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Preliminary report on German Ground Radar Equipment Apparatus FuSE 62 (Wurzburg). "D" type display system

- by -

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SUMMARY

This note describes the display and range measuring system employed on the latest known type of Wurzburg equipment, FMG 39T/D, which is a form of FuSE 62 as used for anti-aircraft fire control.

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1. Introduction

This investigation was performed at the request of Air Ministry, Intelligence (A.D.I.Sc.).

The object was to determine the method of operation, and the operational efficiency of the type 'D' display system. The two units comprising the display and range-measuring equipment were available in reasonably good condition, together with other specimens in a worse state of repair. No information has been received on this part of the apparatus, and all circuits were traced from the units themselves. Later in the investigation, some captured notes came to light, including some block diagrams; these, however, were found to be misleading rather than helpful, and they are not included in the report.

At the present time no operational tests have been carried out, so a part of the information contained herein must necessarily be conjectural. The ease of operation of the equipment, accuracy of measurement, etc., will therefore form the basis of a further report, this one being concerned primarily with the electrical performance.

2. Description of display and range-measuring system.

See Diag. Nos. 9265B, 10054/B and 10259/B.

This system employs four display tubes: one with an 11 cm. screen, as a search tube, with a continuously running circular time base, calibrated in kilometres up to 40 Km, and three small tubes with 6 cm. screens, each showing an approximately linear time base derived from a sine-wave at the pulse recurrence frequency (3750 c/s), the length of time base visible on each tube being approximately 10 kilometres. These strobed portions can be selected at will from the complete time base on the search tube, their position relative to the latter being indicated on it by means of a dark spot, beyond either side of which the strobed time base extends to a range corresponding to 5 kilometres. These three small tubes are used for the precise measurement of range, azimuth and elevation respectively.

The search tube, whose video-frequency input is in parallel with that of the three strobe tubes, is not used for accurate measurements, all of which are taken on the latter. Fine measurement of range is performed by setting up the selected echo on to the dark spot of the range tube, while D.F. for bearing and elevation is obtained by using split on the appropriate tubes, when bearing and elevation are read from the turret and tilting scale, respectively. This method of measurement may seem a little crude, but when the set is used for flak-ranging, all the information - range, bearing and elevation - is fed electrically to the predictor (Kommandogerat) by means of Selsyns, of which two are geared to the range-measuring goniometers, two to the turret and two to the paraboloid, thus obviating all delay and error due to verbal communication of the intelligence.

The principle of the method of measuring range is the measurement of the delay between the transmitted and received R.F. pulses by two mechanically coupled phase-shifters, one of which alters the phase of the strobed time bases at the recurrence frequency of 3750 c/s, while the other, which is geared to the first with an 8:1 ratio, shifts the phase of the black-out pulse on the range tube in synchronism with the range time base. This black-out pulse is produced at 30 Kc/s., so that there are eight pulses per complete time base cycle; the time base voltage is of such an amplitude, however, that only one of these pulses is seen on the screen of the tube. The effect of the ganging of the goniometers is to keep this black-out pulse stationary relative to the screen of the tube, while the time base is shifted. When the equipment is accurately set up, the time bases on the three strobed tubes are identical, so that there can never be any doubt that the range, bearing and elevation operators are all following the same target.

The master frequency of 3750 c/s is obtained by division from a 60 Kc/s crystal controlled oscillator, upon whose accuracy the range-measurement depends, as it does also on the two goniometers.

The measuring of range by a 30 Kc/s dark spot, rather than by one at 3750 c/s, makes for increased accuracy of reading, for since the range scale is coupled to the rotor of the 3750 c/s goniometer, any angular error in the setting of the 30 Kc/s goniometer is reduced by eight to one in the reading of range.

The whole system shows a great advance on the earlier types of Wurzburg display, in that a crystal-controlled master-oscillator is used, range-measurement depending on the accuracy of this and of the phase-shifters, instead of on the linearity of velocity of a circular time base; and also that split is used for more accurate D.F., instead of the earlier method of setting for maximum echo.

As in the 'A' type station, the recurrence frequency is raised to 5 Kc/s for I.F.F. interrogation, but, in contrast with the earlier system, this 5 Kc/s is generated separately, and continuously, by an additional valve, and is switched on to the impulse generator only, all time base and black-out circuits remaining in operation at 3750 c/s, though the traces become meaningless, since they are not synchronised with the transmitter.

The whole of the display and master-oscillator circuits is housed in two units, which are mounted to the right of the control panel, and behind it, respectively, the main display unit being on shock-proof rubber mountings (See Fig.15).

Power packs, except for E.H.T. supplies to the display tubes, are external.

3. Description of the range-measuring unit EAG.62 (See Figs.9-11).

The range-measuring unit EAG.62 is housed in a weather-proof sheet metal case, and contains three detachable units, which make connection with each other and with the phase-shifters, etc., by means of moulded plugs and sockets; in addition to the Selsyns and phase-shifters, with their associated gearing.

The phase-shifters are controlled by means of a large knob on the front panel, for coarse adjustment, and a crank handle on the right-hand side of the unit, for fine movement. These, together with the range tube and dial can be seen in Figs 9 and 10. The separate units are inserted from the back, and are shown in position in Fig.11 and removed from their housing, in Figs. 12 - 14. The right-hand unit (QUARZ-U-TEILERSTUFE) contains the crystal oscillator and divider circuits; the bottom left-hand unit (VERSTARKER-MIT-DUNKELPUNKSTUFE) houses the black-out generator, together with the range tube time-base generator and two 3750 c/s amplifiers; and the top left-hand unit (ANZEIGESTUFE UND EINGANGSSTUFE) the range tube with its power supply, together with the final I.F. stage, detector and video-amplifier. The tube controls in this unit - Brightness and Focus - are accessible from the front of the set, under a weather-proof lid, shown open in Fig.9. Also seen in the front, under another flap, are the 3-position switch in the feed back circuit of V1, and the pre-set variable condenser (Marked "EICHUNG" - calibrate) in the grid circuit of V8, with its locking screw. (FESTSTELLUNG).

The whole unit obtains its supplies - mains, 350V. H.T. and 12.6V heater supply, through the 10-way flat cable entering the right-hand side, which in turn is fed from the relevant sources of supply via the display unit ANG.62. The large 18-way flat cable leaving the underside of the unit is for the Selsyn leads, and the mains to the heater in the chassis.

Both the Selsyn unit and the frame holding the two phase-shifters, with their gearing and dial, are easily removable from the main chassis by loosening three screws, electrical connections being made as before by moulded plug and socket. Most of the gearing is of compressed fibre.

The purpose of the jack on the left of the valves in the range tube unit (see Fig.11) is not known.

Monitor points, accessible from the rear, are lavishly supplied in all the circuits, and also at the front of the chassis, Bu.9 (Diag.9266B and Fig.10).

3.1. Master oscillator and divider circuits.

See diags. Nos. 9265/B, 9266/B, 9267/B and 9275/B and Fig.12.

