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ITEM No. 7

THE DESIGN OF GERMAN TELEPHONE SUBSCRIBERS' APPARATUS

BRITISH INTELLIGENCE OBJECTIVES

SUB-COMMITTEE

LONDON—H.M. STATIONERY OFFICE

THE DESIGN OF GERMAN TELEPHONE SUBSCRIBERS' APPARATUS

reported by

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BRITISH INTELLIGENCE OBJECTIVES SUB COMMITTEE

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1. OBJECT OF VISIT

This visit was one of a series made by representatives of the G.P.O. and British line telecommunication equipment manufacturers to ascertain in what respects German line telecommunications design, operating and manufacturing technique had advanced during the war. This report deals with the Design of German Telephone Subscribers' Apparatus. Other reports being issued concurrently deal with:

The Manufacture of Line Telecommunications Equipment in Germany (B.I.O.S. Final Report No. 486)

The Design and Operation of Telephone Exchanges in Germany (B.I.O.S. Final Report No. 695)

The Design of German Line Telecommunications Transmission Systems (B.I.O.S. Final Report No. 687)

The Design of German Telegraph Apparatus and Teleprinter Switching Systems (B.I.O.S. Final Report No. 583)

Although the information in this report is mainly that obtained by the authors, use has been made in Sections 9 & 10 of information gathered by the Telephone Exchange team.

2. REICHSPOST POLICY FOR SUBSCRIBERS' APPARATUS 7/57

2.1 General

The number of different types of subscribers' apparatus in service appears to have been greater than in Great Britain, as the Reichspost purchased proprietary types from the various manufacturers. Latterly an attempt (though little actual progress) appeared to have been made towards standardisation on the basis of the best available proprietary types, orders for which were then divided between several suppliers.

Telephone instruments on direct exchange lines had to be rented from the Reichspost, but larger installations were usually purchased from approved contractors, though they could be purchased or rented from the Reichspost if desired.

Apparatus purchased by subscribers from contractors had to have the prior approval of the Reichspost, and permanent records of such approvals were contained in the "Reichspost catalogues of Systems" stated to be a black book about 2" thick (Braun).(1)

2.2 Standards for Exchange Service

Exchange service over extensions from a subscriber's installation was allowed only where the transmission equivalent of the extension line was better than 0.2 neper, and the line (if outside the subscriber's curtilage) was rented from the Reichspost. Extensive use was made on privately-owned-and-maintained installations of private circuits, i.e. circuits on which exchange service was not permitted. Inter-switchboard circuits were not allowed exchange service, and were limited to 25 km in length (Hertz).

2.3 Maintenance

Apparatus purchased or rented from the Reichspost was always maintained by them. Theoretically a maintenance visit was made every two years, and a proposal had been made that on these occasions transmitters and receivers should be replaced and taken in for test. In practice visits were made only when faults were reported except

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(1) The names in parenthesis refer to the sources of the information. Further details of these persons are given in Section 14.

except where a monthly visit was necessary, for inspection of secondary cells. Apparatus purchases by subscribers from Contractors was maintained by the subscribers own staff, or by contractors' staff centred in the larger towns. (Braun).

2.4 Telephone Installation work

In Berlin and some other cities a scheme for installation work had been introduced by Litzinger, as follows:-

1. The survey officer visited the subscriber's premises to decide on the location of the telephone and the quantity of stores required.

2. All stores were delivered by van in a special box containing everything necessary down to the smallest items.

3. Two fitters arrived to do the installation and wiring. Surplus stores were left in the box.

4. The survey officer returned, inspected the work and secured the subscriber's acceptance.

5. The box containing any surplus stores was collected by van.

The plan was successful and would probably have been extended. (Gladenbeck).

2.5 Superposed Wire Broadcasting

A wire broadcasting service at radio frequencies was included as a standard feature of the Reichspost telephone system.

During the war it became impossible to maintain supplies of the necessary filters for superposing the radio-frequency carrier on to subscribers' telephone circuits in the normal manner, and the expedient was adopted of applying the carrier at about 100 mV to earth to several bunched pairs in each main cable in the local networks. Signals could then be picked up by connecting the aerial terminal of a radio receiver to the metal base-plate of any telephone instrument, through the pair-to-pair capacitance of the cable, and the wire-to-frame capacitance of the telephone (Braun).

Regulations for the wiring of telephone and wire broadcasting stations are filed in the B.I.O.S. library under reference B.I.O.S. Docs/1533/146/2(391)/14.

SUBSCRIBERS' TELEPHONE INSTRUMENTS

3.1 General Mechanical Features.

German telephone instruments differ from their B.P.O. equivalents in the greater use of metal pressings. The main body of the instrument is usually of pressed sheet steel, with only the upper part housing the receiver rest moulded. The handset and other moulded parts are designed with projecting ribs along the mould joint lines, so that the moulding "flashes" can readily be removed without risk of damage to the finish of the principal surfaces of the moulding.

All telephones are of the handset type, with both receivers and transmitters as insets.

A mechanical lock is usually provided between the receiver rest and the dial, to prevent the latter being rotated when the receiver is on the rest. This is a necessary feature where earth dialling is employed, as is common in the German system, but the mechanism is flimsy and often inoperative.

Receiver rests of the type in which the cradle, including "horns," moves up and down as a whole are commonly used, but an instrument was seen which was used by the Wehrmacht, in which the handset rested on two pivoted arms instead of a sliding cradle. This instrument was provided with a ring above its centre of gravity for convenience in lifting. (Figs. 1 & 2).

Extensive use is made of press-buttons for earthing the circuit to give discriminatory signals for various purposes. The press-button is incorporated in the telephone. (Fig.1).

3.2 Trends in Electrical and Acoustical Design.

During the war research and development work on telephone instruments had largely been discontinued, so most of the information gathered on this aspect applies to the pre-war period. At that time attention was being directed to the development of improved microphones and receivers almost without regard for the cost of the final product. The decision to follow this policy originated from Gladenbeck, Chief of the Reichspostforschungsanstalt, the German Post Office research establishment, from its inception in 1936 or 1937 until 1942.

The cost of a subscriber's installation was stated to be made up as follows:

Subscriber's telephone	RM 17
House wiring	RM 50-60
Exchange apparatus	RM 150
Lines	RM 400-500

So the total cost was of the order of 600 to 800 marks. Compared with this the cost of microphone and receiver capsules was absurdly small being RM 0.65 and RM 2.50 respectively; their cost could therefore be increased several times without appreciably affecting the total expenditure. (Gladenbeck, Trage).

The Ministry adopted the recommendations and the Minister Ohnesorge wrote an article to this effect in the 1941/1942 Yearbook (Jahrbuch des Elektrischen Fernmeldewesens).

At the same time it was appreciated that close limits on the costly lines were not consistent with wide deviation between samples of the relatively cheap microphones and receivers, so attention was directed to the closer control of those instruments, with a grading system to use the better samples on the longer local lines (Braun).

3.3 Grading of Microphones and Receivers

Formerly the Reichspost examined only a small proportion of a contract by articulation testing. If these were below standard the whole delivery was returned to the contractor. Individually the instruments were tested only for D.C. resistance. (Gladenbeck, Trage, Hertz).

More recently the practice had been to test every instrument on the Reference Equivalent Meter described in Section 8.1. Instruments of abnormally low sensitivity were rejected; about 5% of microphones and 20 to 30% of receivers were returned to the contractor as being too insensitive. Under the existing contracts the Reichspost paid for their repair but it was intended to try to arrange future contracts to include a specified volume test. (Hertz, Braun).

Under the recent system of testing the instruments were classified into three categories marked with one, two or three dots according to their sensitivity. For microphones the reference equivalents in the three classes were 0 to 0.2, 0.2 to 0.4, 0.4 to 0.8 neper. C.B. microphones by Siemens & Halske had typically 32, 32, 31% in these three classes respectively and 5% were rejected. (Hertz).

The ultimate intention was to use the three categories of instrument to compensate for differences in the local lines; the fitters' work sheet would be endorsed to show which class of receiver and microphone to use. This scheme had not been put into practice; instead the better class insets were being used on exchanges whose junctions to the main exchange exceeded the normal 0.3 neper limit. Only a small proportion of the microphones and receivers in use had been graded, certainly less than 25%. (Hertz, Braun).

3.4 The Anti-sidetone Circuit

Before the war Reichspost telephones had been designed to give the best possible reduction of sidetone when fed from a 600 ohm non-reactive line. The line balance used was a 240 ohm resistor; the value is accounted for by the transformer ratio of the induction coil.

It was decided that in future the line balance should be a 600 ohm resistor shunted by a 0.3 microfarad condenser. This gave the best balance when used on long underground lines. For overhead and short underground lines an approximate match was to be obtained by disconnecting the condenser. Some 10,000 instruments had been made using this scheme. It was described in T.F.T.5, 109-113, 1935. (Gladenbeck, Braun).

3.5 Diagrams

A folder containing loose leaf diagrams of subscribers' apparatus is filed in the B.I.O.S. library under reference B.I.O.S/Docs/1533/146/2(391)/8.

4. CARBON MICROPHONES

4.1 Local Battery Microphones

The early L.B. (= German O.B.) microphone used a small number of carbon balls. It had a resistance of 12-23 ohms at 50 mA. It frequently packed and the volume then dropped by 3 or 4 nepers. It has been superseded by the type O.B.35 which is similar to the C.B. design but uses coarser granules to give a resistance of 20-60 ohms at 30 mA. The Army used the latter type of inset. (Trage and others).

The granules used were stated to pass a sieve of 40 meshes per inch and to be retained in one of 60 meshes (Hölzler).

Samples were secured from the German Naval Land Line Signal Equipment Store at Elmshorn.

4.2 Central Battery Microphones

The vast majority of German microphone insets use carbon diaphragms; only a few types for special purposes use any other material. The "star electrode" microphone described by Panzerbeiter (1) in 1938 is the latest type produced commercially by Siemens & Halske. Two models have been made having identical electrode and granule systems coded 32 and 38 by the Reichspost and 32a and 67a by Siemens & Halske. In the former the diaphragm is covered by an acoustical resonator having one small hole for the ingress of sound; about $1\frac{1}{2}$ million have been made for the Reichspost. The type 38 has a more normal type of grille and was made for the newly designed handset with reduced speaking distance. It incorporates a disk of transparent plastic film ("Vinifol") to exclude moisture. No other special precautions are taken to seal the microphone; the casing is spun over in the usual way. Although it will withstand brief immersion in water the sealing is imperfect; the humidity inside eventually becomes equal to that of the outside air. (Hölzler).

The moving electrode of the "star electrode" microphone is moulded integral with the flat carbon diaphragm in the form of a blunt cone cut back to leave only five narrow radial strips in the form of a star. The fixed electrode is in the form of a concave star and is covered by an insulating cap which leaves only the radial ribs exposed. This is to concentrate the current to the useful part of the granule chamber; it was found unnecessary similarly to insulate the moving electrode. The insulating cap is of lacquered aluminium; this being used in perference to painting the carbon since the Siemens' production staff found it to be cheaper. Originally it was intended to align the two stars so that the ribs were in juxtaposition but this has been found unnecessary;

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(1) Europ. Fernsprech., 51. 48, 1938

the performance and resistance are not appreciably affected by rotating one star relative to the other. (Hölzler, Janovsky).

It was stated that the chief advantage of the star electrode system is that its volume and quality of reproduction are practically unaffected by changes of position of the instrument. An older design with a pointed conical moving electrode was good in this respect but gave frying trouble due to the high current density in the neighbourhood of the point of the cone. (Hölzler, Janovsky).

An employee of the Reichspost considered that the star electrode microphone was not free from defects; due to the inadequate clearance between electrodes it was possible for packing troubles to arise (Trage). It was stated to be inferior to the latest American type (Hertz, Janovsky).

Fine granules are used for C.B. working; they pass a sieve of 100 meshes per inch and are retained in one of 220. (Hölzler).

4.3 Transverse Current Microphones

A microphone of superior performance was demonstrated at the 1938 C.C.I. meetings by the Dutch. This stimulated the Germans; their representative Braun made an optimistic speech regarding the German development of a transverse current instrument. This was described by Panzerbeiter (1) of Siemens & Halske. The normally low sensitivity of the instrument was partly restored by giving it a higher resistance, but it was still inferior to normal types by about 2 nepers; the fact was glossed over in published descriptions. "The articles were better than the microphones!" (Gladenbeck).

In order that the forces communicated from the diaphragm should penetrate the granules it is necessary to keep their front-to-back depth small, whereas to obtain a low current density and a low value of alternating pressure a large cross sectional area of granules was desired. In a microphone of normal type too low a resistance would result and this appears to be the main reason for adopting the transverse principle. This principle was stated to avoid distortion should the diaphragm and granules part company when loud sounds were applied. (Janovsky).

The present design of instrument is almost free from non-linearity up to sound pressure of 400 dynes/cm^2. (Janovsky). This, of course, is a comment on its poor sensitivity; if the

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(1) loc. cit.

fluctuation of the resistance of a microphone is comparable with the total resistance only at such large sound pressures, its output must inevitably be low at normal speech pressures.

To recover some of the lost sensitivity the resistance w as increased to 200 ohms compared with 60-100 ohms which are typical values for normal German C.B. microphones. This increase was considered permissible since it is small compared with the resistance of line and feeding bridge which totals up to 1000 ohms. (Braun). Presumably the above values for normal microphones refer to typical samples of recent types; the acceptance limits for the older C.B. (= German Z.B.) inset are 150 to 350 ohms (Reichspost Central Office).

It was confirmed that the transverse current microphone had never been put into service, and there had never been any prospect of it (Hölzler). There had been no basic change in the design since the Panzerbeiter article, but the frequency response characteristic had been improved somewhat (Janovsky).

4.4 Regenerative Microphone under development by RPF. C7/571

Following the decision by the Ministry to spend more on the subscriber's instrument, the German Post Office research establishment (Reichspostforschungsanstalt) had started work on a new development to improve the sensitivity of a microphone of the transverse current type. The principle is shown in Fig.3. The diaphragm was of sheet iron about .08 mm. thick, stove enamelled on the underside which bore directly on the granules. These passed a sieve of 60 meshes per inch and were retained in one of 80; they were made by Hoffmann of Friedrichshaven. This instrument was basically about 2 nepers less sensitive than the normal German types.

It was proposed to restore part of this loss by the use of more sensitive receivers and to recover the remainder by the following ingenious method.

An electromagnetic unit was coupled to the diaphragm and fed from the microphone output circuit. This increased the motion of the diaphragm by a form of mechanical regeneration. To give a gain at all frequencies, particular attention must be paid to the phase of the current in the magnetic unit; if the feedback path had purely resistive impedance the effect was only to improve the sensitivity at low frequencies and to reduce the resonance frequency. In the final circuit the feedback system formed part of the line balance of the anti-sidetone current, the power loss in an additional balance resistance was therefore avoided.

The work had not progressed very far. It was intended finally to try to dispense with a permanent magnet and to rely on the feeding current to polarise the magnetic system. (Trage).

5. RECEIVERS

5.1 General

The capsule receiver has for a considerable time been the standard type in Reichspost telephones. The present design (Siemens & Halske No. 10a) does not represent any technical improvement over earlier types having detachable diaphragms; it was introduced in response to the decision to adopt capsule receivers to avoid the variation of sensitivity inevitable in handling (and mishandling) of the older types. (Janovsky).

