrecy of his system.

MULTI-CHANNEL SPEECH-SECRECY SYSTEM



CODING GROUP — 'C'   SPEECH GROUPS — 1, 2, 3, 4, ETC.

A.F. SHEWN - - - - - - - -, IS SINGLE CHANNEL ENVELOPE.

FIG. 1. ARRANGEMENT OF GROUPS, SHOWING ONE CHANNEL ONLY

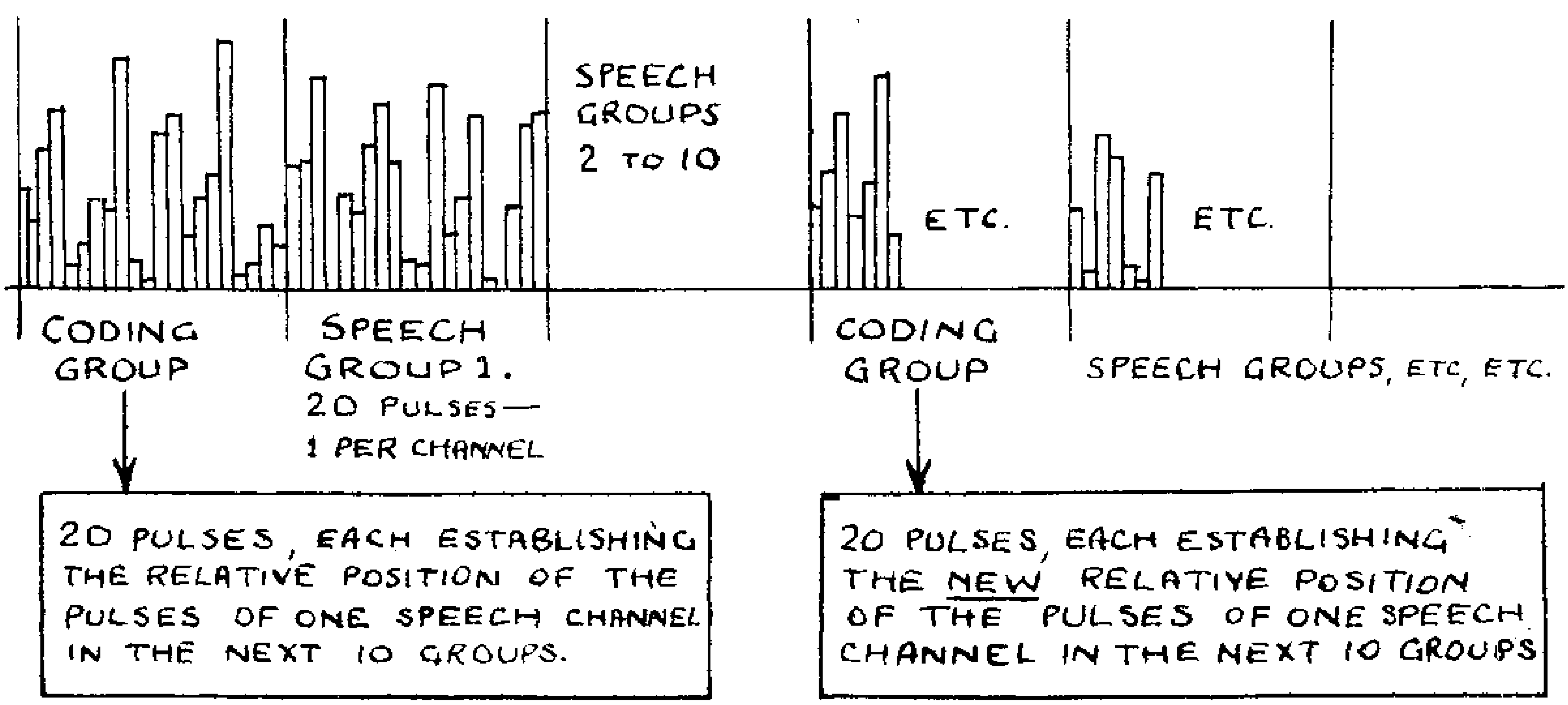


FIG. 2 TYPICAL ARRANGEMENT OF CHANNEL PULSES

2.6. Dr. MESSNER of Lorenz, Lorenzweg, Templehof, Berlin.

C7/303. Messner was unable to give very much information on communications equipment as most of the Lorenz communication engineers are now at Falkenstein in the Russian zone.

Mention was made of the equipment Fu.Ge.13, a single channel pulse communications equipment which used three short pulses for the one channel, the centre pulse of the three being modulated and the other two unmodulated, the advantages claimed for this system being security and freedom from interference.

Messner has promised to obtain a full report on Fu.Ge.13 from Falkenstein to be forwarded to S.R.D.E. via Berlin Military Government.