V.1 is the master oscillator, which is controlled at 60 Kc/s by a crystal in the feed-back circuit from anode to grid. The wave-form of the output from this valve is not a pure sine-wave, but since it is used only to control the 30 Kc/s oscillator, V.2., this is of small importance. The purpose of the switch in the grid circuit of V.1 (Diag.No. 9266B) is not known definitely; in its three positions it is : (a) inoperative (b) shorting out C.3 or (c) shorting out C.3, C.22 and D.2. It is a reasonable assumption, however, that this has the effect of altering the pulse recurrence frequency to a few cycles above and below 3750 c/s, to avoid interference due to neighbouring Wurzburg stations, as in the 'A' type master oscillator. (See Para.7. Reference No.1.). The test instruments available were not sufficiently sensitive to determine this.

V.2. is a 30 Kc/s oscillator synchronised by the 60 Kc/s oscillation from V.1. The output from this valve is a reasonably pure sine-wave, and it is used to supply the frequency dividing circuits, by transformer coupling to V.3, and also feeds the first phase-shifter in series with the anode.

The division of 8 to 1, from 30 Kc/s to 3750 c/s, is performed by the cyclic chain of valves V4 - V6 - V5 - V4 etc. Perhaps the mechanism of this is best visualised as follows:

The 30 Kc/s sine-wave at the anode of V.2 is fed to the grid of V.3 via the high resistance W.11, which cuts off positive half-waves by means of grid current. This wave excites the damped oscillatory circuit formed by the transformer U.2 and condenser C.12, and so gives short pulses at the grid of V.4.

Now assume a small voltage at 3750 c/s to exist in the oscillatory circuit containing the transformer U.3, the stator of goniometer No.2 and the condenser C.20. It will be passed to V.5, where positive half-waves are cut off at the grid by W.21. The discontinuities in the resulting wave-form excite the ringing circuit D.4 and C.18, and negative half-waves of this oscillation are cut off by the parallel-connected metal rectifier G1.1, giving a wave-form at 3u.24 as shown in Diag.No. 9275/B. This is of such an amplitude that when fed to the screen grid of V.4, it conducts only at the positive peaks of the wave, passing short pips at 3750 c/s to the grid of V.6., and hence re-exciting the ringing circuit in the anode of V.6., and increasing the amplitude of oscillation. Thus a 3750 c/s oscillation is maintained.

The purpose of the condenser C.14 from the anode of V.4 to earth is to by-pass any 30 Kc/s component, while presenting a high impedance to the 3750 c/s.

The output is a good sine-wave, with slight kinks at 30 Kc/s - i.e. 8 to every whole cycle. These, however, are so small as to be negligible, and they are not shown in the diagram.

An output is also taken from the cathode of V.4 via point 12 on Bu.1, feeding V.10 in the black-out generator unit.

3.2. Phase-shifters (Goniometers)

See Diag. No. 9266B.

The two phase shifters, one for 30 Kc/s and one for 3750 c/s, are mounted rigidly inside the main chassis, and are mechanically geared to each other, the gear ratio being 8 to 1.

They are both series fed, in the anodes of V.2 and V.6 respectively, via the phase splitting network W80,82,83, C.60 and W.81, 87, 88, C.61. The settings appear to be such that the two halves of the stator winding of either phase-shifter are fed in quadrature. The output from the rotor is of sensibly constant amplitude, though the wave form is impure. No measurements on the accuracy of phase-shift with physical position, upon which the range-measuring system depends, have yet been made, but a fuller investigation will be the subject of a further report.

3.3. Black-out and range time-base generator unit and 3750 c/s amplifiers.

See Diag. Nos. 9268B and 9276B and Fig.13.

The 30 Kc/s dark spot for the range tube is produced in valves V7, 8 and 9. The grid of V.7, which is a 30 Kc/s amplifier, is fed with the shifted 30 Kc/s sine-wave from the rotor of goniometer No.1. The amplified sine-wave at the anode of V.7., is passed to the grid of V.8, there being a phase-shifting circuit from grid to earth. This includes a variable condenser, which is situated at the front of the main chassis, labelled "EICHUNG" (Calibrate). This is locked by the knurled screw to its left marked "FESTSTELLUNG". The purpose of this is to provide a very small range of phase-shift of the 30 Kc/s black-out with respect to the 3750 c/s range tube time base, and it is used for setting up. The amplified 30 Kc/s sine-wave has its positive half waves cut off by grid current, due to the 50K resistance W.39, and the discontinuities thus produced excite the damped ringing circuit formed by the transformer U.5, the condenser C34, and the two parallel resistances W.41 and W.42. The short pulses thus produced are passed to the grid of V.9, where the negative-going portion is cut off by the bias produced by W.44, and at the anode are seen the short negative pulses at a recurrence frequency of 30 Kc/s, which, applied to the grid of the range tube via the condenser C.52 (Diag. No. 9269B), produce the dark spot.

V.10 is fed from the cathode of V.4 in the master oscillator unit, producing by means of the R.C. network in its anode, a 3750 c/s wave which is a form of saw-tooth with a very sharp negative going edge. This is used to operate the impulse generator IG62A, and gives increased precision of timing of the transmitter pulse with respect to the display time bases, over the earlier system, when the impulse generator IG.62 was locked from a sine-wave (See Para.7. Reference No.2.). When this earlier type is used, V.10 is inoperative, and the switch which selects this is in the display unit (See 4.5.4).

V.11, triode-connected, amplifies the 3750 c/s sine-wave from the anode of V.6 in the master oscillator unit, to feed the time base generator in the main display unit, ANG.62 (See 4.1).

V.12, supplied with the shifted 3750 c/s sine-wave from Goniometer No.2., amplifies this to provide the sinusoidal time base of the range tube. A very large swing is put on to the X-plates of this tube, only the centre (almost linear) portion being visible on the screen. The phase-shifting circuit in the grid of this valve has the effect of a horizontal shift control for the range tube.

3.4. Other functions performed by the Unit

The remaining sections comprise the final I.F. stage, detector, and video-amplifier, together with the range tube and its power supply.

The I.F. circuits (V1-V4, Diag. No. 9269B) will be dealt with in the report on the whole I.F. unit.

The power supply for the range tube is completely self-contained. It is fed with the 180V regulated mains supply from socket 8 (through the display unit ANG.62) and provides heater supply and 2KV H.T. for the tube, the latter from the bank of copper oxide rectifiers G1.2-5 (See Diag. No. 9269B and Fig.14).

4. Description of the display unit ANG.62 (See Figs. 1-4)

The main display unit contains three display tubes - the main search tube, and the bearing and elevation tubes. (See Fig.1.). Four removable units make contact with the main chassis by means of moulded plugs and sockets, and house the circular time base generator, the bearing and elevation tube time base generator, the dark spot generator for the main search tube, and the I.F. output stages respectively. These are accessible, for changing valves, operating the control, etc., by opening two flaps at the right-hand side of the equipment (See Fig.2). The separate units removed from the frame are shown in Figs. 5-8. All pre-set controls - circular time base setting, zero adjustments etc., are accessible from the side of the unit under the hinged flaps, while tube controls (brightness and focus) are all at the front (Fig.1.).