5.2 Recent Developments by Siemens & Halske C7/211

In the design described by Panzerbeiter [1] an armature attached to the apex of a light cone was driven by a magnetic system of the usual type, but provided with magnetic shunts to reduce its reluctance to the alternating flux. This was not proceeded with as it had been found unstable in use. (Hölzler).

Subsequently attention had been directed to the balanced armature principle which is inherently superior. The instrument developed is described in Section 6. It was primarily for use as a sound powered (i.e. batteryless) telephone and was about 1 neper more sensitive than the ordinary Reichspost receiver. Subsequently work was started to develop a lighter unit having a smaller magnet; this was only about 0.5 neper better and was expected to have applications for normal telephone use. (Janovsky, Hölzler).

5.3 Receiver under Development by RPF.

The German Post Office research establishment had been working on an improved design of receiver, shown diagrammatically in Figure 4.

A thin steel conical diaphragm about .08 mm. thick and 4.5 cm. diameter was used to give a high resonance frequency, well damped by the acoustical loading of the ear. It was made of "Hyperm O" by Krupps of Essen, a material showing high magnetic saturation. Several pairs of poles were used to increase the force on the diaphragm while avoiding high flux densities in it. They were arranged in a ring and all were acted on by a single circular coil. The magnet was made of "Oersted gesintert" by Deutsche Edelstahlwerke of Dortmund. This sintered magnetic material containing aluminium and a little cobalt combines a fairly high coercive force with sufficient incremental permeability to avoid the need for magnetic shunts. (Trage).

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(1) loc. cit.

With the diaphragm described above the resonance frequency was about 1200 c/s. Attempts were being made to raise it to 2000 c/s. It was sufficiently well damped to make artificially added damping unnecessary.

This arrangement was successful in improving the frequency response characteristic of the receiver but it was not found practicable to improve the sensitivity appreciably as trouble was experienced from instability of the airgap when a powerful magnet was fitted. The practical conclusion was reached that a large gain of sensitivity could be obtained in a magnetic receiver only by the use of a balanced armature system.

The situation was changed by the development of the sensitive Siemens sound powered telephone instrument (see Section 6) and of moving coil receivers by E. Baier and by Neumann u. Borm of Berlin. These instruments were all about 1 neper more sensitive; the moving coil receivers were expensive but the manufacturers were of the opinion that the price could be reduced to about 10 marks if a large number were ordered. Work on the new receiver was therefore shelved in favour of the regenerative microphone described in Section 4.4 above. (Trage).

Only some half dozen samples of the RPF receiver were made with different details of design, having 6 to 10 pairs of poles. No description has been published and the samples and all note-books were left behind at Prieros (where the RPF was last evacuated) after leaving Lueben when Trage left there.

6. SOUND POWERED TELEPHONES BY SIEMENS & HALSKE

The early Siemens & Halske sound powered telephone was an imitation of the Western Electric Co's. instrument and was coded No.33 b. Types 53, 56 and 68 were similar but with detail changes. Type 69 was a large instrument using laminated poles. All these had conventional balanced magnetic systems with a tilting rectangular armature. (Janovsky).

The latest type, No.70, was said to be a considerable advance on these both in performance and in ease of manufacture. It employs a circular armature clamped round its periphery with a driving rod communicating the motion of its centre to a light conical diaphragm. The polepieces are circular; the active poles above and below the centre of the armature are surrounded by circular coils and the return poles surround the coils and clamp the armature through rings of brass foil about 0.2 mm. thick. These two pot shaped poles are made of a 40/60 nickel iron alloy (Siemens stock number M89) by Heraus of Hanau near Frankfurt. The two permanent magnets are semicircular and together form a hollow cylinder surrounding the pole assembly. They are made of "Oersted 500," an aluminium nickel alloy without cobalt. Steel disks carry the flux from the magnet to the poles. The diaphragm is fabricated from two aluminium cones rivetted together at the centre and at their periphery clamping between them an annular surround of "Vinifol" plastic film. The driving rod is soldered in the central clamping rivet of the diaphragm. (Janovsky, Hölzler).

The resonance frequency of the armature alone was stated to be between 6000 and 8000 c/s, but this falls to 3000 c/s when loaded by the diaphragm. Another resonance at about 1000c/s was stated to be due to acoustical resonance inside the case. Above about 4000 c/s the response drops rapidly due to the combined effect of the flexibility of the diaphragm and of the compliance of the air in the chamber in front of the diaphragm. When used as a microphone a horn is added which contributes numerous minor resonances. The measured flux density in the active poles was 5000 lines/cm^2. (Janovsky).

The frequency response characteristic of the instrument (as a receiver) was measured at Siemens & Halske by the quasi-subjective method outlined in Section 8.1 using a miniature microphone inside the human ear canal. Over the range 300 c/s to 3000 c/s or higher, it was stated to be level within $\pm$ 0.2 neper ($\pm$ 1.75 db). Below 300 c/s the response declined slowly. The peak sensitivity was 100 dynes/cm^2 per volt for an instrument wound to an impedance of 1000 ohms at 1000 c/s. It was stated that when tested on a "hard ear" coupler the resonance peaks were higher. The receiver is at least 0.7 neper more sensitive than the ordinary German telephone receiver. (Janovsky).

Tested as a microphone the unit showed the usual rise of 6 db. per octave with the two resonance peaks super-posed. Due to the different acoustical loading under this condition of use the resonance frequencies in receiver and microphone do not correspond and the overall result is very good. (Janovsky).

These statements on the sensitivity and uniformity of the frequency characteristics are, in the main, borne out by the curves shown in Figs. 5-7 from measurements made on samples at the B.P.O. Research Station.

Although the receiver response is not so uniform as was claimed, it is still outstandingly good. It should be borne in mind that this test on an artificial ear gives results which are not an exact statement of the behaviour on a human ear. Taking into account the impedance of the instrument tested, the sensitivity is about equal to the value claimed.

7. MISCELLANEOUS TELEPHONE INSTRUMENTS

7.1 Operator's Telephone Headset with Microphone

The armed forces used a headset in which a light capsule microphone is supported by an arm extending from the earpiece. The Reichspost were beginning to use this design but service requirements stopped their supplies and they had perforce to continue to use the older breastplate type. The microphone in the new instrument is equal in sensitivity to the normal subscriber's telephone but has inferior frequency response characteristics. (Janovsky). Samples were secured employing one and two receivers.

7.2 Telephones for the Deaf.

Although receiving amplifiers could be bought they were not in general use even by the deaf, who could purchase special receivers made by Hagenuk of Kiel and Siemenss-Reiniger of Berlin and Ottingen. (Hertz.)

7.3 Telephones for Long Lines

No instruments have been made specially for use on long lines in Germany, nor have L.B. telephones been used on C.B. exchanges for the same purpose (Hertz.) Note however, that the new grading scheme for receivers and microphones (see Section 3.3) would supply specially sensitive capsules for telephones remote from the exchange.

7.4 Subscribers' Amplifiers

An amplifier could be purchased which gave an improvement of 1.5 nepers in receiving. This was the maximum permitted to avoid loss of secrecy due to crosstalk. Such amplifiers had been widely used by the Army but more recently an auxiliary receiver had been used instead to give an equal improvement. (Hertz, Braun). See section 7.5 below.

Hagenuk of Kiel were stated to have developed a mechanical amplifier using a crystal receiver coupled to a carbon microphone. It was switched in by hand for receiving; the telephone feeding current was then diverted to the amplifying microphone. It was not very satisfactory. (Lennertz).

7.5 Auxiliary Receivers

The use of receiving amplifiers (Section 7.4 above) was declining since the same 1.5 neper improvement could be had by the use of an auxiliary receiver held to the other ear. (Braun). The instrument used by the Army was normally the Siemens & Halske design made originally as a sound powered telephone (see section 6)

when used as an auxiliary receiver it was wound to an impedance of 200 ohms at 1000 c/s. It was about 1 neper better than the ordinary instrument, so that when both ears were used the improvement in effective transmission was approximately 1.5 nepers, the maximum gain permissible on the score of secrecy (Janovsky, Braun).

If the second receiver was held close to the microphone howling occurred, but this was not troublesome in practice. As an experiment, Janovsky had fitted one of these instruments in an ordinary handset without howling trouble; he considered that the ideal arrangement would be such a handset fitted with a button switch which would normally introduce some attenuation for use on local calls.

When the German army used the sensitive auxiliary receiver a push button was fitted to leave it normally disconnected. This was primarily to avoid the danger of operators overhearing conversations in the room as in the German telephone the receiver is left connected to the line when the handset is on the cradle switch. When the normal receiver is used alone, such overhearing is not possible without the use of an amplifier (Janovsky). Ordinary subscribers were not normally allowed to have sensitive receivers, though they could have receiving amplifiers (Lennertz).

Another type of auxiliary receiver made by Hagenuk of Kiel was seen. This was a crystal receiver, with a separate matching transformer in a moulded case. The sample heard gave a considerable improvement of volume but its quality seemed poor. (Lennertz).

7.6 Loudspeaking Telephones

The difficulties encountered with loudspeaking telephones had not been satisfactorily overcome. Only a few hundred sets were manufactured, employing initially relay switching, and later valve switching. Room damping was not insisted upon. (Braun).

7.7 Zweiband System of 4-wire Working on Single-Pair Lines.

For trunk calls experiments had been made to permit 4-wire working up to the subscriber. The Lorenz Zweiband system was contrived so that each subscriber sent at audio frequency and received on a carrier frequency of 6 to 10 kc/s which was demodulated by a copper oxide rectifier in the telephone, no circuit alterations being required when receiving at audio frequency on local calls. The Reichspost made some tests on this but were stopped by the war. At their Central Office (Reichspostzentralamt) Braun was working on an alternative scheme using audio frequency transmission from one subscriber to the other (with D.C. feed to the sending microphone) and using carrier throughout in the reverse direction. Carrier feeding current was to be fed from the exchange to the second subscriber exactly as D.C. is used now. No trouble was caused by phase shift between exchange and microphone, because of the low carrier frequency used. The system was described by Dietrich in the 1941/2 Yearbook. (Braun).

8. MEASURING APPARATUS & LABORATORY TECHNIQUE

8.1 The Telephone Instrument Tester

The Siemens & Halske falling shot noise generator used with the portable tester called "spechstellenprüfgerät had not been found satisfactory. Instead of carrying a tester to the telephone instruments it had been found preferable to test microphones and receivers at a central point. It was emphasised that this was practicable only with instruments of the capsule type as the rating of the older type of receiver was liable to change during the process of fitting it to a telephone. (Braun).

The "Reference Equivalent Meter" has been described elsewhere (1). It uses a tone the frequency of which varies logarithmically with time, with suitable weighting of the frequencies produced, to give a measure of loudness. To this end a voltmeter is used which has a special law to give an approximate summation of the loudness of the various frequencies. It was intended to manufacture a number of these instruments but only two were actually made and both were in Berlin. (Braun).

8.2 Calibration of Receivers

The German Post Office research establishment normally used a "hard ear" i.e. a rigid walled coupler of definite volume to couple the testing microphone and the receiver. Before the war they had been experimenting with a type of artificial ear similar to the design of the British Post Office. (Trage).

Physikalische-Technische Reichsanstalt normally used a "hard ear" for comparing receivers of similar type. But when a more exact knowledge of the receiver characteristics was required a subjective comparison was used to obtain a loudness balance against the tone produced by a loudspeaker. For example in comparing the merits of electromagnetic and electrodynamic receivers for use by the services in about 1943 four subjects were used in such a comparison. At a given frequency they were given ten different levels and chose the level which was nearest to giving a loudness balance. In this way a response curve was slowly obtained, taking about 5 minutes per point. (Grutzmacher).

The Siemens & Halske laboratories had developed a miniature condenser microphone which was put in the ear canal of a subject and measured the sound pressure developed by the receiver under test. This was thought to be vastly superior to existing methods using couplers or artificial ears, while avoiding the large expenditure of time taken by the purely subjective comparison. (Janovsky).

(1) T.F.T., 223, 29 Aug. 1940.

8.3 Sound Absorbent Room 7/131

At Atlas-Werke, Bremen, (see Appendix II) a sound absorbent room was seen. This was installed by Mix & Genest to the design of Spandoech and Janovsky of Siemens & Halske. (A similar room has been described in Akustische Zeit., Nov. 1937). Its dimensions before treatment were about 7 x 5.5 x 5 metres. The walls were not parallel. They were treated to a depth of 35 cm. with cotton wool sewn to sheets of paper for mechanical support and mounted edgewise to the wall. Behind these were slabs of glass wool supported on netting and finally a flexible membrane was mounted, spaced away from the wall. About every 2 metres a double sheet of wire gauze penetrated the cotton wool and projected into the room. This was a safety measure in the event of fire; it was expected to retard the speed of flame propagation enough to permit the operating staff to escape. (Maass).

8.4 Recording Wave Analyser

A recording analyser was seen at Physikalische-Technische Reichsanstalt. This was a development of the design described by Jacobi in W.V.S.K. A single resonant circuit was used, tuned to 12,000 c/s with a valve to improve its Q by regeneration. The equipment occupied four racks. During the war it had been used to analyse records of scrambled telephone speech (see Section 13) and of the underwater sound of ships, made on an AEG Magnetophone. This also was seen; it used a plastic tape incorporating iron dust. It was stated to be equalised up to 10,000 c/s and played 30 minutes at a speed of 70 cm/sec. (see also BIOS Final Reports Nos. 207-8). (Grutzmacher).

8.5 Impedance Measuring Set

Grutzmacher had a simple impedance measuring set which is worthy of mention for the ease and rapidity with which measurements of the magnitude and angle of an impedance were measured approximately. Figure 8 shows the circuit. R1 and R2 are equal resistances. A valve voltmeter is connected in turn across AB and BC and the dial resistance box R is adjustable for equality of the two voltages. The value of R then gives the magnitude of the impedance Z directly.

The voltmeter is next connected in turn across BD and DE and the slider on R2 is adjusted until these two voltages are equal. The dial of the potential divider R2 is calibrated to read the angle of the impedance directly in degrees.

Finally a condenser is inserted in series with the impedance R1 and according to whether the voltmeter reading rises or falls the sign of the angle is known to be positive or negative. (Grutzmacher).

8.6 Calibration of Condenser Microphones

The method of absolute calibration used at Physikalische-Technische Reichsanstalt is an adaptation of methods already described in the literature.

The microphone and a source of sound form two of the walls of a small cavity. A small steady gas pressure is applied and the change in polarising voltage required to restore the microphone capacity to its original value is noted. The additional pressure is now removed and sound pressures are produced by the source. An A.C. voltage is applied to the microphone with magnitude and phase adjusted until the diaphragm is at rest, as shown by a radio frequency circuit. The sensitivity of the microphone can now be calculated.

Errors at the higher audible frequencies are avoided by filling the cavity with hydrogen continuously supplied. A check is kept on the excess pressure due to hydrogen stream; no special measures are considered necessary to reduce the pressure to zero. The apparatus is at Göttingen. It occupies three racks and is completely self-contained.

For the measurement of free wave pressures the practice at this laboratory is to use a condenser microphone 1.5 cm. in diameter using a pressure calibration obtained as above. For frequencies above 3000 c/s, the microphone is set in the surface of a sphere and a correction factor is calculated by Ballantine's method. This technique is considered to be sufficiently accurate for all practical purposes. (Grutzmacher).