3. High Stability Tuneable Oscillator C7/304.

Interrogation of Herr PROTZE of TELEFUNKEN at MAXSTRASSE 8, SCHONBERG, BERLIN.

As a result of a Naval requirement for a very stable transmitter which had to be capable of continuous tuning, Telefunken had done a considerable amount of work on high stability circuits, in close liaison with various ceramic manufacturers.

It was decided to use fixed condensers and vary the inductance to provide the desired tuning range; change of inductance was effected by rotation of short circuited coils within the main coil thus avoiding any moving contacts.

As the maximum change in inductance is obtained by only a 90° rotation of the coils, 2:1 reduction drive was used. This was obtained by attaching the control spindle at 45° to the effective plane of the coils, 180° rotation of the spindle thus being necessary to obtain a 90° rotation of the tuning coils in relation to the plane of the main coil.

By the use of 3 short-circuited coils mounted at different angles as great-circles on the surface of a ceramic sphere, an approximately linear relationship between frequency and spindle rotation was obtained. Over a spindle rotation of 170° this relationship lay within ± 5% of a straight line.

The main coil consisted of a ceramic tube with colloidal silver baked on the inside and galvanised with copper, the exposed surface being highly polished. The greatest current density was therefore at an extremely regular and homogenous surface. In order to reduce self-capacity, the ceramic between conductors was ground out.

The frequency range obtained with this type of coil was 1:1.26. The dimensions of the largest coil produced were:- diameter 10 cm; 25 turns each 2 mm wide, separation 1 mm; the deposit was 0.06 mm thick.

Protze mentioned a new method of depositing metal on ceramic surfaces by heating molybdenum almost to softening point. He thought that the resulting joint was probably stronger than the ceramic itself, thus allowing conductors of any depth to be built up. This system was developed by Dr. PULFRICH who, it was thought, had been killed in BRESLAU.

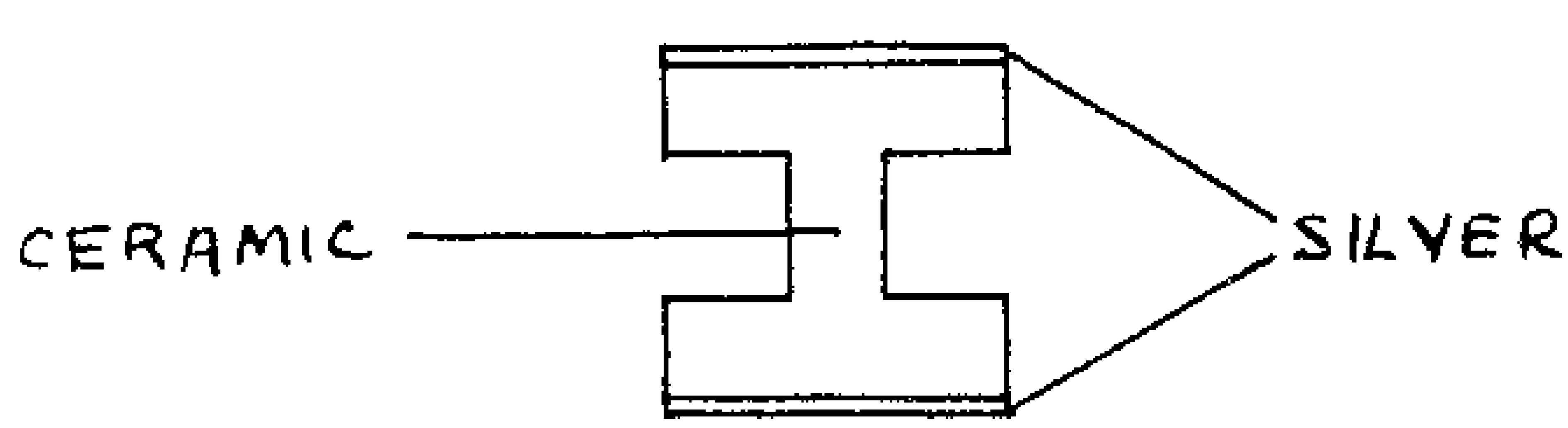
Temperature coefficient of inductance of the coil was minimised as far as possible by use of different materials in the rotor and stator and mounting the rotor on one thrust and one sleeve bearing by use of small masses and by keeping circulating currents as low as possible.

The coil was finally lacquered to prevent any ingress of moisture. It had a temperature coefficient of inductance of +7 to $10 \times 10^{-6}/^{\circ}C$.

A ceramic, stated to be "between Tempa S, and Tempa T but more stable" was specially developed as dielectric for the fixed condensers with a linear K/temp. characteristic from -50 to +70°C. The condensers had a temperature coefficient approximately equal and opposite to that of the inductance.