The frame is cast in sections, spot-welded together, and is completely weather-proof. Detachable hoods are provided for screening all the tubes from direct light.

Since split is employed on the two small tubes (bearing and elevation), both are fitted with transparent adjustable screens, engraved with lines at $\frac{1}{2}$ cm. intervals parallel to the trace, in order to facilitate the setting of the two adjacent echoes to the same amplitude. The plate glass screen of the large search tube is calibrated directly in kilometres, up to a maximum of 40 Km. (Fig.1.).

Supplies to the unit - mains, H.T. and heaters - are fed from a plug and socket in the base of the unit, and these are passed to the range-measuring unit EAG.62 via Socket 17, at the back of the chassis (See Fig.4). The concentric screened leads to and from the I.F. output stages - i.e. to the identical unit in the EAG.62, and from the I.F. amplifier, ZFV.62 - also enter at the base of the unit, as does the 6-pin plug (Bu.21) carrying the split and brightening pulses from the dipole head cam switch.

The chassis is fitted with a heater, whose supply is obtained via an extra lead from the pre-regulated mains. A monitoring socket (See Diag.9280B) is accessible from the side of the unit, under the top flap. (Figs. 2 and 3).

4.1. Circular time base generator. (Unit 'A').

See Diag. No. 9270B and Fig.5.

This circuit is similar in operation to the corresponding circuit in the 'A' type, display unit, OSZ.62 (See para.7, Reference No.1). The chief differences are in the input circuit to V.5., which in this case is a straightforward potentiometer device, no phase compensation being made; and in the fact that a phase control is provided, in the shape of the variable condenser C.20, for shifting the circular trace round bodily about its own centre. This is used for setting the zero-pulse to 0 on the scale.

The two tuned circuits containing as their inductive element the time base coils, operate slightly below resonance, the ranges of the variable condensers C.20 and C.24 being insufficient to bring the resonance point below the operating frequency, 3750 c/s.

The operation of the two coil circuits near to resonance is to be commended as being an economical means of obtaining a high current from a comparatively low-power source.

4.2. Time-base generator for bearing and elevation tubes (Unit 'C').

See Diags. No. 9272B, 9274B, 9277B and Fig.7.

This unit is fed with the shifted 3750 c/s sine-wave, amplified in V.12 of the range-measuring unit. A variable condenser C.30 in the anode of V.6., provides a moderate range of phase shift of the output wave-form, and has the effect of moving the strobed time-bases of the bearing and elevation tubes, and hence the dark spot on the search tube, relative to the main search time-base, and is used for setting up the equipment. This sine-wave is further amplified in V.7, whence it is fed, via transformer U3, to the X-plates of the bearing and elevation tubes, and to unit 'D', the black-out generator for the search tube.

The resistance W.38 and rectifier G1.1 and 2 provide a short brightening pulse at the grids of the two tubes.

Into the socket Bu.20 (Fig.3) can be inserted a twin screened lead attached to a small weatherproof unit containing a variable condenser, controlled by a large knob. The electrical effect of this is the same as that of the control "DUNKELPUNKT", though the operational necessity for duplicating this control is not known. This small unit can be seen on top of the control panel in Fig.15.

4.3. Black-out generator for search tube (Unit 'D').

See Diags. Nos. 9273B, 9278B and Fig.8.

The sine-wave input to V.8 is obtained from the transformer U3 in Unit 'C', and so is in a fixed phase relationship with the time bases of the bearing and elevation tubes.

Positive half waves of the input sine-wave are cut at the grid of V.8. by the 100K resistance W.39, and from the negative half waves are produced positive and negative going pips, by means of the pulse transformer U4. These appear at the grid of V.9 reversed in phase, and the negative going pips are cut off by the cathode bias of this valve (W.48), while the amplified and reversed pulses at the anode are fed to the grid of the search tube via the condenser C.50 (Diag.9280B).

The potentiometer W.111 and W.112, apparently a modification, judging by the numbering of the components, applies the black-out pulse and a variable positive bias to the cathodes of the two valves in parallel which form the final I.F. stage, in unit 'B' (Diag. No. 9271B), when the changeover switch marked Normal-Sonder is in the "Sonder" position ("Special" operation). The application of this is not known.

The unmarked condenser across the primary winding of U4 is inside the transformer case, and has a value of approximately 14 pF.

4.4. The split and brightening circuits

See Diags. Nos. 9274B and 9280B.

Shift and brightening pulses for split presentation on the bearing and elevation tubes are produced by a simple cam sequence switch on the driving shaft of the rotating eccentric dipole.

The closing of any of the contacts earths one of the points 7, 8, 10 or 11 on Bu.21, producing a long negative pulse which is applied to the cathode of the appropriate tube via the network W94, C62, W59 or W95, C63, W62. This brightens the trace while the contact is closed - i.e. for about 6.5m/secs., assuming a 60° arc of contact for the cam switch, which rotates at 1500 r.p.m. Hence about twenty or more traces are illuminated. At the same time, a pulse is also applied, through the windings of the time base transformer U3 to the X-plate of one tube, giving a small shift. Thus the trace on the screen shows two echoes side by side, one as received with the dipole in one position, the other as received with the dipole in a diametrically opposite position (Dipole horizontal - elevation tube; dipole vertical - bearing tube). See Diag. No. 10054/3.

In the dipole head, the resistors W.1 to W.4, the high frequency chokes D.1 to D.4 and the condensers C.1 to C.8 are for spark suppression only.

Centring of the traces during initial setting-up, is performed by the two potentiometers W.77 and W.78, respectively marked SEITE-VERSCHIEBUNG and HOHE-VERSCHIEBUNG.

4.5. Other functions performed by the unit.

4.5.1. Final I.F. Stage. See Diag. No. 9271/B and Fig.6.

The final I.F. stage, together with detector and video-amplifier, is in unit 'B', and is almost identical with that in the range-measuring unit, the only difference being the inclusion of the switch marked "Normal-Sonder", already referred to in section 4.3.

This switch applies a large positive bias to the cathodes of V.1 and V.2. and also disconnects the deflecting cones of the main search tube from their normal video input, and connects them to an external concentric socket, Bu.22 (Diag. 9280B). The application of this is not known.

4.5.2. The 5 Kc/s oscillator. See Diag. No. 9271B and Fig.6.

V.16 is a single valve oscillator (RV.12P.2000), and is housed in unit 'B', with the I.F. output stage. It is used to synchronise the impulse generator when I.F.F. interrogation is performed and is placed in circuit by the push-button switch U3 which breaks the lead from the 3750 c/s saw-tooth to the impulse generator, (see Diag. 9265B), and which is accessible from the outside of the unit, even with the flaps closed. Since exact timing of the impulse generator is unnecessary, no radar information being required during interrogation, a sine-wave only is used, instead of the 3750 c/s. saw-tooth.