8.7 Condenser Microphone for Explosion Measurements

During the war Siemens & Halske had developed two condenser microphones; one was suitable for sound pressures of .03 to 1000 dynes/cm^2 the other for pressures of 30 dynes/cm^2 to 10 atmospheres. The latter instrument used as a diaphragm an unstretched plate 2 mm. thick. (Janovsky).

8.8 Gramophone Recording

As the team was passing the factory of Gramofonwerke (Hanover) a visit was paid. The firm has now a single Neumann recording machine, and that without a cutter head. All recording was done on wax. During the war the material used for disks had been old records ground up and mixed with shellac. Synthetic shellac, "Troschell" made by I.G. Farbenindustrie was used. This was stated to be quite as good as natural shellac in all respects save that it softened at a lower temperature.

9. DIALS AND OTHER IMPULSING DEVICES

9.1 Former German Dials

One make of dial similar to the B.P.O. type was seen, manufactured by Bosse of Berlin, but since 1924 the dials used by the Reichspost have been of the Siemens & Halske design having a single-tooth impulse cam on the governor shaft, which thus runs at 10 revolutions per second, and is driven directly by a worm wheel on the main spindle. A sample was evacuated.

Heavy lead governor weights with ebonite friction pads, controlled by light wire springs, were employed. In the original type the weights were pivoted parallel to the governor axis, and rotated inside a cup, but in 1930 this was changed to provide for the weights being pivoted at right angles to the axis, with a flat plate as the friction surface. British engineers have known that, to get a high degree of uniform speed, a governor running at high speed is desirable and experiments with these old types of Siemens & Halske dials showed the running to be more erratic than on other types.

9.2 Latest Siemens & Halske Dial

Figs. 9 & 10 show a dial of the type being manufactured in the Siemens & Halske factory in Munich in January 1946. Information and samples were also available at their works in Berlin. This dial was designed just prior to the war and up to the present is in very limited use. The interesting thing about this new dial is its departure from previous designs and conformity with other present day types. At long last Siemens & Halske have changed to a governing system driven at a higher speed (about 40 revolutions per second) in the orthodox manner through a toothed wheel and pinion on an intermediate spindle which carries the 3-tooth impulse cam.

A further point is the introduction of "lost motion" and to obtain this the dial now employs a finger plate spaced at 14 finger holes to the circle instead of the previous 12. When a digit is pulled, the impulse springs open and close for a number of times equal to this digit, plus two, but special contacts are fitted for short-circuiting the last two impulses, thus the number of impulses sent out is the same as the number appearing in the finger hole. This is similar to the arrangement employed on the Automatic Electric Co. Chicago's No.24 dial, and in fact the general impulsing and gearing arrangements are very similar.

With the Siemens & Halske new dial, however, the whole of the lost motion can be placed in front of the train of impulses, as on the British Post Office dial, by fitting a special cam, but samples operating in this manner were not available. It would appear that this feature gives added complication, but would avoid the present disadvantage that the controls open if the dial is very slightly rotated from normal while conversation is in progress.

Another point of note is the use of synthetic resin mouldings both for the main body of the dial and the finger plate. The mechanism is of simple construction, and a receiver-rest interlock is not fitted. A sample dial was evacuated.

9.3 Dial characteristics

Each dial leaving the works has attached to it a small strip of paper showing the make and break characteristics of the dial for the 10 impulses, and also bears the date the record was taken.

The dial ratio is:- break to make, 1.6 to 1, but the exchange equipment should operate satisfactorily between the limits of 1.3 to 1 and 1.9 to 1. The normal running speed of the dial is 10 impulses per second the inspection limits being between 0.9 secs. and 1.1 secs. for 10 impulses.

9.4 Operators' Dial

Figs. 11 & 12 show the so called "straight pull" dial used on operators' positions, in which the finger plate is part of the curved surface of a cylinder and moves vertically. The advantage of this design lies in the fact that it facilitates the actual dialling operation, and this is of particular importance on operators' positions owing to the fatigue that arises from frequent rotary dialling. The switching mechanism is the same as in the normal type of dial. By means of a gearing device (see Fig.11) the (nearly) straight line movement of the operating detail is converted into a circular one for the switching mechanism.

9.5 Dials for Coin-collecting Telephones

Dials used with coin-collecting telephones incorporate mechanical and electrical interlocks with the coin mechanism and the trunk-call lock, in addition to that with the receiver-rest.

9.6 Other Impulsing Devices

Electrical keysenders ("Zahlengeler") are used on P.B.X's. but mechanical keysenders and auto-dials are unknown.

10. COIN-COLLECTING TELEPHONES

10.1 Table Type for Subscribers' Premises

For fitting in subscribers' premises, a coin-collecting table telephone is available. Only local fees can be collected, and the subscriber is provided with a special key to release the "barred trunk" facility when trunk calls are required. The mechanism is complicated, and somewhat flimsy. A sample was evacuated.

10.2 Wall Types - General

Wall-mounting coin-collecting telephones are generally similar to their British equivalents, with the exception that the receiver rest is incorporated into the main housing, which also carries the dial. Armoured handset cords are fitted, and the transmitter and receiver caps are locked with screws requiring a special tool for removal. An air dash-pot is fitted to the receiver rest of all coin-collecting telephones to prevent illicit impulsing. (Figs.13-16)

10.3 Wall Types - Manufactured by Zwietusch

Two types of coin box are made by Zwietusch.

10.3.1 A single coin buttonless box for local traffic incorporating a telephone set and using an armoured cord. The approximate dimensions are 14" x 12" x 16".

10.3.2 A one button box to take 5, 10, 15 pfennig and one mark coins. The box arranged to take two 5 pfennig coins or one 10 pfennig coin for local calls. The approximate dimensions of the box are 24" x 14" x 7".

A coin must be deposited before dialling. The front of the box is detachable and the necessary connections between the two halves are made by springs being pushed together.

10.4 Signalling conditions for Coin-box Working

The 1st selector provides a "b" wire battery signal for coin boxes. Long conversational periods have proved to be troublesome and a 3 minute cut-off is contemplated with a 10 seconds prior warning. Manual calling condition from multi coin boxes is flicker and the usual gong and bell signals are provided.

10.5 Multi-fee Working

Multi-fee automatic coin box working is used in Bavaria.

11. SUBSCRIBERS' INTERCOMMUNICATION SYSTEMS

11.1 Zwischenstellenumschalter (Extension Plan 7) System.

In contrast to the B.P.O. method of including all equipment in the bell-set at the main station, the German system uses a number of relays, which are accommodated in a wall-mounted relay set. Facilities are available for the extension to obtain an exchange connexion without the intervention of the main station and (as an optional feature on the latest type) for the incoming exchange calls to be extended if the main station does not reply within about 30 seconds. Calls are normally secret, but either the main or extension station, or both, can be provided with facilities for monitoring calls to the other station. A local battery is not provided, the necessary power being drawn over the B wire of the exchange line. Loop calling is used from the extension to the main station, and generator calling, using a ringing vibrator, from the main station to the extension. The main station apparatus is shown in Fig.17 and a sample was evacuated. *

Use of this system is now discouraged except where an external extension is concerned, since where the extension is internal (and consequently more than two wires can readily be provided) the 1/1 Reihen-apparat is cheaper and provides improved facilities.

11.2 Reihen-anlagen (Series or House-Exchange systems.)

These systems are similar to the B.P.O. house-exchange system, but the circuit arrangements are much simpler, and the apparatus correspondingly cheaper and more compact. Instead of employing parallel connexions to the various telephones, the exchange lines are connected in series through changeover contacts in each telephone to a magneto bell fitted at a selected point. In this way the need for a main station unit with guard relay, and a connecting relay in each telephone, is avoided. Secrecy is normally given on exchange calls by the series arrangement, but can be suppressed at one or all stations if desired. An indication than an exchange line is engaged is given by a rotary indicator in each telephone, operated from auxiliary key contacts at the station which is connected to the exchange. Power is supplied over the B wires of the exchange

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* A description of the system and the associated diagrams are filed in the B.I.O.S. library under reference B.I.O.S/Docs/ 1533/146/2(391)/9.

lines but the resultant voltage variations are too great to permit satisfactory D.C. calling between extensions on systems larger than 1/1, consequently hand generators must be used on these unless a ringing vibrator is rented.

The sizes of instruments available were as follows:-

1	exchange line	with	1	extension	station	
1	"	"	1 to 5	"	stations	
3	"	lines "	5 to 15	"	"	
5	"	" "	15	"	"	

Calls between internal stations are normally completed over a multiple, as in the B.P.O. house-exchange system, but a simplified system is available in the smaller sizes (up to five stations) in which only a single connexion circuit for internal calls is provided. Alternatively, in the larger sizes, a P.A.X. using relays or selectors may be provided for internal connexions, instead of a multiple between instruments.

Auxiliary switchboards have been designed by the Reichspost to permit the connexion of 2-wire extension lines to these systems. Such extensions can be called direct from internal stations via the multiple, but calls originated from the 2-wire extension can only be answered by the switchboard operator, who then requests the wanted station to call the 2-wire extension. These switchboards were available as follows:-

1	exchange line	with	2	two-wire	extensions		
2	"	lines	"	"	"	"	
3	"	"	"	5	"	"	"
4	"	"	"	4	"	"	"

(Lennertz)*

11.3 Private Manual Branch Exchanges.

Except for 50- and 100-line lamp-signalling switchboards. P.M.B.X's had been regarded as obsolescent in Germany, and the intention had been to meet all smaller requirements either by Reihen-apparat or P.A.B.X's. Present supply difficulties have forced the introduction of an interim range of wall-mounted cord type P.M.B.X's. (Lennertz).

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* A description and diagrams of the system are filed in the B.I.O.S. library under reference B.I.O.S/Docs/1533/146/2((391)/10.

No new local battery P.M.B.X's had been introduced by the Reichspost during the last 20 years, and the C.B. "cordless" P.M.B.X's used are of the pattern first introduced in 1913, though somewhat modernised since. On these switchboards exchange connexions are made by press-buttons, and extension connexions by short cords.

Floor-pattern indicator-signalling cord-type P.M.B.X's are of the pattern first introduced in 1921. These switchboards are constructed from self-contained units for (i) the base, (ii) cord circuits and operator's equipment, (iii) line indicators and jacks. The cord-circuit apparatus is also in self-contained units for (i) keyshelf equipment, comprising cords, keys and rotary supervisory indicators, (ii) three relays per cord circuit, connexion to these units being made by multi-way plugs and cords. Additional cord-circuits, and additional line-indicators and jacks can readily be fitted. Flap-type indicators have been found satisfactory both for the loop-calling extensions and the generator-calling exchange lines, the only difference being in the resistance, which is 600 ohms for the former and 1,500 ohms in series with 1 μF for the latter. The indicator flap is restored by a pivoted lever when a plug is inserted in the associated jack, and the alarm contacts are operated from the armature instead of from the flap as in the B.P.O. type.

The circuits of the 50- and 100-line lamp-signalling P.M.B.X. switchboards are generally similar to those of the B.P.O. P.M.B.X. 1A except that in accordance with normal German practice a local feed of 24 V. through 400 ohms is provided to the extension during exchange calls, and dialling-impulses are repeated by a relay. The P.M.B.X. operator may be called-in by an earthed press-button at the extension and warning of her intervention is given by a "ticker" tone. Through-clearing and through dialling are provided on outgoing exchange calls and non-through clearing on incoming exchange calls; there is no follow-on call trap for incoming calls, but a trap can be provided to prevent follow-on outgoing calls being made from extensions at hotels etc. without the knowledge of the operator. Four-way switchboard cords and plugs are used. Up to eight sections may be installed en suite, with a series multiple. (Lennertz).

Pamphlets containing descriptions and diagrams as follows are filed in the B.I.O.S. library.

BIOS/Docs/1533/146/2(391)/11 P.M.B.X. (Indicator signalling)
" " /12 " (Lamp signalling)

11.4 Private Automatic Branch Exchanges.

Very small private automatic branch exchanges have been popular in Germany. The smallest, for one exchange line and three or five extensions, were either all-relay, or had two or four uniselectors respectively. Larger sizes used uniselectors or two motion switches (Lennertz).

Direct access for outgoing exchange calls is always provided, but selected extensions may be barred from this either entirely, or at the discretion of the operator. It was formerly the practice to use entirely separate equipment for exchange connexions, discrimination being effected by an earthed press-button at the extension telephone; this appears to have been a survival from an earlier practice of associating a P.A.X. for internal calls with a P.M.B.X. for exchange calls. In the latest equipments the B.P.O. practice of dialling a code digit to seize an exchange line is adopted.

Incoming exchange calls at P.A.B.X's of all sizes are normally dealt with on a cordless attendants cabinet, but certain P.A.B.X's in South German cities are provided with the Siemens & Halske "Sana" (Selbst anschluss nebenstellen anlage) system, in which additional digits may be dialled through the public system to select the desired extension automatically. A slow acting relay calls the operator if the extension digits are not dialled within a certain period. (Sernon). A description and diagrams are filed in the B.I.O.S. library under reference BIOS/Docs/1533/146/2(391)/13.

Call-back and automatic transfer facilities are normally provided and privately-owned-and-maintained P.A.B.X's may be equipped with immediate access, conference, staff locator, fire alarm, synchronised clock and other miscellaneous facilities.

11.5 Heat Coils.

It was observed that little use is made of conventional fuses in German telephone apparatus. Large power fuses are now mostly replaced by electromagnetic circuit breakers, whereas individual apparatus circuits are protected by heat coils. Heat coils are also used with carbons, for line protection, to the exclusion of fuses. An interesting design of heat coil was noticed, in which the fusible metal is in the form of a loose disc held under pressure from a spring plunger, and easily replaceable when necessary. These heat coils are rated for 0.5, 0.75, 1, 1.2, 1.5, 2 and 3 amps, identified by different coloured end caps, all using identical fusible discs. In use they are held in spring mountings incorporating an auxiliary alarm contact. Samples were evacuated.

11.6 Switchboard Plugs and Cords

All German switchboard plugs incorporate a helical spring device to protect the cord. This appears very attractive at first sight, but was rejected by the B.P.O. many years ago as it was found to cause excessive wear of the braiding. A sample was evacuated. No moulded switchboard plugs were seen.

12. FLAMEPROOF TELEPHONE AND SIGNALLING EQUIPMENT

12.1 General.

The construction of German electrical apparatus for use in inflammable or explosive atmospheres is governed by Specifications and Police-orders (See Section 12.2) contained in the "Vorshriftenbuch des Verbandes Deutscher Elektrotechniker" published by ETZ-Verlag at VDE-Haus, Berlin-Charlottenburg 4. (Schuler, Mangelmann).

The edition of this publication held by Funke & Huster (see 12.6) was dated 1942, but 1943 editions of the specifications discussed in this Report have been secured, and there may be a 1943, or even later, edition of the whole book in existence.

So far as can be ascertained, the principle of "intrinsic safety" is not made use of in Germany, all electrical apparatus for use in inflammable or explosive atmospheres being required to be of the type known in Great Britain as "flameproof." Flameproof enclosure appears however to be insisted upon only for those parts of the apparatus regarded as liable to be dangerous during normal working, and in telephones such parts as terminal chambers, battery chambers, and bell coils are unprotected.

A distinction is made in Germany between "Fire-damp-proof" (Schlagwettergeschutzte) and "Explosionproof" (Explosionsgeschutzte), the former being for coal mines, and the latter for explosive industrial atmospheres. The difference is mainly one of degree, and of the body responsible for certification.