A range switch was used to cover the required frequency range, and this, together with the fixed condensers was built into a metallised ceramic box. The whole assembly was dried out, slightly pressurised and sealed. A manometer was installed to check the pressure in the box.

The leads consisted of silver burnt on to ceramic H sections; thus by variation of the dimensions of the ceramic it was possible to compensate for capacity changes due to variation of the mechanical size of the conductor with temperature.



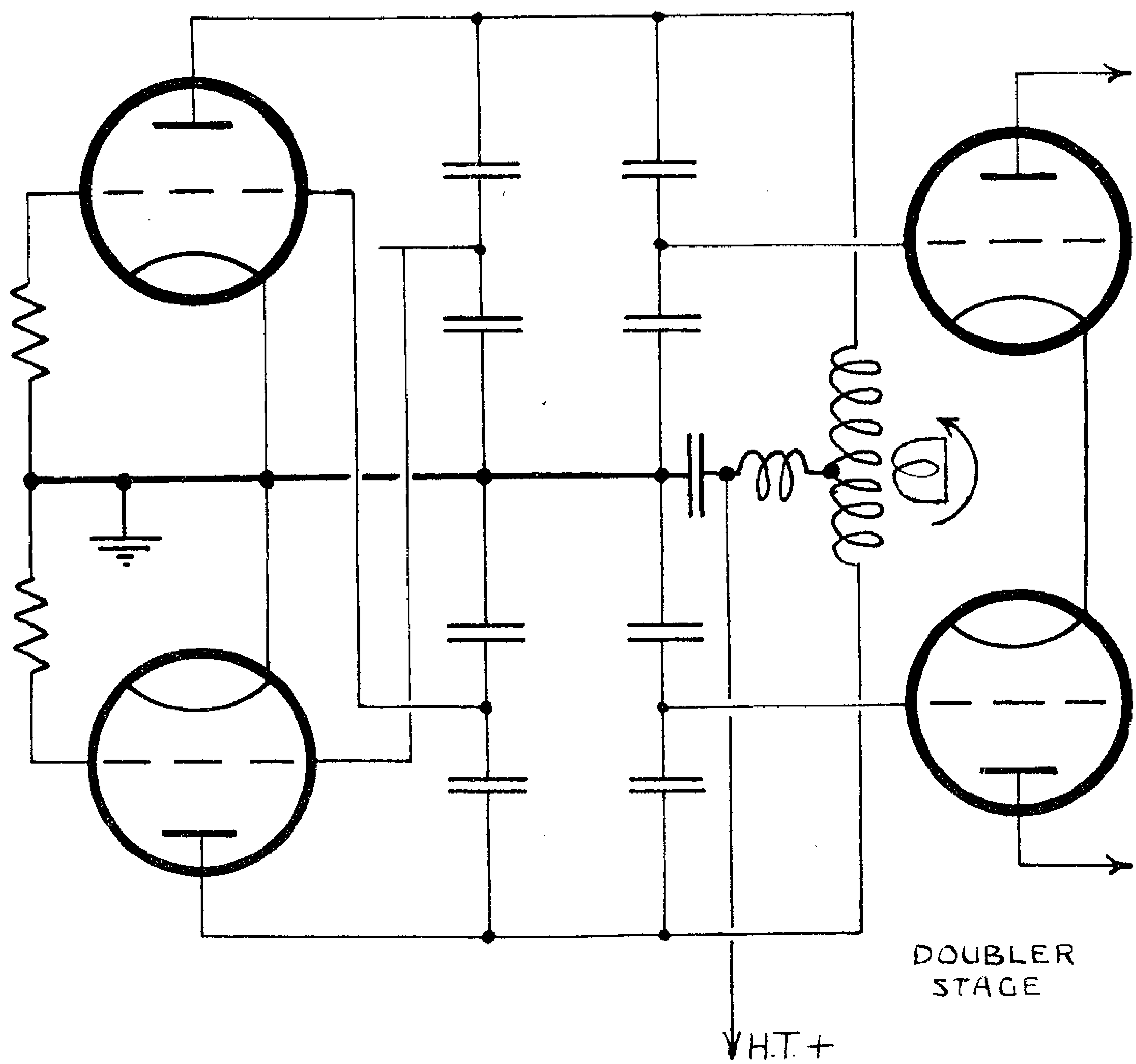
TEMPERATURE COMPENSATED LEADS.

After assembly of the complete transmitter, minor adjustments, compensation, calibration (by photography) and general testing were carried out. These operations usually took about 1 week.