The switch U.3 also operates a relay in the impulse generator to diminish the R.F. pulse-width during interrogation at 5 Kc/s. (See Para.7. Reference No.2).

4.5.3. The elevation indicator

A rough indication of elevation of the paraboloid is given to the operator by the Meter J.1, beneath the bearing tube. (see Fig.1) This is illuminated by means of the 12V. lamp V.15, and a reading is produced from the 350V., supply and a resistance chain including a potentiometer whose contact arm is operated directly by the mirror. In order to make this reading correspond with the reading of angle on the paraboloid scale, a pre-set variable shunt, W.97 and W.98 is provided (Diag. No. 92303).

4.5.4. The switch U.2. See Fig.4.

This three-pole change-over switch is not accessible without removing a small panel at the rear of the unit. Its function is to provide the appropriate synchronising pulse for the impulse generators IG.62 and IG.62a, i.e. a 3750 c/s sine-wave, and saw-tooth respectively, the former being identical with that supplied to the circular time base generator, V.5. Its two positions are marked 'C' and 'D', thus seeming to indicate that the IG.62a is used only on a type 'D' equipment, it being remembered that the ANG.62 unit is common to both 'C' and 'D' stations.

4.5.5. Power supplies for display tubes. See Diag. No.9280B and Fig.4.

The E.H.T. and heater supplies for the display tubes are self-contained, being fed with 180V regulated mains from Bu.18. The mains circuit includes a thermo-magnetic cut out U.1, whose nominal rating is 300 m/A.

As in the range-measuring unit, the rectification is performed by a bank of copper oxide rectifiers - ten, in this case. They can be seen in Fig.4.

All three tubes are fed from the same potentiometer chain, the two small tubes being tapped off at something less than half the full voltage of 4 KV.

The neon indicator lamp V.14, at the earthy end of the chain, strikes on overload, and is visible when the upper flap on the case is lowered. (Fig.2).

All the tubes are provided with separate focus and brightness controls accessible from the front of the unit, the former being pre-set, as the tubes and their power supply circuits are so designed that focus is sensibly independent of brightness.

5. Setting-up procedure.

See Diag. No. 10054/B. and Figs. 1, 2, 9 and 11.

1. Set range dial to zero.

2. Set bearing and elevation tube phase control fully anti-clockwise.

3. Set I.F. gain control to give a zero-marker pulse of $\frac{1}{2}$ to 1 cm. amplitude.

4. Adjust shape of circle by means of two potentiometers marked FORM.

5. Adjust position of circle by means of shift controls marked KREISVERSCHIEBUNG.

6. Adjust size of circle by pot marked DURCHMESSER. Correctly set, the circle should just touch the inner edges of the kilometre calibration marks on the face of the tube.

7. Shift the whole circle about its centre, using the control NULLPUNKT, until the leading edge of the zero marker pulse coincides with 0 on the kilometre scale.

8. Move the dark spot on the circular trace, by means of the control DUNKELPUNKT, until it also is at 0 on the kilometre scale.

9. Adjust the pairs of marker pulses on the bearing and elevation split tubes to the centres of their respective traces by means of the potentiometers SEITEVERSCHIEBUNG and HOHEVERSCHIEBUNG respectively.

10. Using the control EICHUNG, after unlocking the set-screw FESTSTELLUNG, adjust the dark spot on the range tube to be exactly in the centre of the zero marker pulse. Re-lock the screw FESTSTELLUNG.

11. Shift the dark spot and marker pulse on the range tube to the centre of the trace, by means of the pot W.60 at the back of the range unit, also marked DUNKELPUNKT in some units.

Until the apparatus is thoroughly warm, the above procedure must be carried out at frequent intervals - say every $\frac{1}{4}$ hr. for the first hour, every $\frac{1}{2}$ hr. for the next two hours, and then hourly.

6. Conclusions.

While no investigation of the accuracy of the equipment, either absolute, or in comparison with corresponding British apparatus, has yet been made, it is safe to state that the operation is fairly easy, even with comparatively untrained personnel. The smooth following of range - essential for use with a predictor - is particularly simple to perform, and the split is very satisfactory, provided that the echo is well above mean noise level.

A consequence of the fact that the dipole rotation is not locked to the recurrence frequency, is that for varying dipole positions different amplitudes of pulse are received, ranging from zero to the maximum.

These are all superimposed on one another on the trace, so that the echo is a solid patch of illumination with, quite frequently, no break in the time base. This tends to make searching rather more difficult than is usually the case.

The circuit design in these two units is efficient, and sometimes ingenious, and no circuit faults have yet occurred since the equipment has been in use here - i.e. for two months or more. Setting-up can be performed simply and quickly.

The construction of both units leaves nothing to be desired, from the point of view of interchangeability of units, robustness and simplicity.

No comment can yet be made on the quality of the components, which will be dealt with in a further report, except to remark on their smallness as compared with their British counterparts.

Reports on the valves used, and on the I.F. end stages, will be issued at a later date.