12.2 Relative Specifications and Police-orders.

(Copies of these may be consulted at the B.I.O.S. Library under reference BIOS/Docs/1533/146/2(391) 1 to 5)

Polizeiverordnung uber Schlagwetter-und Explosionsgeschutzte elektrische Betriebnmittel VDE/0051/X.43

(Vorschriften fur Schlagwetter geschutzte elektrische Betriebsmittel VDE/0170/V.43)
(" " Explosionsgeschutzte " VDE/0171/V.43)

Leitsatze fur die Bestimmung der Zundgruppe und Explosionsklasse von Gasen und Dampfen VDE/0173/V.43

Markblatt uber Anforderungen an Werkstatten, die Schlagwettergeschutzte und Explosionsgeschutzte elektrische Betriebsmittel andern oder instandsetzen VDE/0191/V1.43

12.3 Summary of Testing Procedure for Gases and Vapours given in VDE 0173/V.43. Ignition Temperature. (Zundtemperatur)

12.3.1 Mixtures of gas or vapour with air are heated through 3°C per minute in a steel tube 1" diameter x 800 mm long until ignition takes place. Four ignition groups are defined as follows:-

Ignition Group (Identification letter)	Ignition Temperature °C
A	over 450
B	" 300
C	" 175
D	" 120

12.3.2 Explosion Pressure (Explosionsdruck).

Mixtures of gas or vapour with ordinary air at 20° C (and at higher temperatures if appropriate for vapours) and a pressure of 760 Torr are ignited in a sealed cylindrical steel chamber of capacity 5 litres, provided with two sparking plugs, to ascertain the proportions of gas or vapour to air (and the temperature for vapours) which gives the highest explosion pressure.

12.3.3 Ignition-transmission (Zunddurchschlag).

By inserting spacers between its 200 mm diameter flanges, the 5-litre chamber is arranged to provide a flame-path to the surrounding atmosphere of length 25 mm and width 0.8 or 0.5 mm. The chamber and surrounding atmosphere are filled with the mixture of gas or vapour with air which gives the highest explosion pressure, and the mixture inside the 5-litre chamber is ignited. If no ignition of the surrounding atmosphere takes place during ten tests, the test is repeated with mixtures of different proportions which yield at least 75% of the highest explosion pressure. Three explosion-classes are defined as follows, according to the flange clearance that allows an ignition of the surrounding atmosphere during twenty repetitions of the test:-

Explosion Class Number	Flame-path width in mm. for an ignition transmission along a 25 mm. path
1	over 0.8
2	from 0.5 to 0.8
3	0.5

12.3.4 Classification of Gases and Vapours according to Ignition-group and Explosion-class.

The results obtained from the tests for Ignition-group and Explosion-class are given as follows:-

Identification number of Explosion class	Identification letter of Ignition group.			
	A		B	C	D
1	Athan Ammoniak Azeton Benzin* Benzol*	Methan Naturgas Pentan Propan Toluol	Azetaldehyd Athylalkohol	Athylather Hexan	
2	Athylen Kohlenoxyd	Stadtgas			
3	Wassergas Wasserstoff		Azetylen		Schwefelkohlenstoff
*) Vergaserkraftstoffe nach DIN 6511					

12.4 Notes on Constructional Details of Apparatus Specified in VDE 0170/0171/V.43.

Two alternative standard sets of flange widths and clearances are specified as follows.

Minimum flange width	25 mm	40 mm
" " at screw holes	10	15
Maximum flange clearance formerly permitted for Schlagwettergeschutzte	0.3	0.5

Maximum flange clearance now permitted for Schlagwettergeschutzte Maximum flange clearance for Explosion-Class 1	0.3 mm	0.4 mm
Maximum flange clearance for Explosion Class 2.	0.2	0.25
" " " " "	(Half the limiting clear- (ance ascertained by (explosion tests on the (apparatus in question.	

Reduced flange widths (subject to reduced clearances in certain cases) are however permitted for enclosures of internal volumes under 2 cc., 100 cc. or 500 cc. as the case may be.

The flameproof enclosure is required to be capable of withstanding an internal pressure of 6 - 10 atmospheres depending upon its volume and the explosion-class concerned. A hydraulic test to the specified pressure is required to be carried out on each individual item during manufacture.

Maximum permitted temperatures, and temperature-rises, are specified according to the ignition-group concerned. Minimum dimensions for insulation paths, and many other details of design and construction, are also laid down.

12.5 Type Tests of Flameproof Apparatus required by VDE 0051/X.43.

Type tests of flameproof (Explosionsgeschutzte) apparatus, for use in explosive industrial atmospheres were made by the Chemisch-Technische Reichsanstalt, or by the manufacturer if specially authorised for the purpose.

Type tests of flameproof (Schlagwettergeschutzte) apparatus for use in coal mines were made by the Berggewerkschaftliche Versuchestreche in Dortmund-Derne. The type test for telephones and signalling apparatus in this case comprised a detailed examination for compliance with the requirements of VDE 0170/V.43, followed by four ignitions of a mixture of 8-9% Methane (CH_4) in air inside the flameproof enclosure. During these tests the apparatus was surrounded by a mixture identical with that ignited inside and not, as in British practice, with a different mixture, more easily ignited.

A number of reports and addenda issued by the Berggewerkschaftliche Versuchsstreche on Telephone and signalling apparatus manufactured by Schuler & Vershoven and by Funke & Huster have been filed in the B.I.O.S. Library under reference BIOS/Docs/1533/146/2(391)/6-7.

12.6 Report on visits to Manufacturers' Works.

12.6.1 Names of Firms Visited

C7/277 * Schuler & Vershoven
Fahrenberg 6
ESSEN-KUPFERDREH

Funke & Huster, C7/280
Montebruche Strasse 2
KETTWIG vor den Bruche.

* Also known as Fernspreche & Signalbaugesellschaft see BIOS Final Report No. 486.

12.6.2 Personnel Interviewed

Herr SCHULER

Herr MANGELMANN (Works Manager)

12.6.3 Date of Visit

9th Jan. 1946

9th Jan. 1946

12.6.4 General

The number of employees at Schuler & Vershoven was stated to be about 90, and at Funke & Huster 58. Both firms were in production of flameproof and waterproof telephones, hooters and bells. Schuler & Vershoven were also making metal-cased portable telephones, and Funke & Huster signalling transformers. The production of electrical components is limited to such items as transformers, bell coils, contact springs etc.

12.6.5 Apparatus Details

Transmitter and receiver insets are purchased from telephone manufacturers, and are of normal types as used on non-flameproof telephones, with the addition of a cellophane diaphragm to exclude dust and water.

It was noted that, (besides the terminal chambers, battery chambers for L.B. telephones, and coils of magneto bells being without flameproof enclosure, as is permitted by VDE 0170/V.43) the telephone handsets and their connecting cords are also unprotected (as in British flameproof telephones) although the transmitter and receiver caps are locked with special screws to prevent unauthorised removal of the insets with consequent possible sparking at the connecting springs.

The flameproof enclosure normally comprises the whole body of the telephone, excluding the terminal chamber etc. but Schuler & Vershoven claim to have a patent for converting waterproof telephones (made by Siemens & Halske) to flameproof by fitting small flameproof cylindrical brass enclosures for the various contact spring-sets. Some of this conversion work was seen in progress.

Connexions through the wall of the flameproof enclosure are made by Funke & Huster by connexion bars moulded into a synthetic resin plug which is sealed into a tapped hole in the wall by synthetic resin cement and an S.R.B.P. nut. Samples were evacuated.

For automatic telephones, the shaft passing through the flameproof gland is coupled to the dial mechanism spindle by a pin and plate coupling, but there is no separate return spring for the external shaft, which has therefore to be driven by the normal dial spring during its return.

Flameproof hooters have a D.C.-buzzer movement the armature of which strikes an anvil secured to the centre of a steel diaphragm forming part of the wall of the flameproof enclosure.

Flameproof trembler bells employ a flameproof gland through which passes the shaft forming the pivot for the armature and hammer.

It was observed that the flange surfaces on Funke & Husters' apparatus were finished sufficiently flat (by grinding on a disc faced with emery-cloth) to be watertight when greased during the hydraulic test of the casing. Schuler & Vershoven fitted a temporary rubber gasket between the flanges during this test.

13. TELEPHONE AND RADIO-TELEPHONE PRIVACY EQUIPMENT

13.1 Personnel Interviewed

The information contained in this section was obtained from Dr. Sacklowski of Siemens & Halske, who was interrogated, on 13th December 1945, at Siemens & Halske offices, Friedrichstrasse 1, Hanover. Dr. Sacklowski was formerly employed in the Reichspost-zentralamt. In 1927 he became assistant to Prof. Küpftmüller of Siemens & Halske Central Laboratories at Siemensstadt, who carried out work for the German Navy, and was a member of various committees concerned with the planning and distribution of manufacture during the war. Sacklowski's work on privacy equipments was done under the direction of Minister Speyer.

13.2 Frequency Inversion system for telephone circuits

The carrier frequencies used were 2100 c/s by the Wehrmacht, 3,000 c/s by the Reichspost for civilian users, and 2700 c/s by the Nazi Party Members and Ministers. Total production was less than 1,000 sets, of which about 100 were for civilian use and 33 or 34 for the Party. Several hundred sets for the Wehrmacht were ordered by the Army Development Engineer without proper authority. More extensive use of this type of equipment by the Armed Forces was not made, because of delay by the Army Research Station (Heereswaffenamt) in reaching a decision. Their requirements were specified to be for a very secret, portable and simple apparatus capable of working on poor speech circuits, and were regarded by Sacklowski as impracticable.

Sacklowski said that inverted speech could be understood by a practised listener without special equipment. His personal view was that secret communications should generally be made by secret teleprinter. Only in rare cases should speech privacy equipment be necessary, and then if the need justified the cost a really good secrecy system such as Time Scrambling or Wobble-Frequency should be used.

13.3 Band Splitting System

In this system the speech spectrum, of say 300 c/s to 2,400 c/s is split into two, three or five bands which may be interchanged and/or inverted either at the will of the user or by automatic switching. Where switching is at the will of the user, press-buttons are provided to select suitably-secret combinations, and unsuitable combinations are not made available.

Six or ten pairs of 2-band equipment were supplied by Siemens & Halske to the German Navy for installation in cruisers. A few pairs of 3-band equipments were provided for radio communication between

Berlin and the German Embassies in London and other foreign capitals. A 5-band system with automatic switching was employed by the Reichspost for transatlantic radio circuits to the U.S. telephone system.

Band splitting equipment was regarded by Sacklowski as somewhat better than simple inverter equipment, but not very secure. It is interesting to note here that during a subsequent visit to the Physikalische-Technische Reichsanstalt at Gervinu Strasse 7, Göttingen, a statement was made by Dr. Martin Grutzmacher that his frequency analyser (see Section 8.4) had been utilised to study electro-magnetic tape recordings of scrambled speech, with the object of locating the boundaries between the bands and so facilitating decoding.

13.4 Time Scrambling system

This system was under development as an elaboration of that patented in 1918 by a Dane named Tigerstedt. Synchronism between the transmitting and receiving equipments was maintained by quartz crystal oscillators. Two pairs of equipments of this type were ordered by the Wehrmacht, of which one pair was delivered for field use, and the second pair may have been delivered to Berlin.

13.5 Wobble-Frequency system. This system was developed for use by the Luftwaffe on decimetre-wave beam radio circuits. It was a frequency-inversion system using a modulating carrier of 40 to 60 kc/s wobbled through a range of 3 or 4 kc/s under the control of two rotating variable condensers geared together. Synchronism between the transmitting and receiving equipments was maintained by quartz crystal oscillators, and the wobble curve repeated itself every 15 minutes. Band inversion was used so that the wobbling did not make the total side-band width excessive. The apparatus required two or three men to transport it. Two pairs of equipment were made for test, and 40 pairs ordered for use but never delivered because of air raid disturbances. So far as Sacklowski knew the Luftwaffe had no secrecy equipment actually in service.

The names in brackets are of persons not interviewed but included in the list as being of possible interest.

(Blaum) Present works manager of mechanical department, Atlas-Werke, Bremen.

(Bohm) Stated to be RPZ expert on P.B.X's & Receivers (Braun).

Braun, K. Expert on electro-acoustics and local transmission. Formerly at RPF . More recently at RPZ. Last at RPD, Stuttgart, but dismissed. Interviewed at his home, Stuttgart-Feuerbach, Klagenfurterstr. 39, on 31st December, 1945.

(Dietrich) Succeeded Braun at RPZ. Believed to be employed now at Oldenburg. (Braun).

Etzel Assistant to the production head Zapf, Siemens & Halske, Munich.

(Gerwig) Succeeded Gladenbeck as head of RPF in 1942. Believed to be at the new Postzentralamt at Rastat near Constance in the French Zone (Gladenbeck).

Gladenbeck The chief of RPF till he left in 1942, and editor of Jahrbuch des Elektrische-Femmeldewe. Now emplo at A.E.G. Brandenburger Haus, Hamburg, where he was interviewed on 19th December, 1945.

(Gosewinkel) Siemens & Halske expert on electro-acoustics; thought to be in Berlin. (Sacklowski).

Grutzmacher Head of Physikalische-Technische Reichsanstalt, Gervinu Str. 7, Göttingen where part of the concern was evacuated in February 1945, and where he was interviewed on 19th December 1945.

(Hauptmann) Worked with Janovsky on microphones (Gladenbeck).

(Hausmann) Director of Siemens & Halske, Hanover.

Hertz Described as Chief Engineer of the German Post Office in the British Zone. Interviewed at P.& T Branch, Bad Salzuflen 12th December 1945.

Hölzler Present head of Siemens & Halske laboratories, Munich.

(Huber)	Stated to be Atlas-Werke expert on Rochelle salt and to be at Atlas-Werke, Munich.
Janovsky	Siemens & Halske expert on electro-acoustics, formerly at the Central Laboratories Berlin-Siemenstadt. Now at Wiesbaden, Hindenburgeralles 33, engaged as consultant and attempting to reconstruct the records on his subject, largely from memory.
(Joscheck)	Formerly Siemens & Halske expert on carbon granules; later at Patent Office, Berlin. (Janovksy) or Reichsbauternamt (Braun).
(Kietz)	Physicist at Electro-acoustics Laboratory, Atlas-Werke, Bremen.
(Kunz)	Former works manager of Electrical Dept., Atlas-Werke, Bremen, since dismissed.
Lapp	Administrative head of Hanover RPD.
Lennertz	Was employed in RPM in emergency replacement of damaged exchange equipment. Interviewed at P. & T. Branch, Bad Salzuflen on 7th January, 1946.
Maass	Physicist and manager of Electro-acoustics Laboratory, Atlas-Werke, Bremen.
Mangelmann	Works manager, Funke & Huster, Montebruchstr. 2., Kettwig, makers of Flameproof telephones.
(Mengers)	Formerly physicist at Atlas-Werke, Bremen. Died 1945.
(Ohnesorge)	Reichspost Minister. c. 1942.
(Panzerbeiter)	Siemens & Halske expert on microphones. Believed to be in Berlin (Sacklowski).
(Pfleiderer)	Siemens & Halske expert on microphones, Munich.
Pippert	RP Engineering Dept., Bad Salzuflen.
Sacklowski	Formerly assistant to Prof. Kupfmuller at Siemens & Halske Central Laboratory. Now at Siemens & Halske, Hanover.
Schoeps	expert on microphones; formerly at RPF, now at Wurtzburg (Trage, Gladenbeck).
Schuler	of Schuler & Vershoven, Essen-Kupferdreh, Fahrenbert 6, makers of flameproof telephones.