The final figures given by PROTZE for frequency stability between -50 and +70°C were:-

above 6 Mc/s: 0.5 to $0.8 \times 10^{-6}/°C$
below 6 Mc/s: 1.2 to $1.3 \times 10^{-6}/°C$,

using REN904 valves in the oscillator and a circuit as shown in the diagram. Protze claimed that the warming-up time necessary was only 2 minutes and that the stability figures given and calibration had held over 2 years operational use.



BASIC CIRCUIT OF HIGH-STABILITY OSCILLATOR.

4. Dr. VON. TRANTINI (interrogated at Australia House, Pöking, Nr. Starnberg (S.W. of Munich). C7/305.

Dr. Von Trantini was formerly a department head of E.N.K., Konstanz, and gave the following information on work he had carried out there.

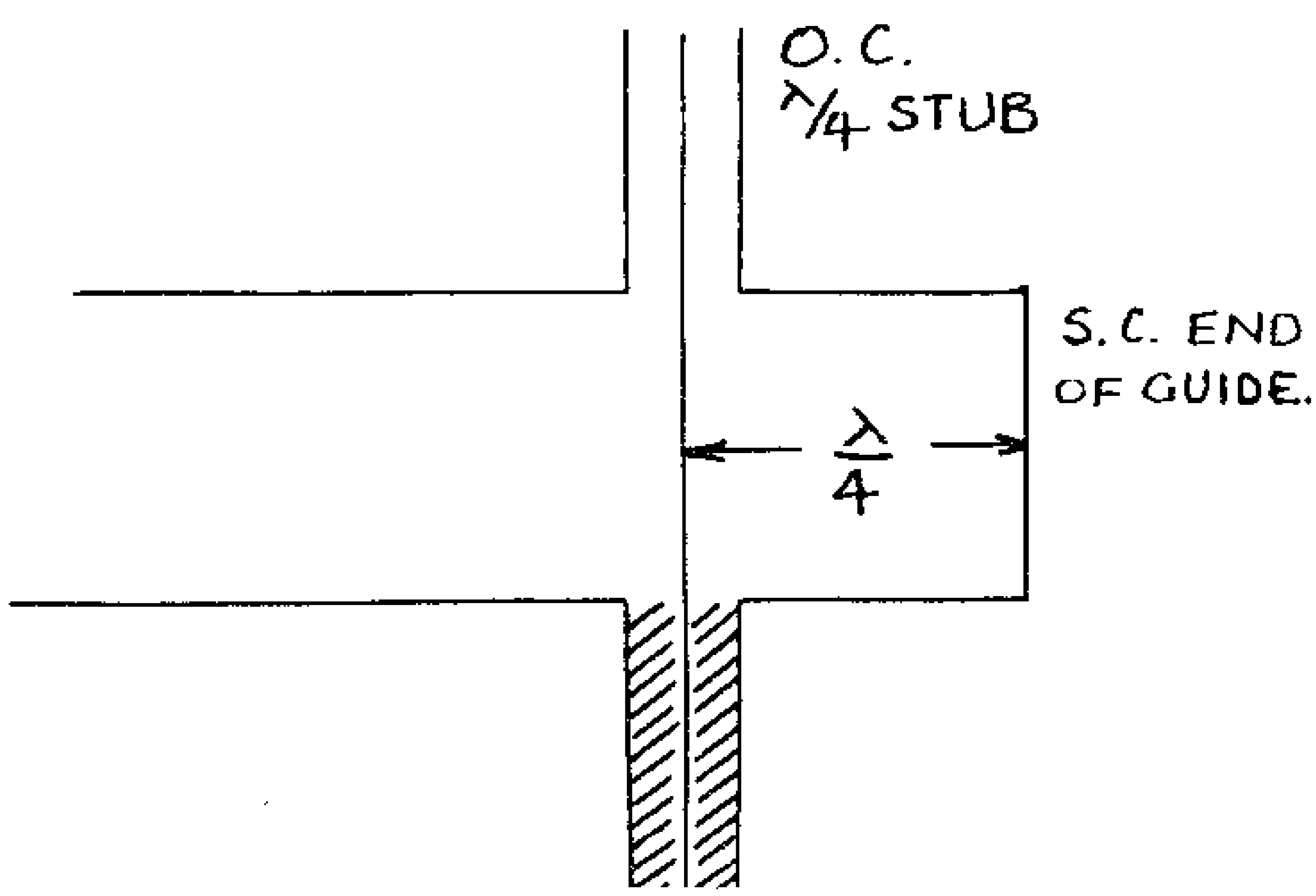
4.1. Search receivers for centimetre wavelengths

These receivers were designed to cover the range of approximately 0.8 to 10 cms. in 4 bands and were of a simple detector type, with the crystal detector mounted directly in the horn. The outputs of the four receivers were simultaneously displayed on four separate time bases on a common cathode ray tube.