7. References :-

7.1. Preliminary investigation of Display Unit OSZ.62 of the FuSE 62.
R.A.E. Technical Note No. Rad.178.

7.2. Impulse generators IG.62 and IG.62 A of the FuSE 62.
R.A.E. Technical Note No. Rad.196.

8. Other relevant reports.

8.01. FuSE 62. Mechanical Aspects and Turning Gear.
R.A.E. Technical Note No. Rad.151.

8.02. FuSE 62. Low Tension Circuits.
R.A.E. Technical Note No. Rad.189.

8.03. FuSE 62. Monitoring Receiver Units K.D.62 and K.D.64.
R.A.E. Technical Note No. Rad.202.

8.04. Examination of German Valves manufactured between 1938 and 1943.
R.A.E. Technical Note No. Rad.114.

8.05. German valve type L.D.2.
R.A.E. Technical Note No. Rad.127.

8.06. German valve type L.G.1.
R.A.E. Technical Note No. Rad.149.

8.07. Examination of Enemy valves and C.R.T.'s
R.A.E. Technical Note No. Rad.155.

8.08. Freya transmitter. T.106.
R.A.E. Technical Note No. Rad. 156.

8.09. Coast-watcher 7 Freya installations; Main Display Unit N.B.110.
R.A.E. Technical Note No. Rad.204.

8.10. German Ground Radar Characteristics. Air Scientific Intelligence. Report No.20. Air Ministry (A.D.I. Sc.).

8.11. Recognition of German Ground Radar. Air Scientific Intelligence. Report No.24. Air Ministry (A.D.I.Sc).

8.12. FuSE 62. Examination of Aerial Feeder System and R.F. circuits. } In preparation

8.13. Telefunken valve type L.S.50. }

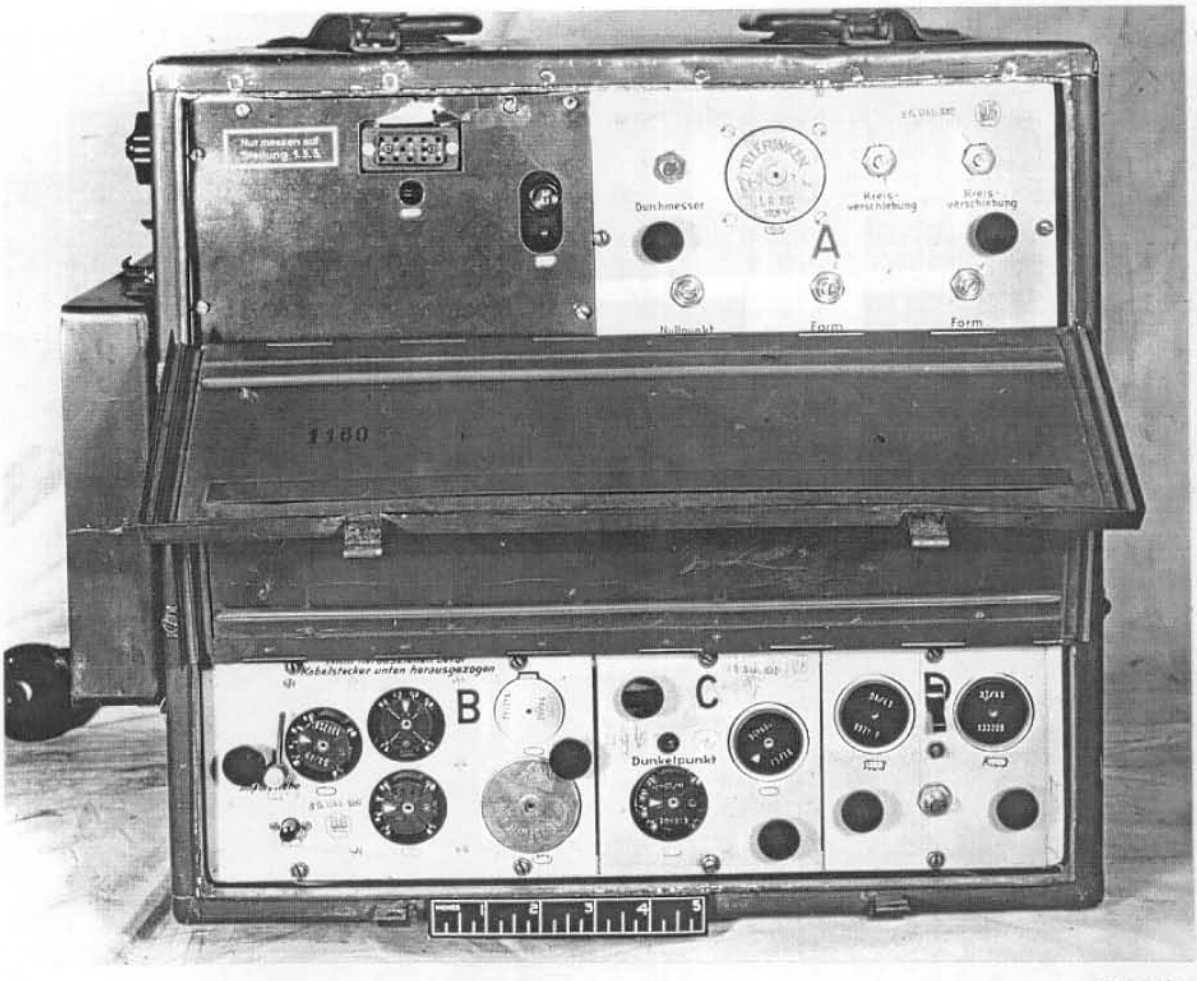
Distribution :-

Air Ministry A.D.I.Sc. (80 copies)
D.C.D./D.D.C.D.2.
D.C.D/R.D.C.7.
D.C.D/R.D.C.13.b.
T.R.E. (Dr. Taylor).

Radio/S4761/GWEB/74.

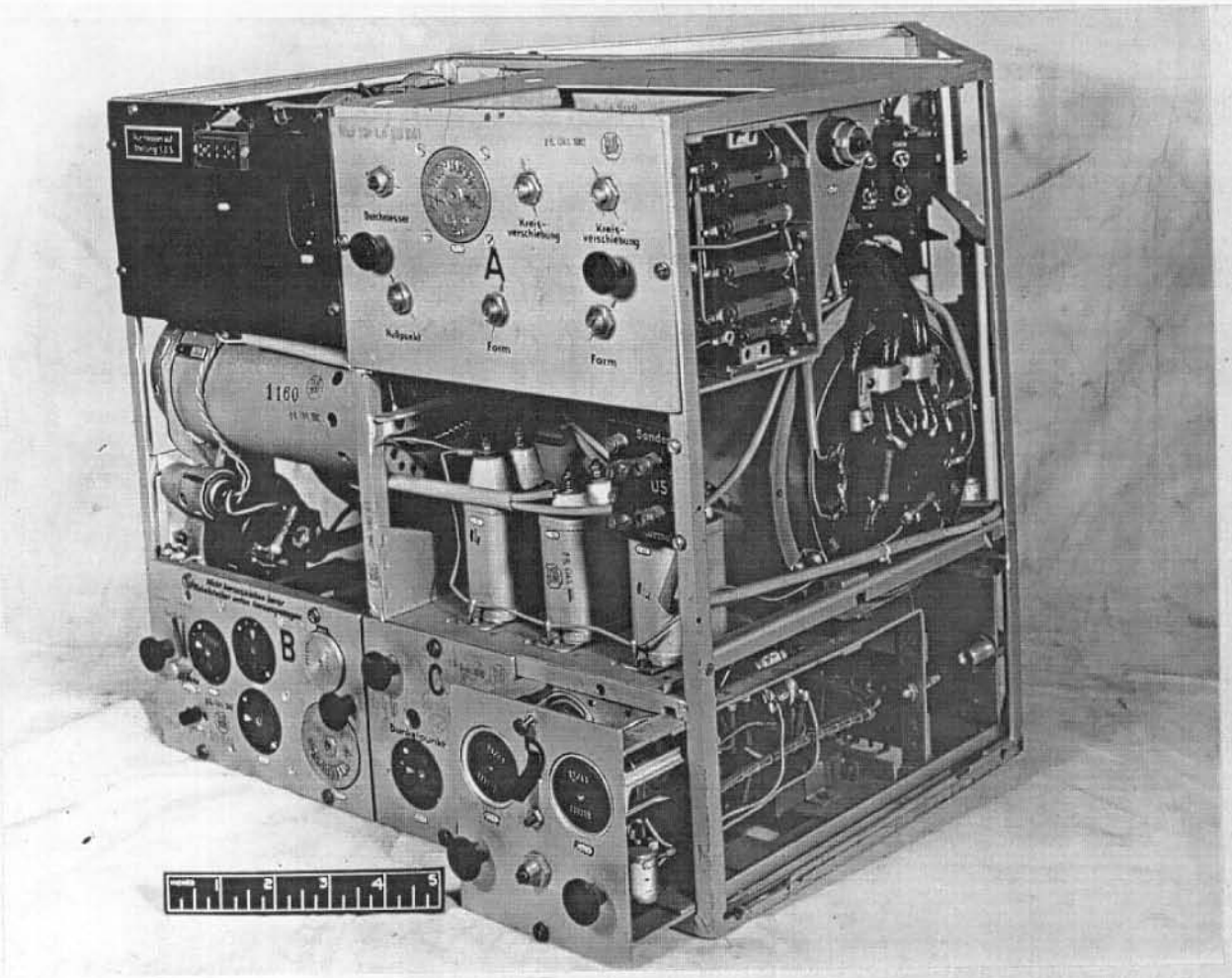
DISPLAY UNIT ANG.62.
FRONT VIEW.