Sernon	P.B.X. expert at Siemens & Halske, Munich.
Sommer	Present works manager of Electrical Dept., Atlas-Werke, Bremen.
(Speyer)	Minister in charge of war developments, under whose direction Sacklowski worked on privacy equipment.
Spandoech	Siemens & Halske expert on electro-acoustics. Now has laboratory at Erlangen. Interviewed at Munich.
Trage	Expert on microphones and receivers formerly at RPF., Berlin, Luebben and Prieros. Interviewed at Hanover where he is now living.
Vondran	Engineering Branch, RPD Hanover.

APPENDIX I

LIST OF APPARATUS EVACUATED FROM GERMANY

The following apparatus was evacuated and may be inspected at the Engineer-in-Chief's Pattern Room, G.P.O., (Castle House), Aldersgate Street, London, E.C.1. under the title of "German Subscribers' Apparatus referred to in B.I.O.S. Final Report No.606."

(1) Zwischenstellenumschalter Type W 33 Main Station Telephone and Relay Set.

(2) Coin-Collecting Table Telephone Type W 33(a)

(3) Dial Type No.24

(4) Double Pole Changeover Switch in Moulded Case

(5) Four-Way Moulded Connector for Flameproof Telephone

(6) One-Way " " " "

(7) Two-Way-and-Earth Terminal Block with Disconnexion Facility

(8) Switchboard Cord and Plug

(9) Cord Weight

(10) Gas Discharge Portector Tube

(11) Two Heat Coils (Non-Renewable Type)

(12) Three Heat Coils (Renewable Type) for 1.2 amp., with spare discs.

(13) Siemens & Halske latest (Moulded Type) Dial.

(14) One carbon microphone Fg. mph 1a

(15) " " " " " 4b

(16) Three " " " " 16a 2

(17) " " " " " 18a

(18) Seven " " " " 18b

(19) One carbon microphone Fg mph 24a

(20) Five " " " " 24b

(21) Two " " " " 27a

(22) One " " " " 25c

(23) Fifteen" " " " 31a

(24) Two " " " " 32a

(25) One " " " " 44a

(26) One " " " " 51a

(27) " " " " " 67a

(28) " " " " " 67b

(29) Eight " " Hmka 40

(30) Seven " " " 41

(31) Six " " 1/20 38A

(32) Five " " C 9305

(33) Twelve " " gepr 7

(34) Thirteen" " CL DRP(L.B)

(35) Three " " CL DRP(L.B. + a green circle)

(36) Four " " CL DRP(C.B. + a red circle)

(37) One " " 30 ∿

(38) One " " Ask 681/1 (L.P)

(39) One electromagnetic microphone Fg mph 70b

(40) Six receivers Fg tph 10a 2

(41) Seven " P.S. 29657

(42) One operator's headset (single receiver)

(43) " " " (double ")

(44) Two slabs Rochelle salt crystals

(45) One telephone receiver with special ear-cap to hook an ear.

APPENDIX II

NOTES ON ATLAS-WERKE A.G.

1. Address

Kirchenweide
(South-West of Europa Hafen)
BREMEN.

2. Personnel Interviewed

Dr. BLAUM — Works manager of mechanical department

Herr SOMMER — " " " electrical "

Dr. MAASS — Physicist and laboratory manager.

3. Date of Visit

17th December 1945.

4. General.

This firm existed to produce auxiliary equipment for ships such as windlasses, steering gear, pumps etc., and also electro-acoustical apparatus, e.g. echo sounders, underwater signalling systems. The main factory is at Bremen, others were at Gnadenfrei (Silesia), Munich and Elmshorn. During the war there were about 3000, 500, 600, 350 employees respectively at these places. In December 1945 only Bremen and Munich were seriously in operation with about 1000 and 100 employees respectively. About 20 remained at Elmshorn.

Submarine acoustical apparatus was designed and developed at Bremen and constructed at Gnadenfrei.

The production of Rochelle salt crystals at Elmshorn is described in Appendix IV.

During the war the following apparatus was in production or under development:

Airborne Fog Signals at 150 c/s and 300 c/s

Submarine Fog Signals at 1050 c/s

Echo Sounders at 1050 c/s, 3000 c/s, 22 kc/s, 30 kc/s.

Underwater Carrier Telephone. Several sets were made working on 20 kc/s but this development was abandoned.

Group Listening System using an array of underwater microphones with electrical delay networks to indicate the direction of underwater sounds.

In these underwater applications Rochelle salt crystals made at Elmshorn (see Appendix IV) were used for microphones, electromagnetic units as senders for audio frequencies and magnetostriction senders for carrier frequencies.

The firm is now engaged on:

Echo Sounders for trawlers, e.g. to detect shoals of fish

Electro-medical Apparatus, e.g. diathermy and electro-cardiographs.

Hearing aids and audiometry. (See Appendix III)

5. Work on Electro-acoustics at Bremen.

Formerly 8 to 10 physicists (now reduced to 4), 8 to 10 engineers and technicians and 15 workmen were employed in the electro-acoustic laboratory at Bremen.

APPENDIX III

DEAFNESS AND HEARING AIDS

1. General

The information in this section is entirely concerned with the work of the firm of Atlas-Werke on deafness and hearing aids for non-telephone use. Before the war this concern was intending to produce hearing aids and a few dozen were made. As they are now debarred from naval construction the work is being continued.

2. Receivers

The receivers used are electromagnetic. A stretched phosphor bronze diaphragm is used with an armature soldered to it of "Megaperm" by Heraus of Frankfurt. The main resonance is at 800 c/s and there is also a resonance of the circular armature disks at 4000 c/s. Both insert (Fig.A) and external (Fig.B) receivers are to be made; also a bone conductor (Fig.C) using a similar magnetic system - in this device the magnet has a springy support to give a resonant frequency of about 800 c/s. (Maass). Details are shown in the figures.

3. Microphones

Rochelle salt crystal plates are used. The present design is of the paper diaphragm type and was stated to have a sensitivity of about 40 mV/dyne/cm^2 (Maass). (This is a high value compared with British and American types which give about 4 mV/dyne/cm^2).

A new sound cell microphone was demonstrated using large crystal plates; it gave very good quality. It was stated to have a sensitivity of 5 to 10 mV/dyne/cm^2 and to have a level response curve up to a peak at 8000 c/s. It is intended eventually to use this type for hearing aids. The crystal plates were protected against moisture by being quickly dipped in molten wax which was stated to be superior to varnish (Maass). Details of both types of microphone are shown in the Figs. D & E.

4. Amplifiers

The three stage amplifier used by the firm for hearing aids had no points of special interest. Batteries are not obtainable in Germany so the instrument was mains operated, using a selenium rectifier made by Suddeutsch Apparat Fabrik, Nuremberg. The amplifier case measured about 9" x 6" x 4".

5. Proposed use of Supersonics

Maass was very proud of a discovery which he claimed was entirely new. While airborne sounds are inaudible at frequencies above about 16 kc/s he stated that bone conducted vibrations could be heard to much higher frequencies. Young persons could hear up to 150 kc/s or more and most people up to 50 kc/s; they could distinguish a pitch difference between differing frequencies. This was claimed to be the case for subjects normally regarded as totally deaf.

The effect was demonstrated using a magnetostriction vibrator fed from an oscillator giving a choice of several fixed frequencies said to be between 30 and 60 kc/s. The tones were clearly heard and could be distinguished from one another. They sounded quite similar (from memory) to tones between 8 and 16 kc/s. Maass was certain that the effect was real and that the inner ear is sensitive to the high frequencies provided they are applied with sufficient intensity. He had analysed the vibrations transmitted through the head and found them free from any subharmonics.

Assuming that the effect is indeed genuine and that the totally deaf can distinguish these frequencies, we have the possibility of conveying some sort of intelligible sounds to subjects too deaf to gain assistance from a normal type of hearing aid. No systematic work had been done to investigate the possibility of ill effects from the vibrations. Maass was quite confident that the demonstration was quite safe as the electrical input to the vibrator was well below 2 watts.

6. Speech Audiometer

The firm of Atlas-Werke had a speech audiometer of their own design. It utilised a loudspeaker mounted inside a large box lined with absorbent material. At the far side was an orifice to which the subject applied his ear. A microphone in a smaller padded box was mounted on the first on the side remote from the subject. Thus experiments could be performed to assess the ability to hear and understand speech, either unaided or with known amounts of amplification.

When testing the worse ear of a subject it is necessary to prevent the idle ear from hearing the speech. A sound excluding earcap was in use which gave about 20 db attenuation; alternatively a second loudspeaker was in use to provide a masking noise.

The same equipment was used for pure tone measurements in conjunction with an audiometer by Siemens & Halske which incorporated a gradual keying circuit to avoid clicks.

APPENDIX IV

THE MANUFACTURE OF ROCHELLE SALT CRYSTALS

1. Atlas-Werke, Elmshorn C7/276

The firm of Atlas-Werke manufacture Rochelle Salt crystals. This was originally done at their Bremen factory but the plant is now at Elmshorn, North-West of Hamburg.

The crystals are grown in rectangular glass jars approximately 4" x 7" x 10" high. The bottom of the jar is filled to a depth of about 1" with soft wax, weighted by a block of glass in it, to enable the jar to be eventually broken without damaging the crystal. A slab of Rochelle salt about $\frac{1}{4}$" thick cut from an earlier crystal is placed in the bottom of the jar which is filled with Rochelle salt solution. A number of jars are stood in a water bath in a cabinet whose air is warmed and they are slowly cooled from 45°C. to 15°C. at the rate of about $\frac{1}{2}$° per day. After a month the crystal has grown in the jar to a height of about $2\frac{1}{2}$". The jar is then scratched and broken away from the crystal. The old plate is cut off and used again.

It was stated that deeper crystals could not be grown as internal stresses would be too large. The firm had spent a year originally in growing their first crystals to the size of the base of the jars used.

Next the crystals are examined optically to determine their axes and scratches are ruled on them to show the planes in which they should be cut. Cutting is done by a machine fretsaw apparently using as a blade a twisted wire of square section. Originally an oil resembling clock oil was used as a cutting lubricant, but ordinary paraffin oil has been successfully used more recently. When the slabs have been sawn they are smoothed and reduced to their final thickness by grinding on disks faced with abrasion paper. The humidity is controlled at 50% in the rooms where this work is done.

The finished slabs are transported to the Bremen factory with no protection against moisture save a wrapping of tinfoil. Their insulation resistance is checked and brought up to standard by putting them in a desiccator.

When the crystal plates were in underwater microphones they were sealed in their cases in rooms whose relative humidity was controlled to 35%. As a further protection they were formerly immersed in a moisture-excluding paste, believed to be made of beeswax and glycerine. Later they were merely painted with the paste before sealing the containers. Crystal microphone units are protected by giving them a quick dip in molten wax.

A number of samples were secured including a complete crystal block as grown. This was stated to be easily broken by sudden temperature changes; it should not be heated and should be wrapped in several layers of paper before taking it out of doors.

The employees interviewed stated that this firm had not used any other basis than Rochelle salt for making crystals, but that small quantities of other ingredients were added. They were ignorant of their composition. It is understood that complete details of the processes have already been given to Allied personnel. (See BIOS Preliminary Reports No.4407 and 5655).

2. Hanseatische Apparatebau-Gesellschaft, Neufeldt & Kuhnke, (HAGENUK) Kiel (see B.I.O.S. Final Report No. 486 Section 8) 7/26

It has been learned that this firm also manufactures Rochelle salt crystals, which are used in their crystal amplifier (Section 7.4) crystal receiver (Section 7.5) gramophone pickup and public address microphone.

E N D

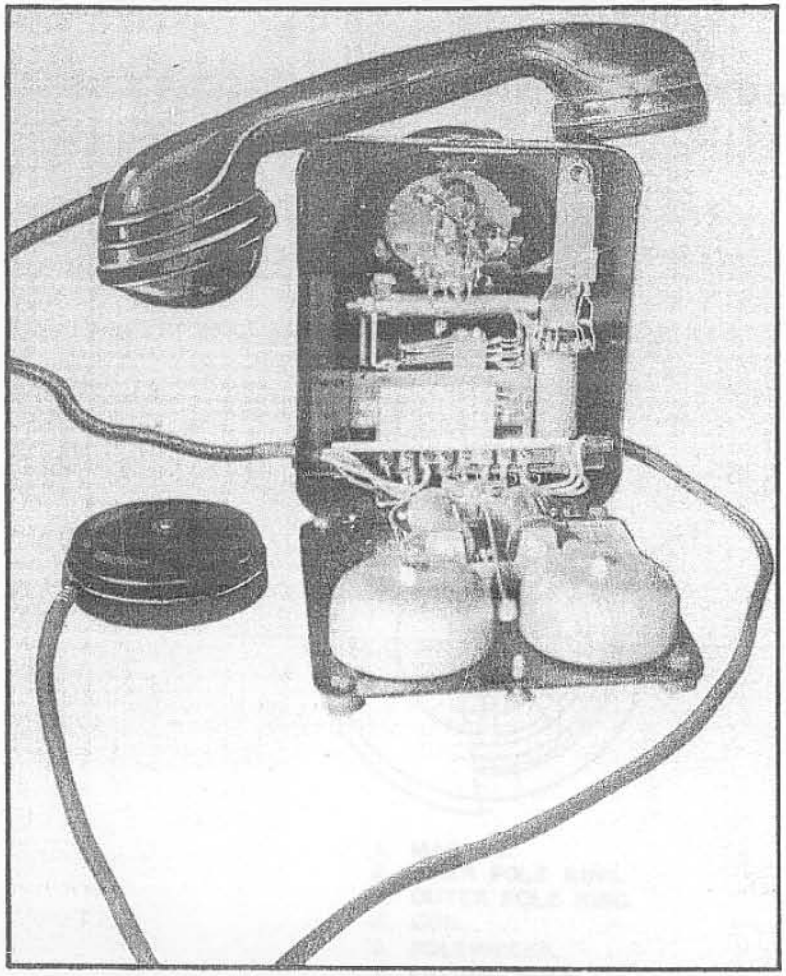


FIG. 2. PORTABLE AUTO-/ LB TABLE TELEPHONE TYPE 35
(INTERIOR)