4.2. Broad-band matching devices

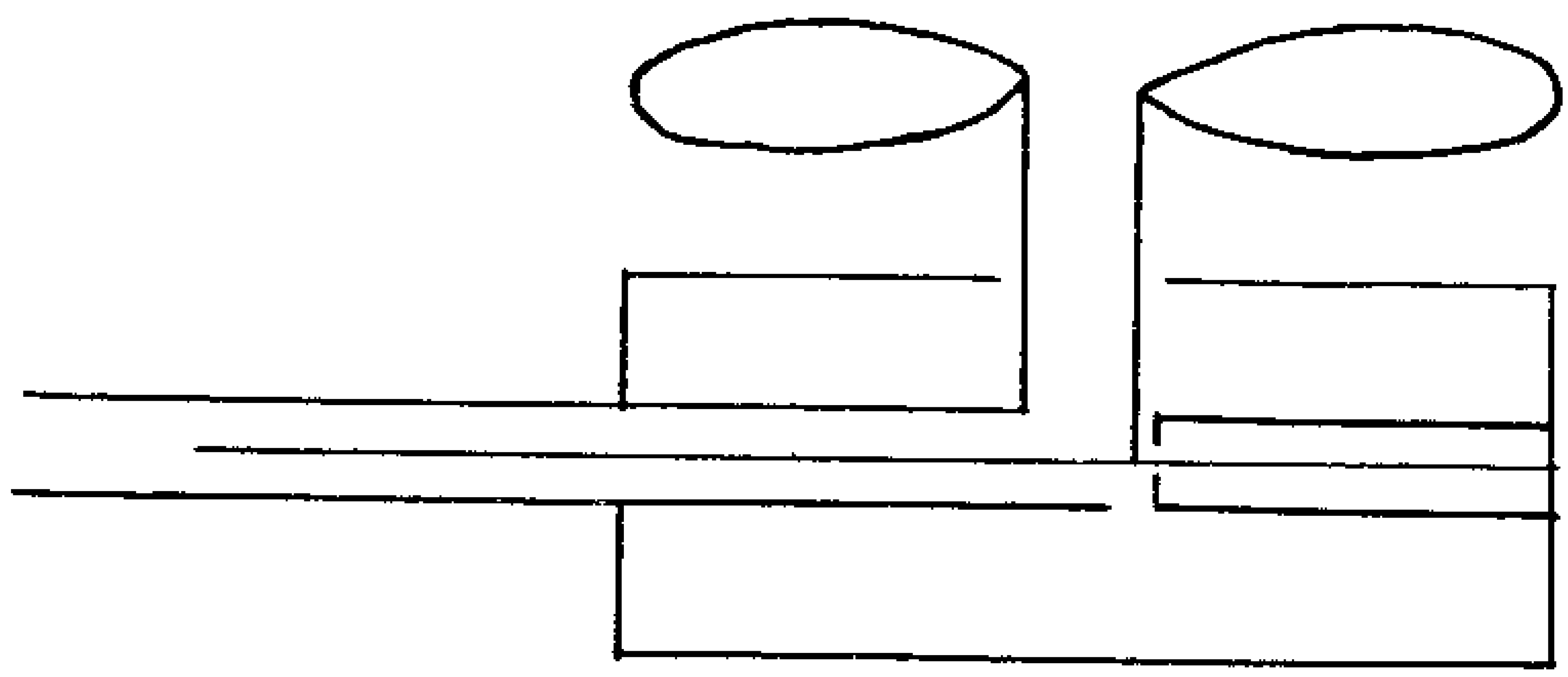
(a) To cover an octave without change of mode, a dumbell section waveguide had been used. The lowest wavelength range for which this type of guide had been used was 8 to 16 millimetres.

(b) A system had been developed for broad-band matching of a waveguide to a concentric cable. The cable was fed into the face of the guide at a distance of $\lambda/4$ from the short circuited end of the guide, and the free end of the cable was terminated at the opposite side of the guide by an open ended $\lambda/4$ stub. The arrangement was as shown in diagram below.