FIG. 1.

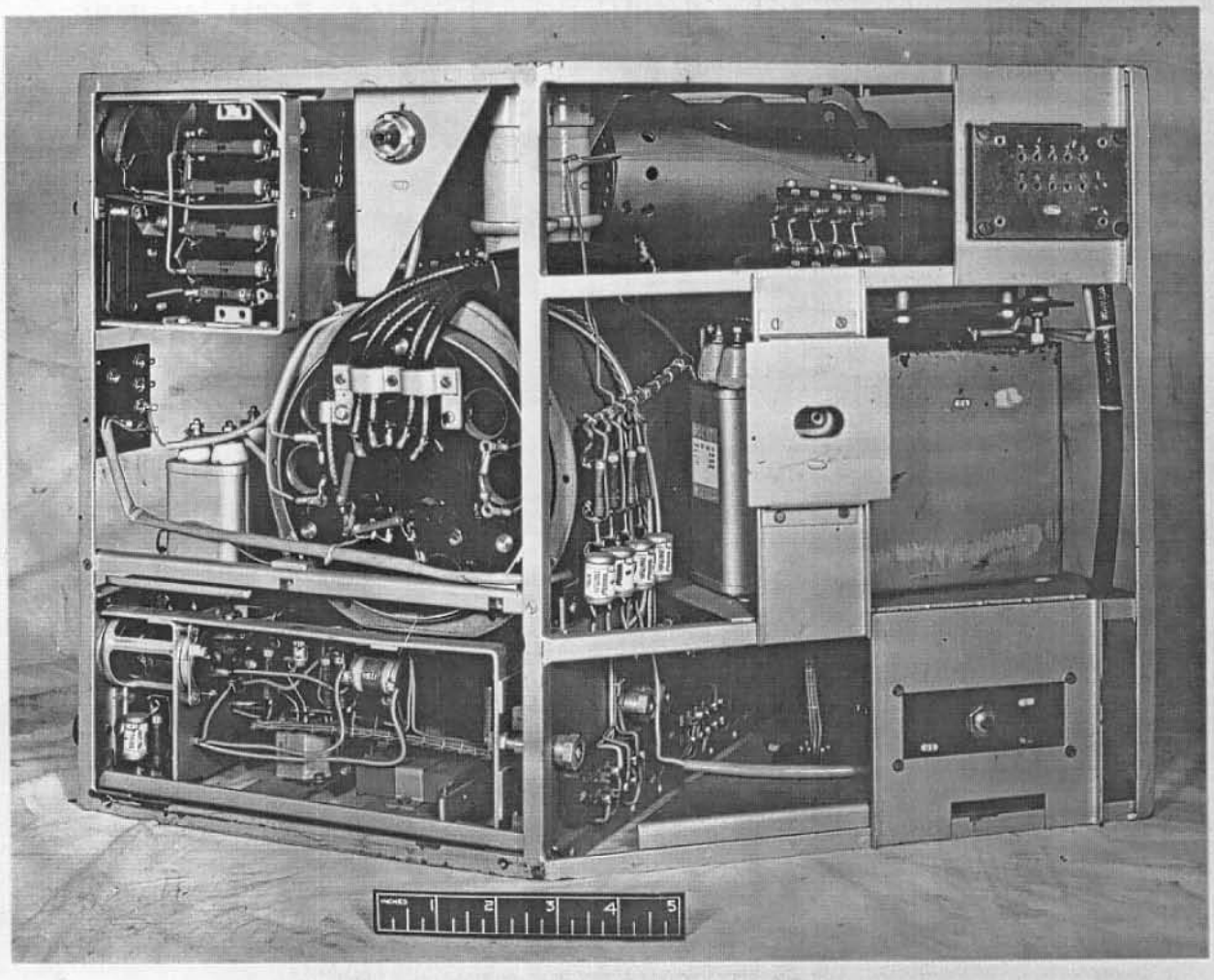


DISPLAY UNIT ANG 62.
SIDE VIEW WITH FLAPS OPEN.