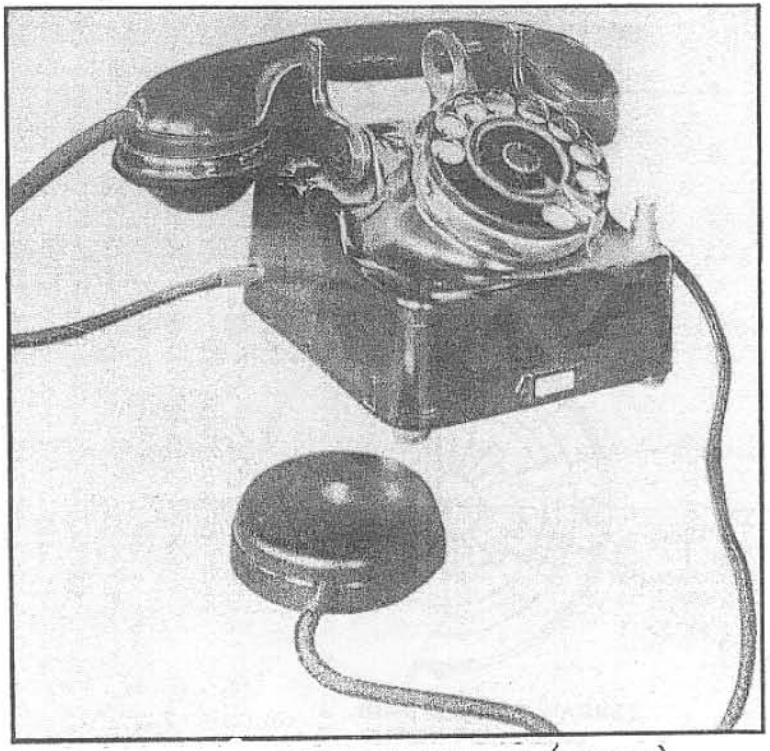
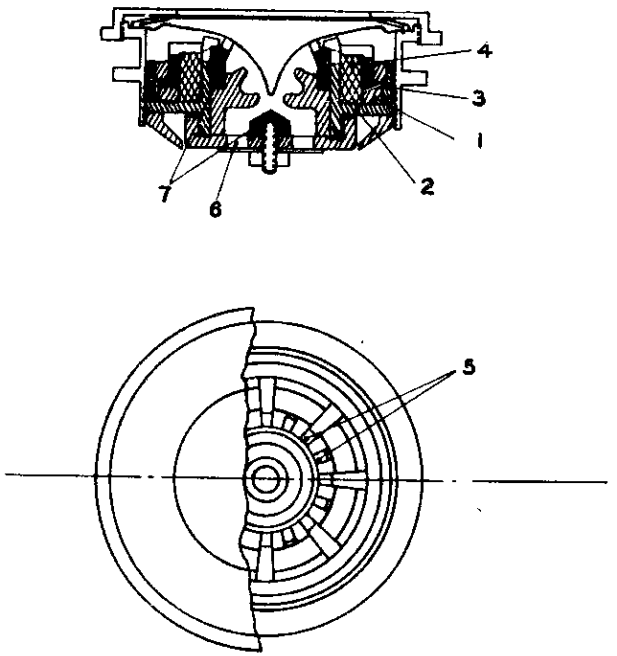


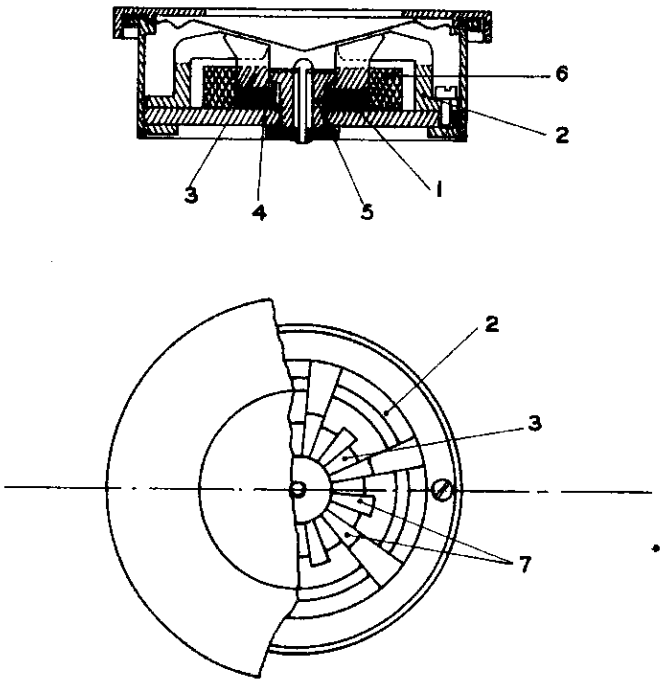
FIG. 1 PORTABLE AUTO / LB TABLE TELEPHONE TYPE. 35 (EXTERIOR)

FIG.3. REGENERATIVE MICROPHONE DEVELOPED BY R.P.F.



1. MAGNET.
2. INNER POLE RING.
3. OUTER POLE RING.
4. COIL.
5. POLEPIECES.
6. FILLING HOLE.
7. CARBON ELECTRODES.

FIG.4. RECEIVER DEVELOPED BY R.P.F.



1. RING SHAPED MAGNET.
2. OUTER POLE RING.
3. INNER POLE RING.
4. BASEPLATE.
5. BRASS CLAMP.
6. COIL.
7. POLEPIECES.

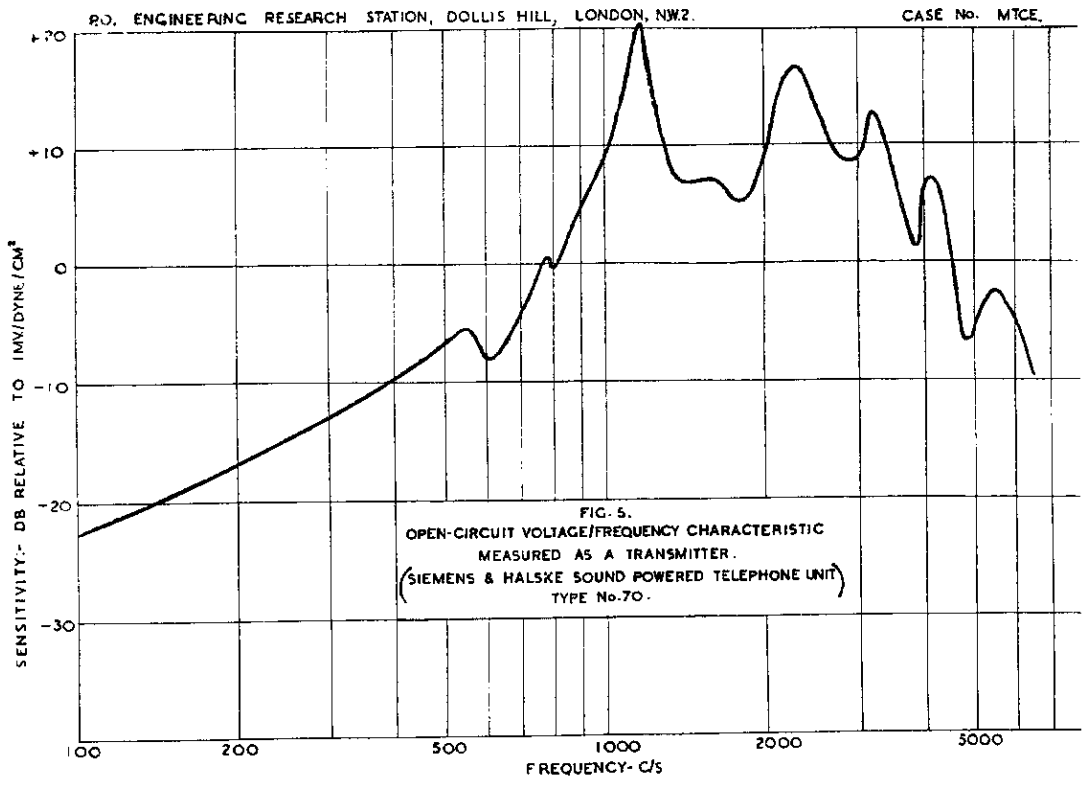


FIG. 5.
OPEN-CIRCUIT VOLTAGE/FREQUENCY CHARACTERISTIC
MEASURED AS A TRANSMITTER.
(SIEMENS & HALSKE SOUND POWERED TELEPHONE UNIT)
TYPE No.70.

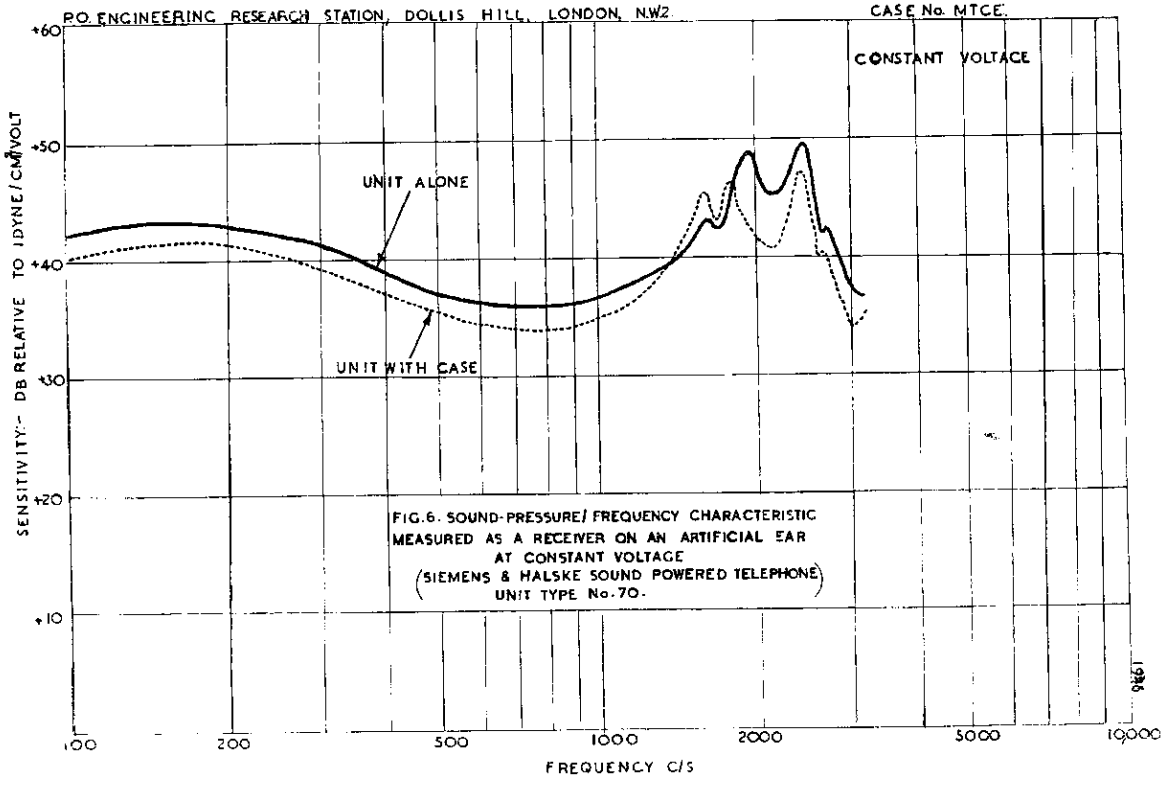
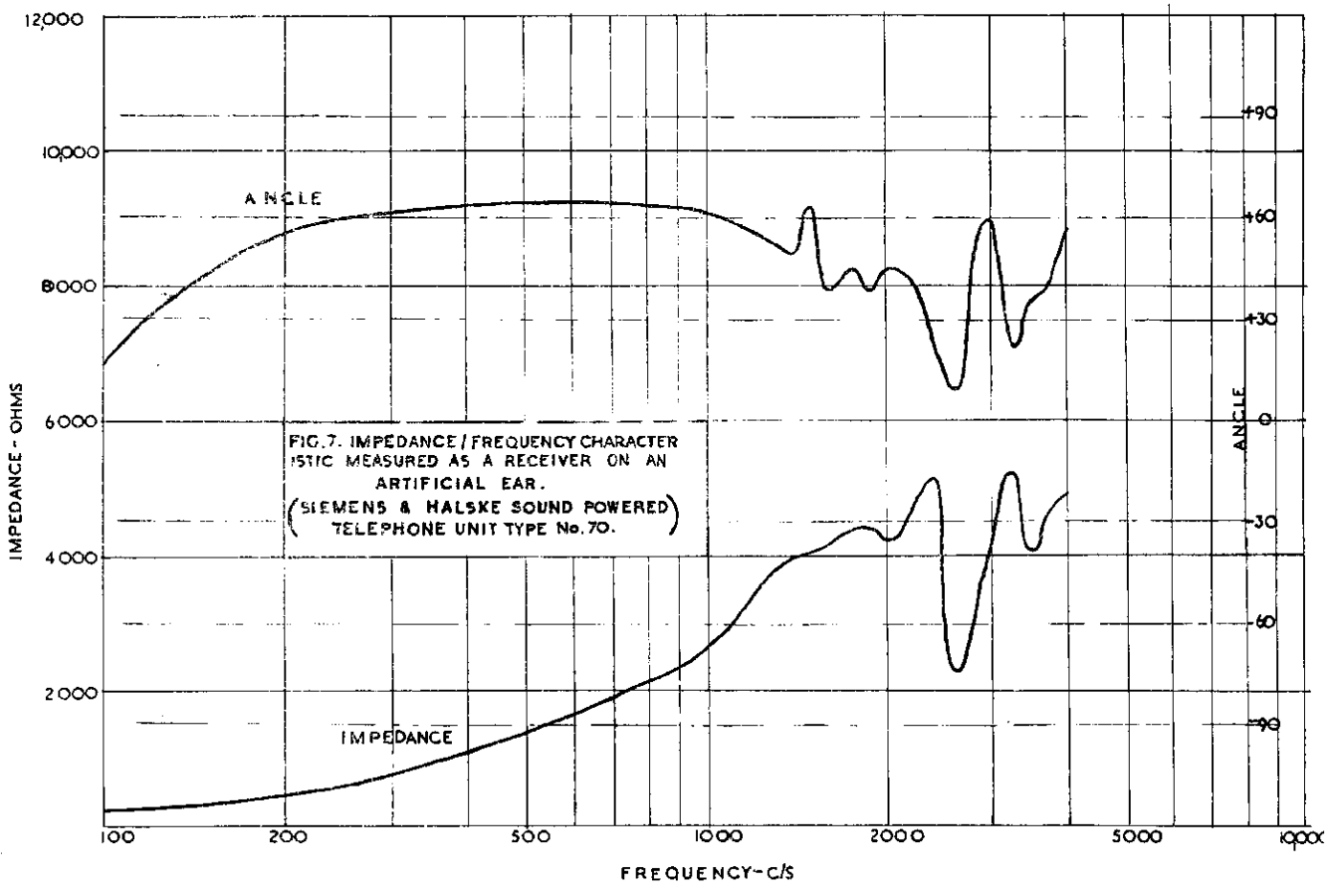


FIG.6. SOUND-PRESSURE/ FREQUENCY CHARACTERISTIC
MEASURED AS A RECEIVER ON AN ARTIFICIAL EAR
AT CONSTANT VOLTAGE
(SIEMENS & HALSKE SOUND POWERED TELEPHONE)
UNIT TYPE No.70.

P.O. ENGINEERING RESEARCH STATION, DOLLIS HILL, LONDON, N.W.2. CASE No. MTCE,



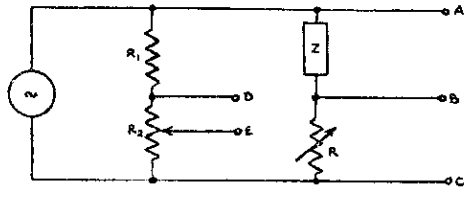


FIG. 8. CIRCUIT DIAGRAM OF IMPEDANCE MEASURING SET.