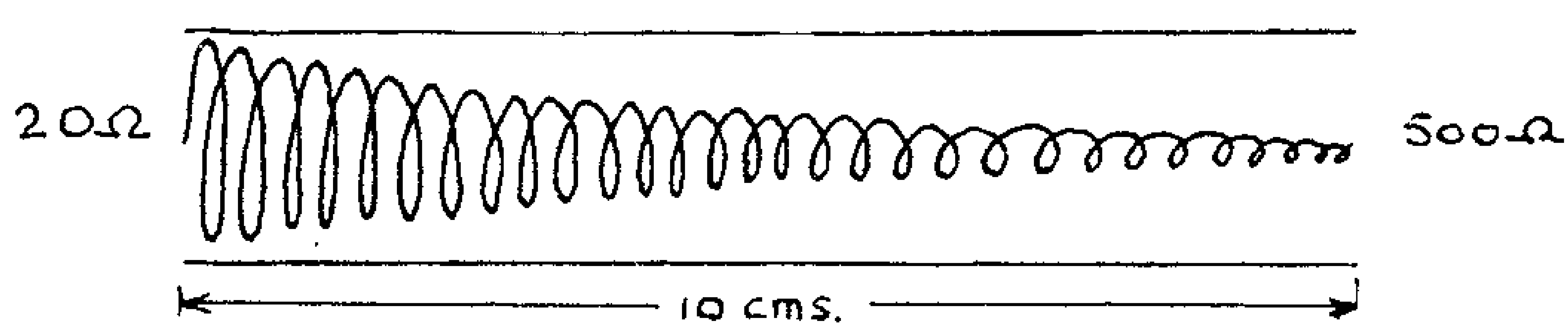
The above arrangement was used for a range of wavelength of 1 to 2 cms.

4.3. Broad-band dipole aerial systems had been developed which covered an octave, the radiators being of lemniscate section. The feeding arrangements from the concentric cable were conventional except for the use of a $\lambda/4$ supporting pillar as shown in diagram.



4.4. Broad-band concentric cable matching transformers of two types had been developed, the first type consisting of a constant diameter inner conductor and an exponentially tapered outer conductor, and the second type having a constant diameter outer and an exponentially tapered inner conductor. The cables were capable of matching from 200 - 600 ohms.

As the length of such cable for a wavelength range of 1.2 metres down to a few millimetres would be about one metre, the more convenient form of cable using an exponentially tapered spiral inner, as shown in diagram below, was used.



DIAMETER OF OUTER 20mm.

DIAMETER OF INNER 18mm TO 2mm

INNER SPIRAL APPROX 3 TURNS PER CM.

5. Dr. HABAAN C7/306.

Dr. Habaan was interrogated at the Berliner Physikalische Werkstätten, Woyrsch Strasse 8, Berlin W.35.

He described a magnetron which had been developed for use as a detector, for which a sensitivity of 80 to 500 times better than the best crystal detector on centimetre wavelengths was claimed. This magnetron has been fully described in SIGESO 56, Section 1.5, A.L. No. 12, Sheet 7.

Habaan also gave information on a negative resistance pellet which had been developed.

The pellet consisted of highly compressed metallic oxides and exhibited a negative resistance characteristic. It was capable of being used in an oscillator circuit up to a frequency of 20 Kc/s.

An oscillator embodying one of these pellets was seen, it had a substantially constant voltage output over a frequency range of about 500 - 3000 c/s with a drain of 5 m.a. from the 30 volt supply.

A full report on this pellet was seen at FIAT FORWARD, Berlin; (Report No. V. 113G).

C7/307. C7/308.

6. Dr. Runge and Dr. Kotowski interrogated at Telefunken, Maxstrasse 8, Berlin, gave information on the following equipments:- (a) Sägefisch, (b) "Michael" and (c) Rudolf.

The two latter equipments have been already reported in detail in Sigeso 56.

6.1. Sägefisch, developed by Kotowski, was an exceedingly reliable link for transmitting and receiving secrecy teletype.

The reliability was achieved by using triple aerial and triple frequency diversity. Single sideband was employed with partially suppressed carrier, and three groups of two-tones were employed to obtain frequency diversity.

Normal army wireless sets were used, the only modification being that the A.V.C. lines for each of the three sets were brought out and combined. The army transmitters used were not crystal controlled but had a stable oscillator developed by Telefunken.

Complete reliability of synchronisation for the secrecy system was obtained up to ranges of 2,000 miles using a transmitter power of 200 to 1,000 watts, feeding into a rhombic aerial system.

The maximum transmitting speed of Sägefisch was about 50 words per minute.

7. Dr. KLEINSTEUBER C7/309.

Dr. Kleinsteuber was interrogated at Funkstrahl (Immelmanstrasse,1), Konstanz, and gave information on the equipments "Moritz" and "Welligerate".

7.1. "Moritz" has been mentioned in Sigeso 56, Section 2.2, A.L. No. 15, Sheet 20, and full report on it has been written by R.A.E.

7.2. Welligeräte was a navigational aid equipment working on a frequency of 2,000 Mc/s.

The aerial system consisted of reflecting troughs of parabolic section fed by a concentric line with a radiating slot cut in the outer. The size of each reflector was approximately 2λ by 2λ, and, in order to obtain a horizontal beam width of $2\frac{1}{2}^{o}$, six of these radiators were used side by side.