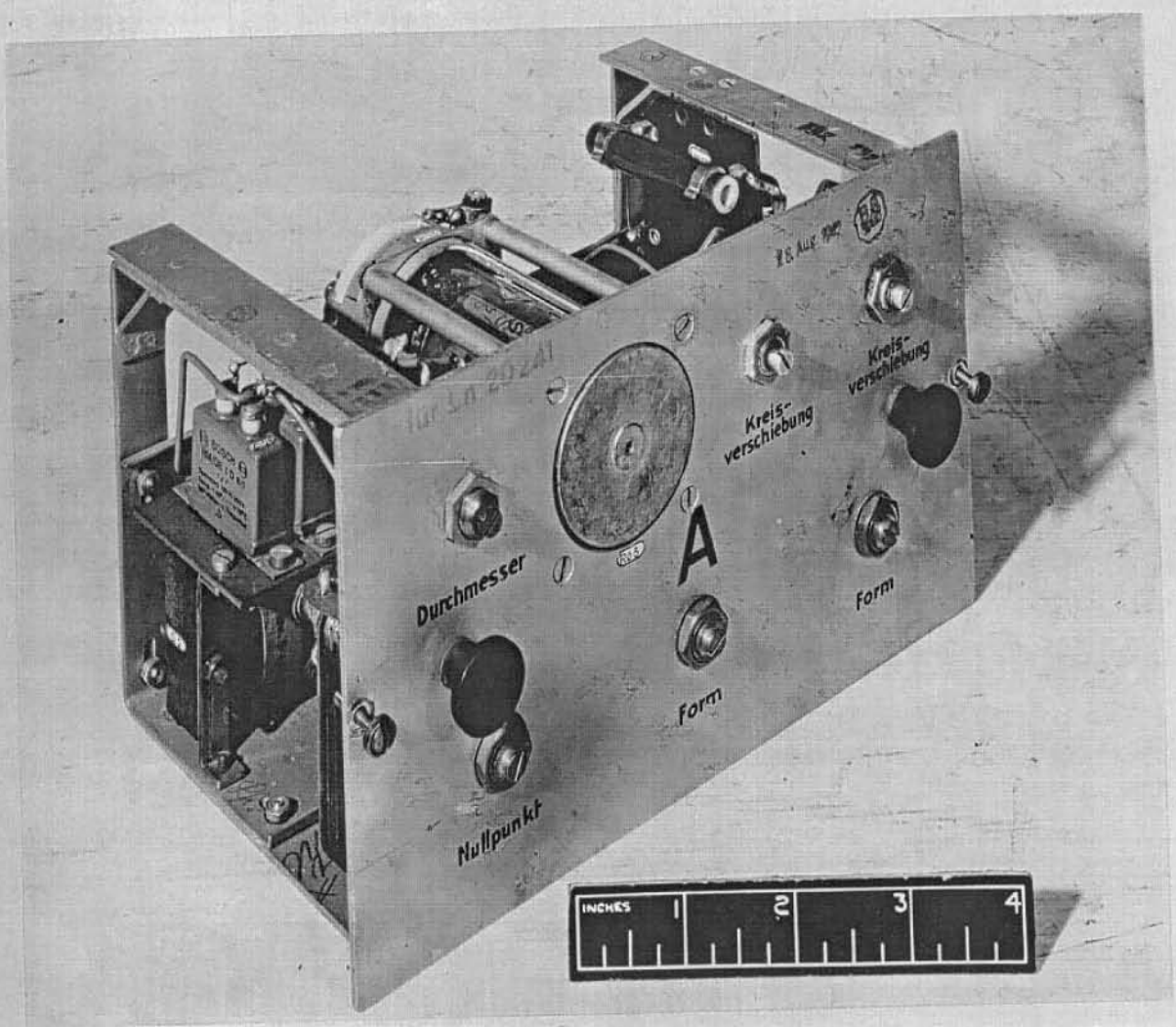
FIG.2



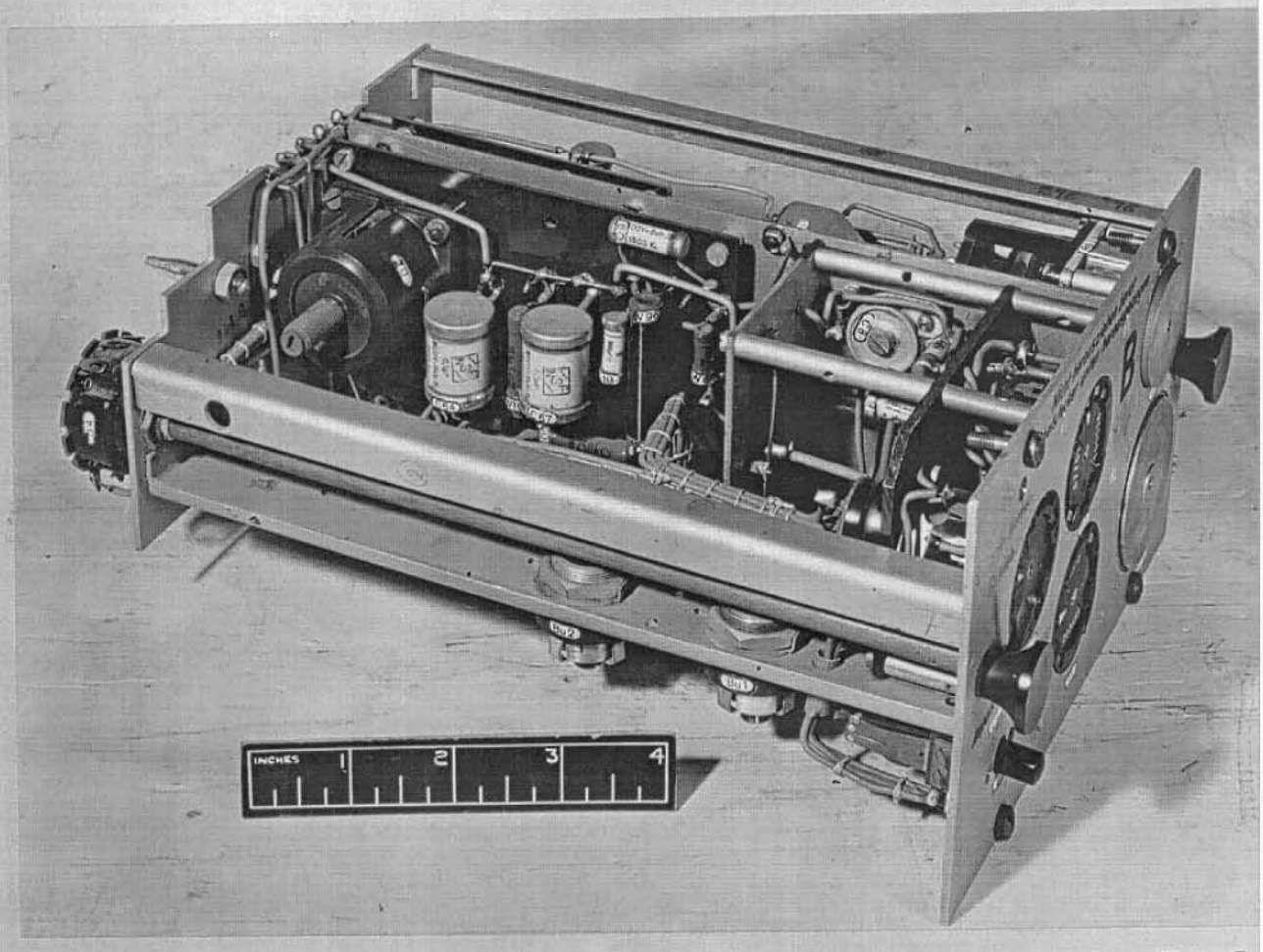
DISPLAY UNIT ANG 62. REMOVED FROM CASE. FIG. 3