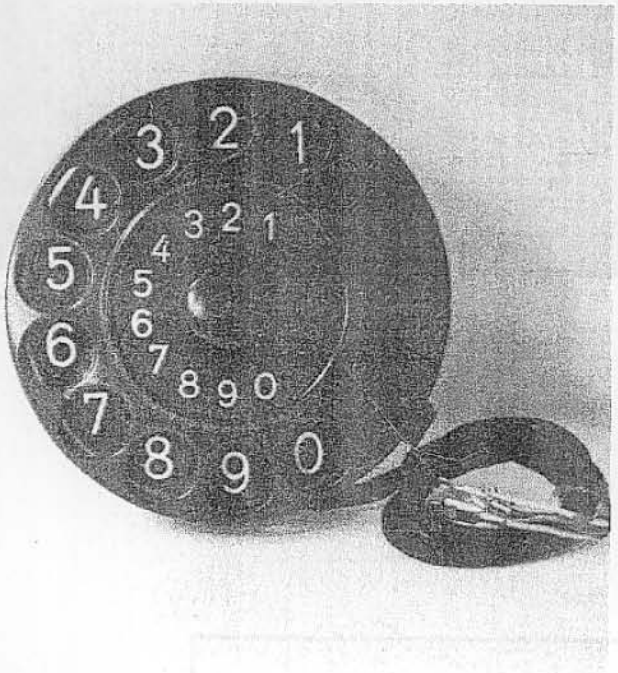


FIG. 9. SIEMENS & HALSKE LATEST DIAL. (FRONT.)

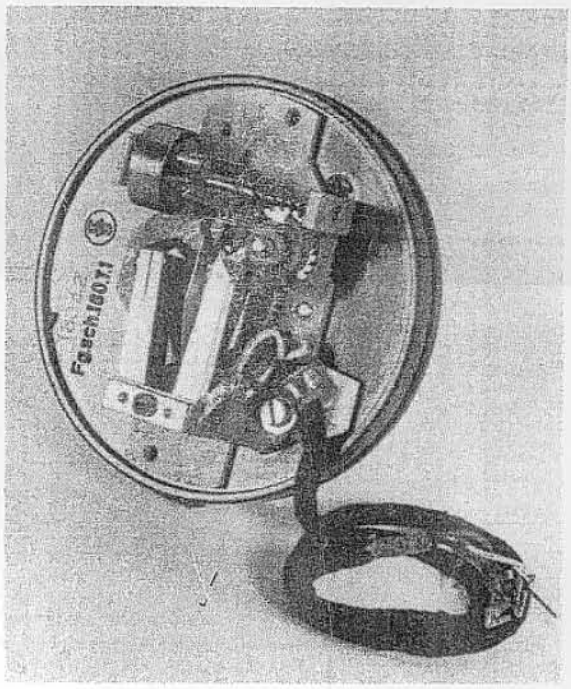


FIG 10 SIEMENS & HALSKE LATEST DIAL.(BACK.)

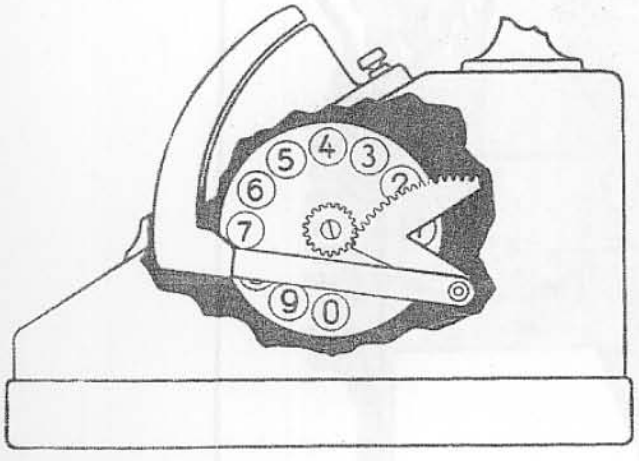


FIG. 11. SIEMENS & HALSKE OPERATORS DIAL.(SIDE ELEVATION.)

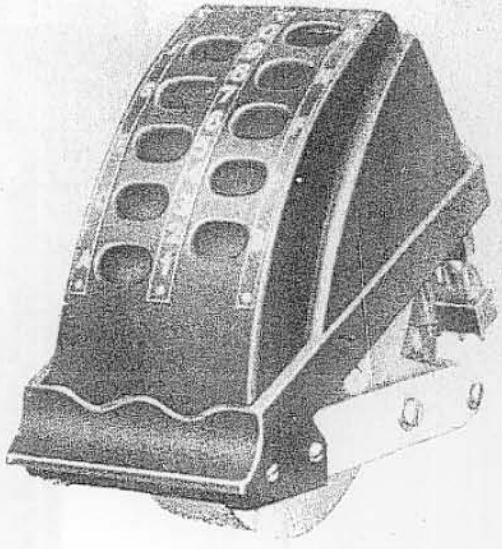


FIG. 12. SIEMENS & HALSKE OPERATORS DIAL (PERSPECTIVE.)

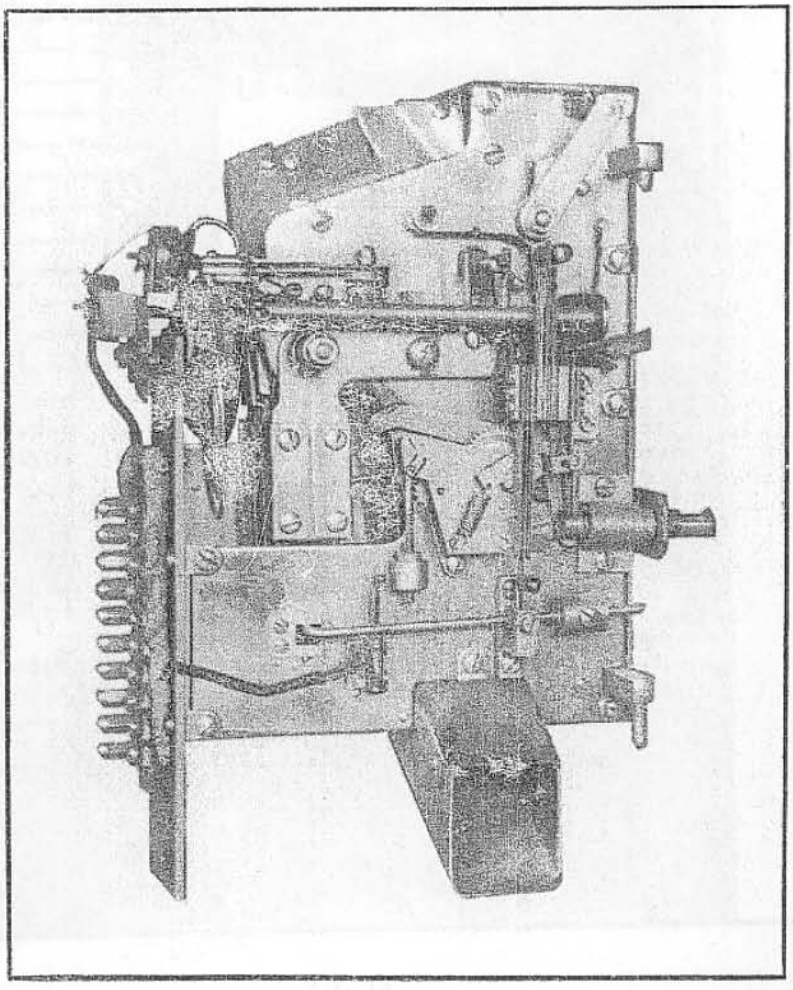


FIG. 13.

MECHANISM OF COIN COLLECTING WALL TELEPHONE, TYPE No. 27.

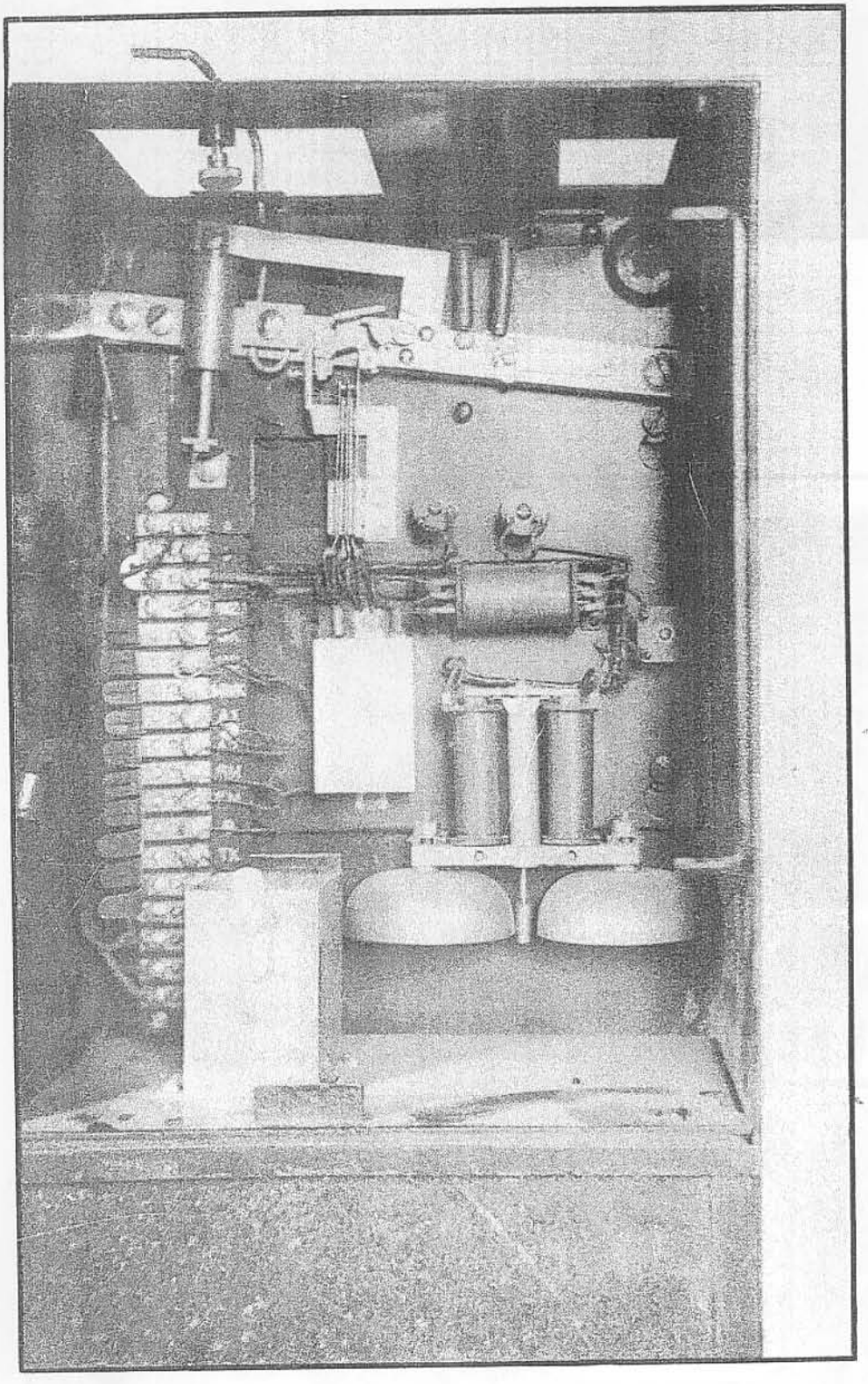


FIG. 14.

INTERIOR OF CASE OF COIN COLLECTING WALL TELEPHONE, TYPE. No. 27.

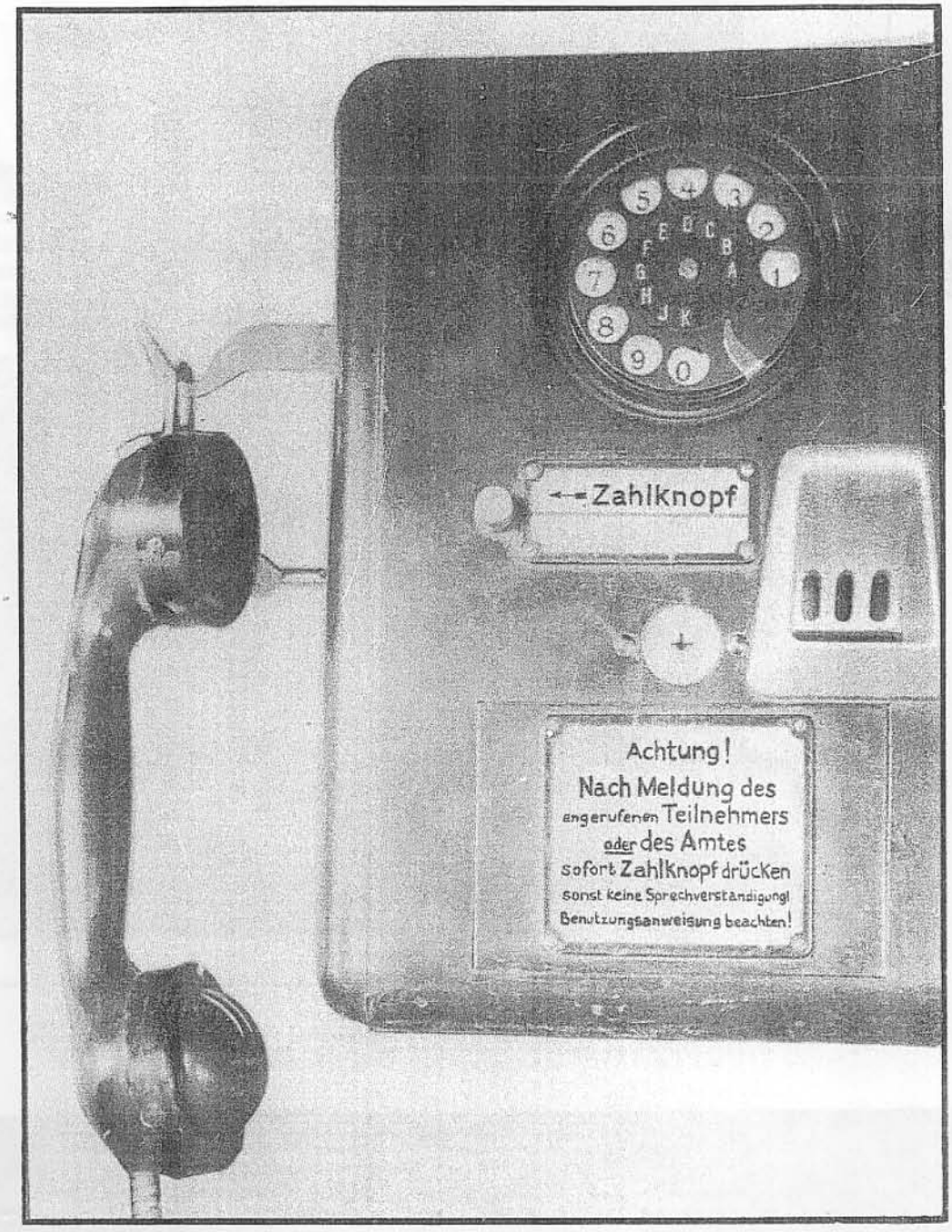


FIG. 15.

EXTERIOR OF COIN COLLECTING WALL TELEPHONE TYPE. No. 33. I.