A vertical beam width of about 15^{o} was obtained by stacking two such arrays one aboe the other.

All radiators were fed in phase from the same concentric line.

8. Antennen Verstärker (HNVK41)

During the interrogation of Dr. KROEBEL at Schloss Bredeneck, he was asked for a description of the HNVK41 which had been briefly reported previously (B.I.O.S. Interim Investigation Report No. E67A).

This apparatus is a conventional wide-band RF amplifier, for use at intercept stations between the receiver and remote aerial, a concentric feeder linking them. The frequency coverage was 0.5 to 20 Mc/s in bands of slightly less than 2:1. Input and output filters were constant K band-pass type, fed through wide-band transformers. Two band-pass coupled EF-14 valves were used as amplifiers.

9. Dr. SEIDELBACH - Interrogated at Lorenz A.G., Berlin. C7/310.

Facsimile System

The system was designed on classical lines using a rotating cylindrical message drum for transmission and reception. At the transmitter a photo-electric pick-up was used, with a chopping disc interrupting the light at 2000 - 5000 c/s. The receiving station is of interest, in that the picture was reproduced by a diamond point pressing a carbon-paper sheet against white paper. Thus, both positive and negative pictures were produced, the negative being in the form of a transparency where the carbon had been removed from the carbon-paper by the diamond print, thus making it possible to photograph as many copies as desired.

The scanning lines were spaced about 1/5 mm apart and the maximum recording speed was 1000 dots per second. A picture, about 4" x 6", could be transmitted in 3 minutes with considerable detail. Only black and white reproduction was possible.

10. Dr. LUDWIG MEYER C7/311.

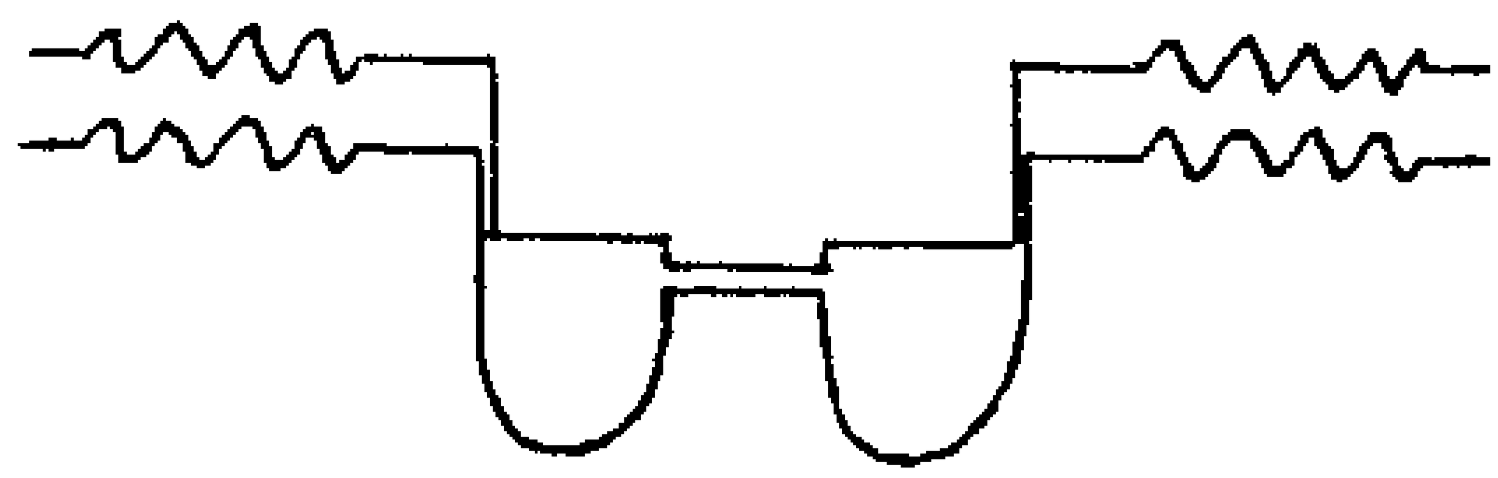
Dr. Meyer was interrogated at the Gräfelfing (Nr. Munich) branch of the Flugfunkforschungs Institut, the headquarters of which were at Oberpfaffenhofen.

Meyer had worked exclusively on centimetre valves, particularly on klystrons and magnetrons.

10.1. Klystrons

Two types of reflector klystron for C.W. operation had been developed, the first type having a substantially constant output over a large tuning range (3.8 - 5.0 cms) and a maximum tuning range of 3.5 to 5.5 cms.