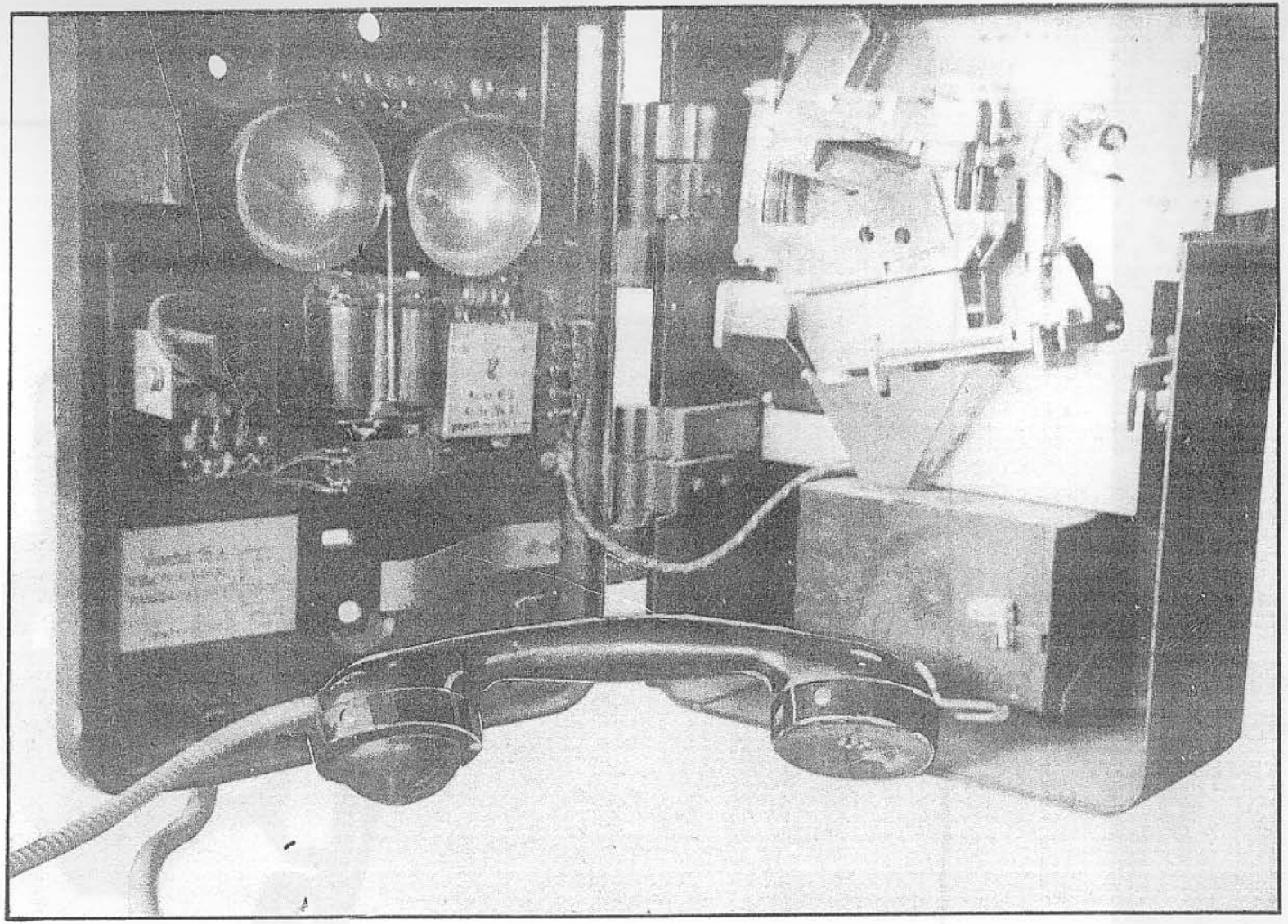


FIG. 16.

INTERIOR OF COIN COLLECTING WALL TELEPHONE TYPE. No.33. 1.

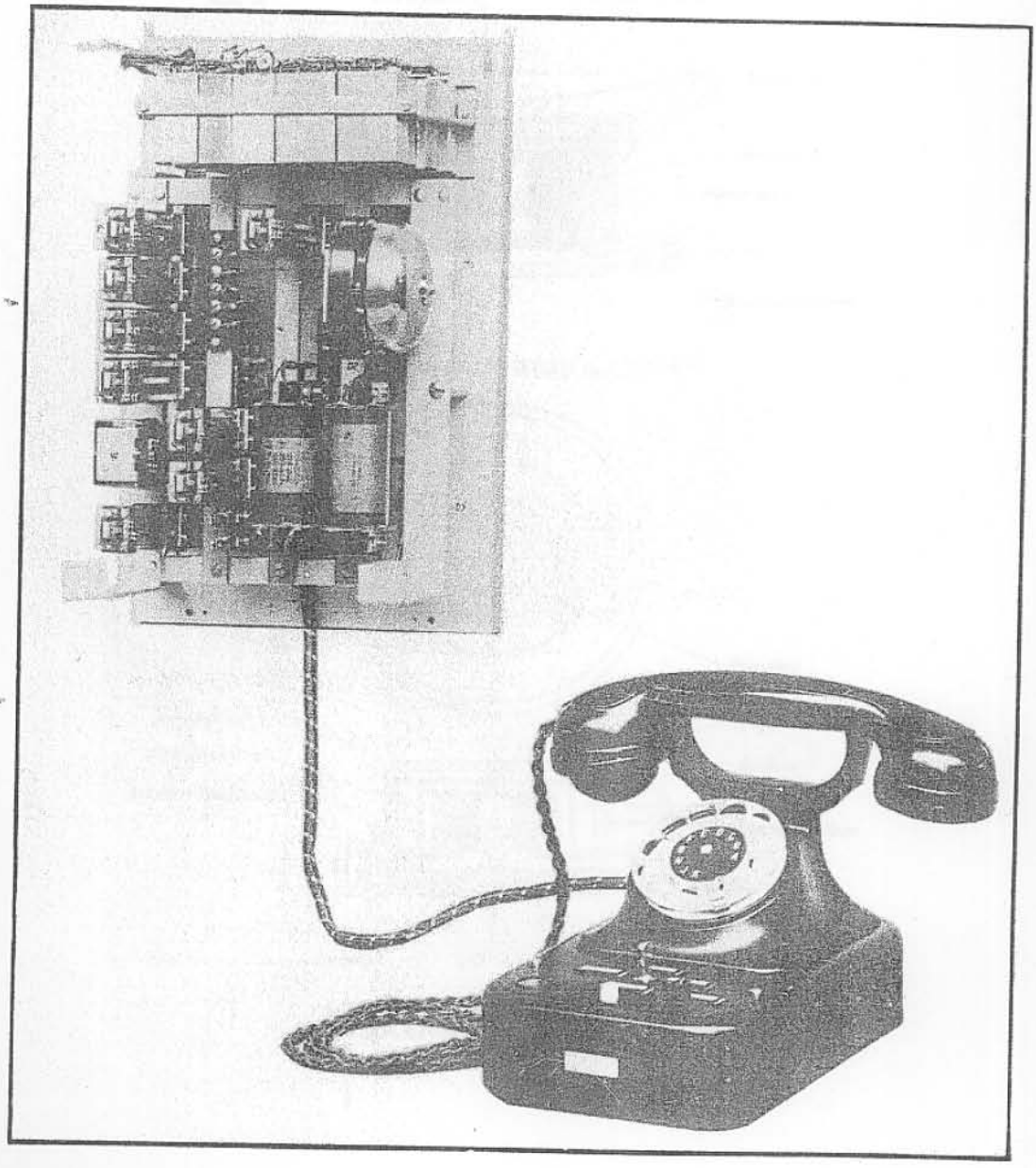
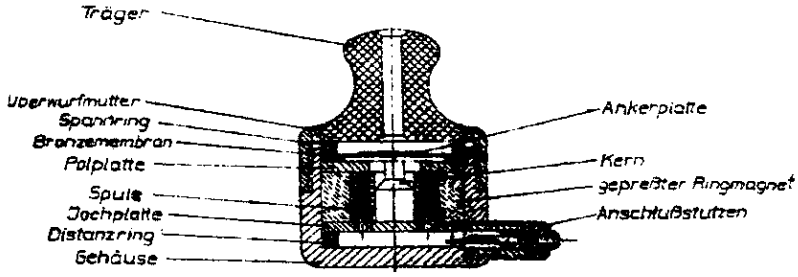
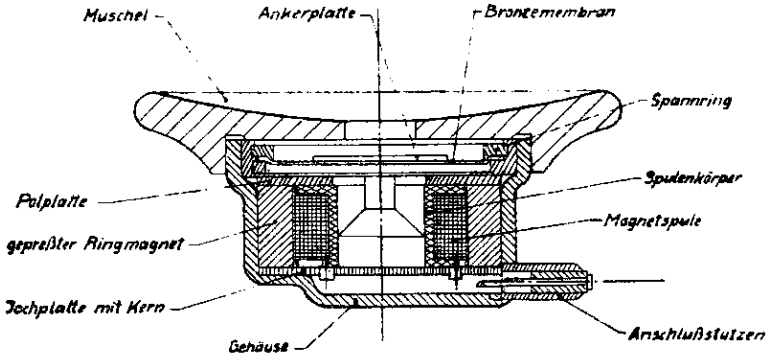


FIG. 17.

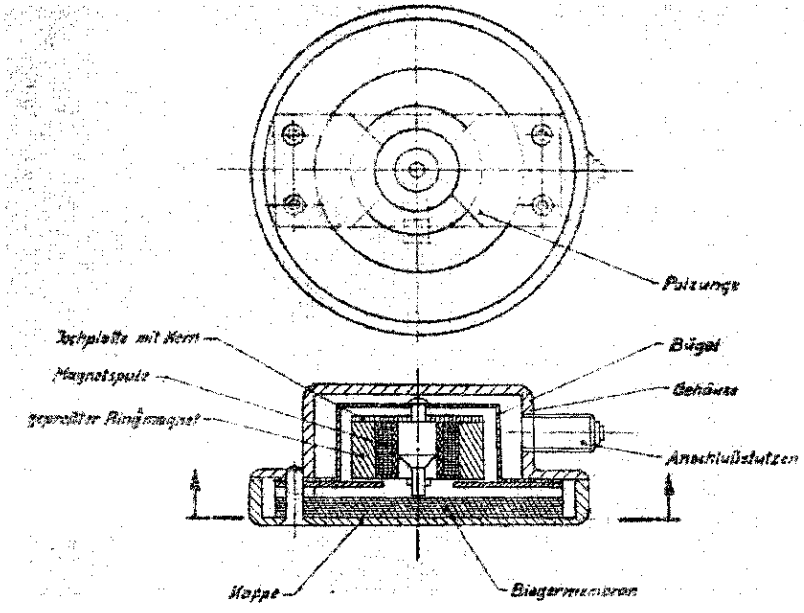
ZWISCHENSTELLENUMSCHALTER (EXTENSION PLAN 7) MAIN STATION TELEPHONE, SHOWING RELAY SET WITH COVER REMOVED.



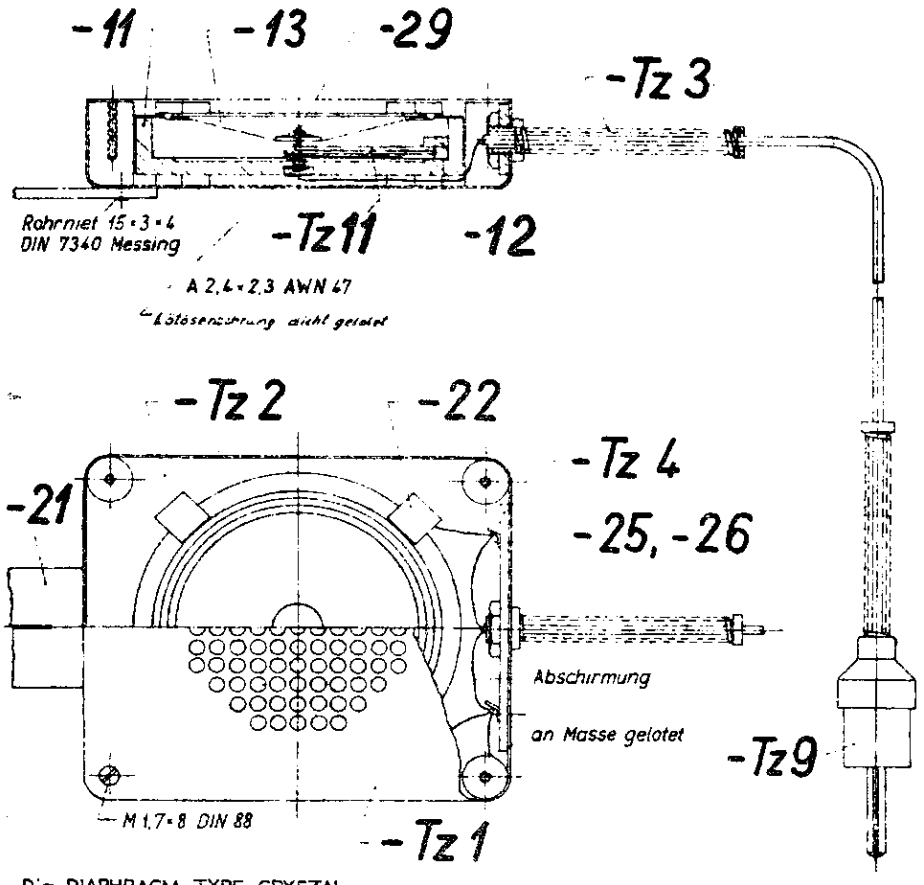
A:- "INSERT DEAF AID RECEIVER" (OLIVE)



B:- EXTERNAL DEAF AID RECEIVER (LUFTHÖRER)

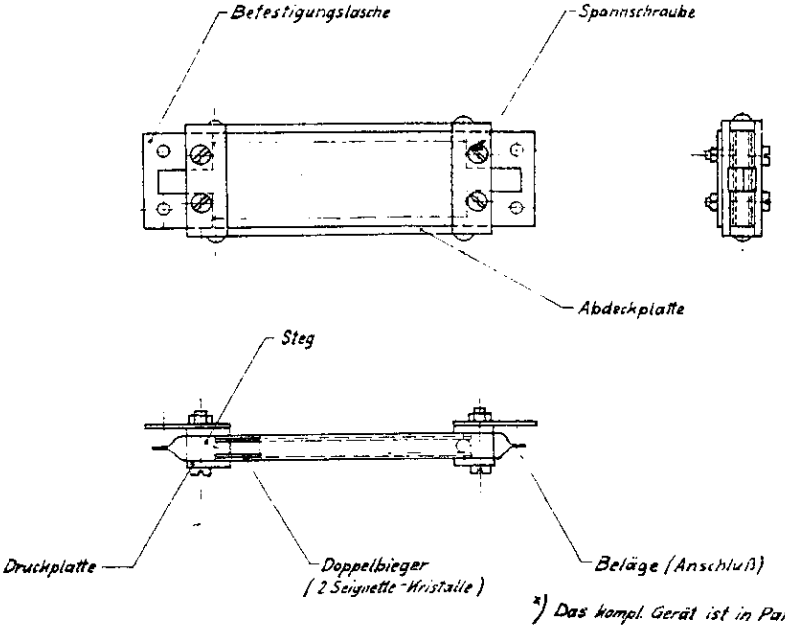


C:- BONE CONDUCTION DEAF AID RECEIVER
(KNOCHENLEITUNGSHÖRER)



D:- DIAPHRAGM TYPE CRYSTAL MICROPHONE (MIKROFON)

-Tz 7 und -13 mit Klebstoff an -14 geklebt
Rand von -13 mit Klebstoff an -11 geklebt
-22 mit Klebstoff an-Tz 2 sowie -13 geklebt



*) Das kompl. Gerät ist in Paraffin getaucht.

E:- SOUND-CELL CRYSTAL MICROPHONE (KLANGZELLE)