The output power of different samples varies between 5 and 80 milliwatts, the efficiency varying from 0.5 to 1.5%. The second type was tunable from 1.7 to 2.1 cms and had an output of 5 - 40 mm with an efficiency of about 1%. The resonator and bellows of these klystrons were arranged as shown in the sketch below in order to obtain a large tuning range with the necessarily small resonator.



KLYSTRON RESONATOR AND BELLOWS

The shortest wavelength obtained with these klystrons was 1.55 cms but the lowest and shortest reproducible wavelength was 1.7 cms.

Some tests had been done with amplitude modulation of these valves over a small range but no information was available on linearity.

Comparisons of the following frequency changer circuits had been made:-

(1) Crystal mixer with klystron local oscillator

(2) Klystron mixer with klystron local oscillator

(3) One klystron as mixer and local oscillator combined

These experiments had not been completed but results indicated that the first alternative gave an improvment in signal/noise of 2 to 4 times, compared with the other arrangements.

10.2. Magnetrons

Continuous magnetrons of the two slot type had been developed for use in measuring equipments; the output was 1 watt at a wavelength of 2 cms and 400 milliwatts or less at 1.2 cms.

Tuning of these magnetrons was by an external line circuit which was coupled capacitatively through the glass to the internal lines attached to the anode structure.

Experimental magnetrons working on 0.9 cms had been made but their life was not considered satisfactory.

Pulsed magnetrons copied from the British and American "S" band types had been made, also similar valves giving 20 - 30 K.W. at 3.8 cms and 4 - 10 K.W. at 1.4 cms.

The above pulsed magnetrons all worked with a duty cycle of 1 to 2,000 or 1 to 20,000.

Some work had also been done on a valve of the resonator type not requiring a magnetic field, and giving an output of 2 to 5 K.W. at 3.2 cms with an efficiency of 1% at duty cycles of 1 to 2,000 and 1 to 20,000.

A full detailed report on all the work had been made to U.S. investigators who had removed all valves and equipment.

11. Dr. GÜLLNER, BLAUPUNKT C7/312.

Dr. Güllner was interrogated at the Blaupunkt works, Forkenbecke Strasse, Schmargendorf, Berlin. He was working for the Russians and devoting part of his time to Blaupunkt.

A brief description was given of Fu.Ke.8d, a receiver designed and made by Blaupunkt and used for navigational purposes in robot tanks. The receiver was a conventional FM superhet operating at approximately 25 Mc/s with the possibility of using one of 3 channels spaced 100 Kc/s in any one receiver. Four types of

Fu.Ke.8d were manufactured, giving a choice of 12 frequency channels. The deviation was ± 20 Kc/s. Navigational signals were transmitted on two-tones and a special relay circuit gave considerable freedom from interference.

Dr. Göllner also described an apparatus used apparently for measuring the distance between a tank and some rear point.

This equipment worked at 25 Mc/s. The transmitter at the rear point was frequency modulated at about 8 Kc/s, picked up by the forward tank receiver, re-transmitted and again picked up at the rear point. At the rear point, the transmitted and received signals were compared in phase by means of a goniometer, thus giving a measure of distance. Dr. Göllner stated that the accuracy was 5 metres at 1 Km and 20 metres at 20 Km.

12. Additional Targets

The following targets were also visited, but were found to have been very thoroughly investigated, or to offer no information of interest to the party.

C7/313,	Technisches Hochschule, Brunswick. (Dr. Lamberts).
C7/244,	Bergedorf Observatory, Hamburg. (Dr. Mueller).
C7/315,	E.N.K. (Konstanz).
C7/211,	Siemens and Halske, Berlin.
C7/314,	Te Ka De, Nuremberg.
C7/214,	A.E.G., Berlin.

13. Items to be forwarded

The following items are to be forwarded to S.R.D.E. via Military Government of Berlin:-

Item	Source
Magnetrons, 6.	To be made by Berliner Physicalische Werkstatten. (Dr. Habann).
Negative resistance cells, 12.	To be made by Berliner Physicalische Werkstätten. (Dr. Habann).
Report on Fu.Ge.13.	Lorenz, Berlin, are trying to obtain a report from their Falkenstein Laboratories.

Items to be forwarded (contd).

Report on propogation tests on 9 and 3 cms.	Siemens and Halske
Report on FM set for navigation of small tanks. (Fu.Ke.8d)	Blaupunkt

14. Conclusions

1. That the Germans had no centimetre of multi-channel pulse-modulated wireless communication equipment in operation. Although development work was proceeding on such equipment, no outstandingly new systems were envisaged.

2. The field of wireless communication investigation has been well covered. In addition, most equipment has now been well covered. In addition, most equipment has now been removed or destroyed and the German technicians have forgotten many of the detailed points of design.