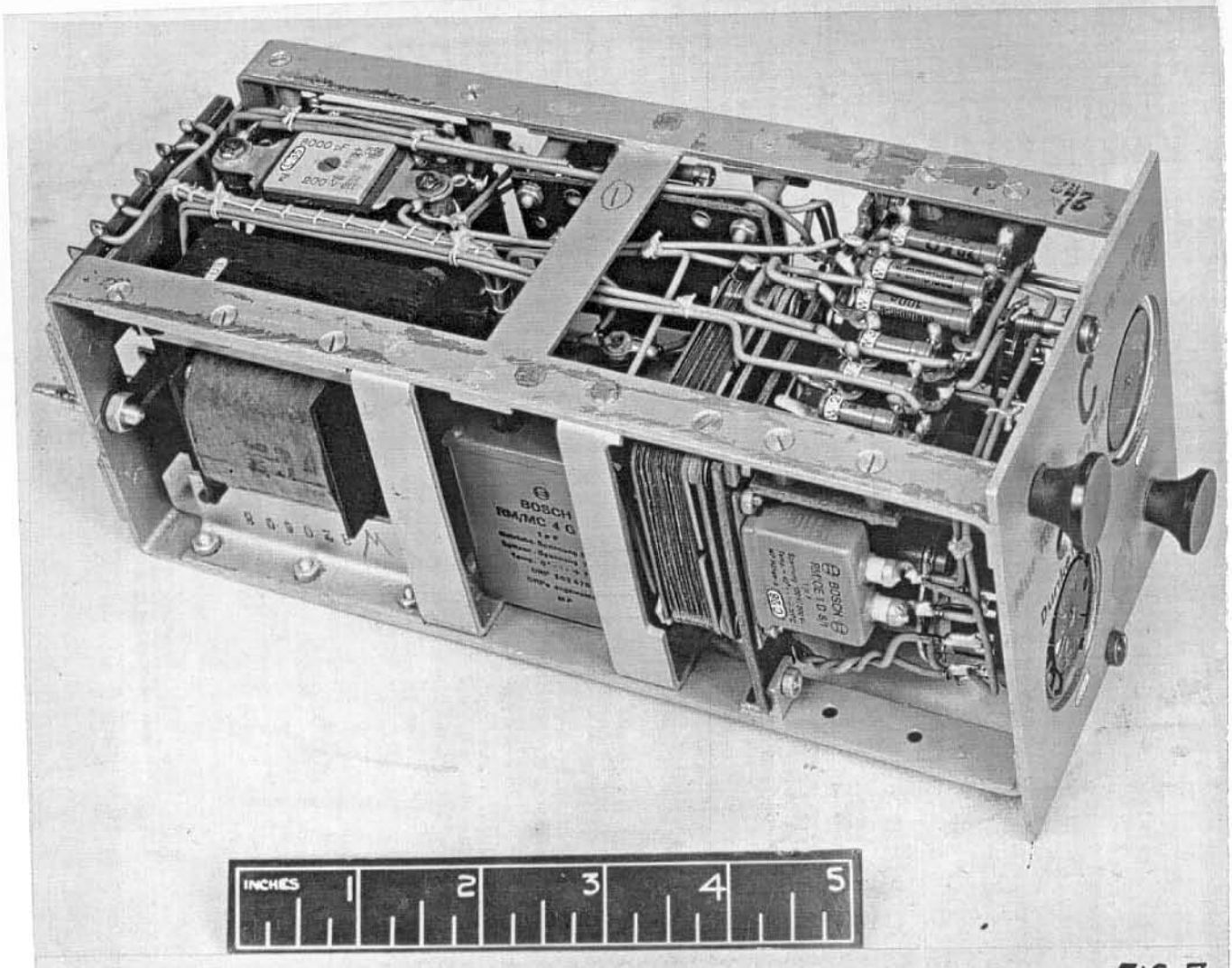
DISPLAY UNIT ANG.62. REMOVED FROM CASE. FIG. 4.



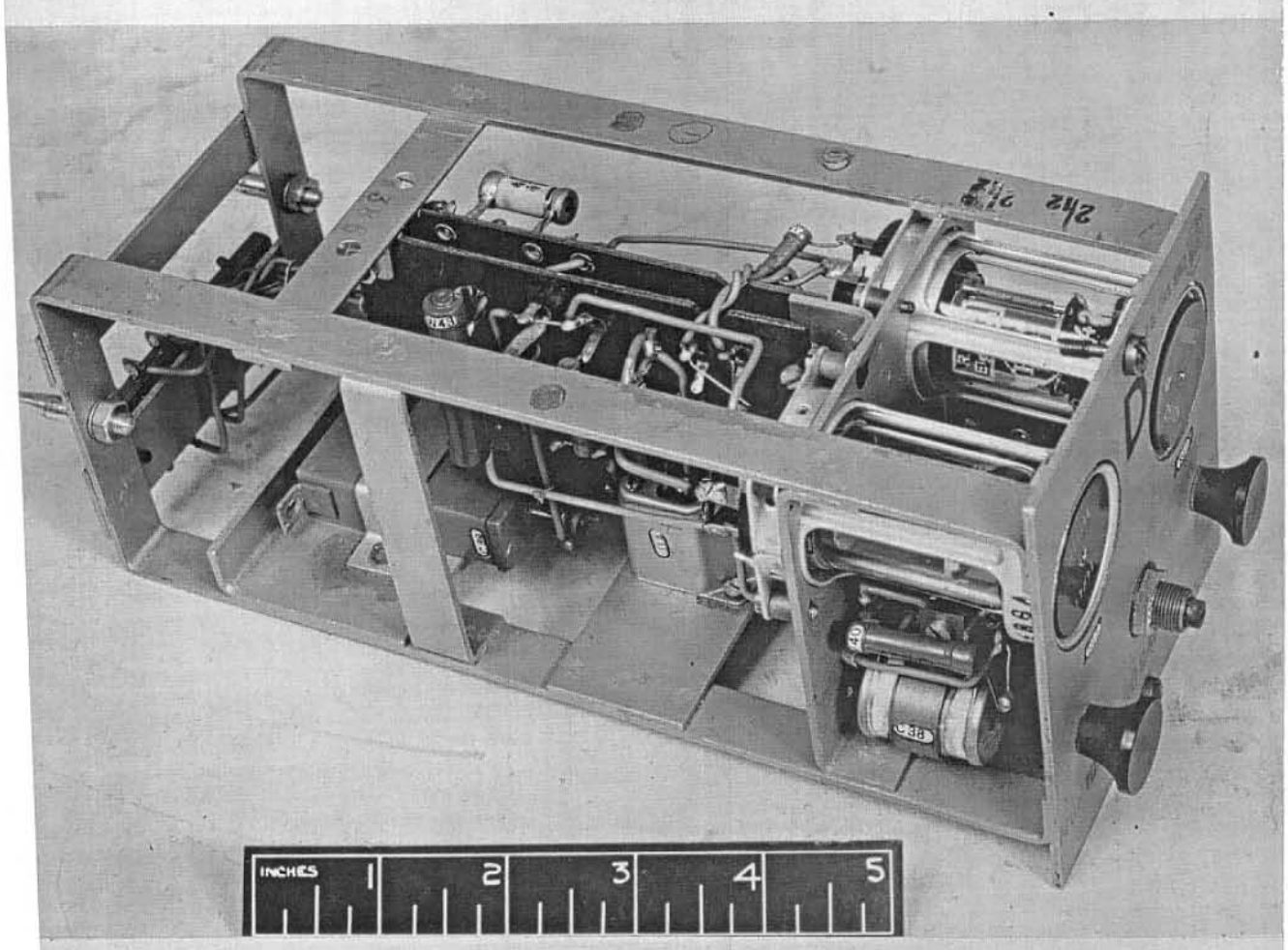
DISPLAY UNIT ANG. 62. CIRCULAR TIME BASE UNIT. FIG. 5.



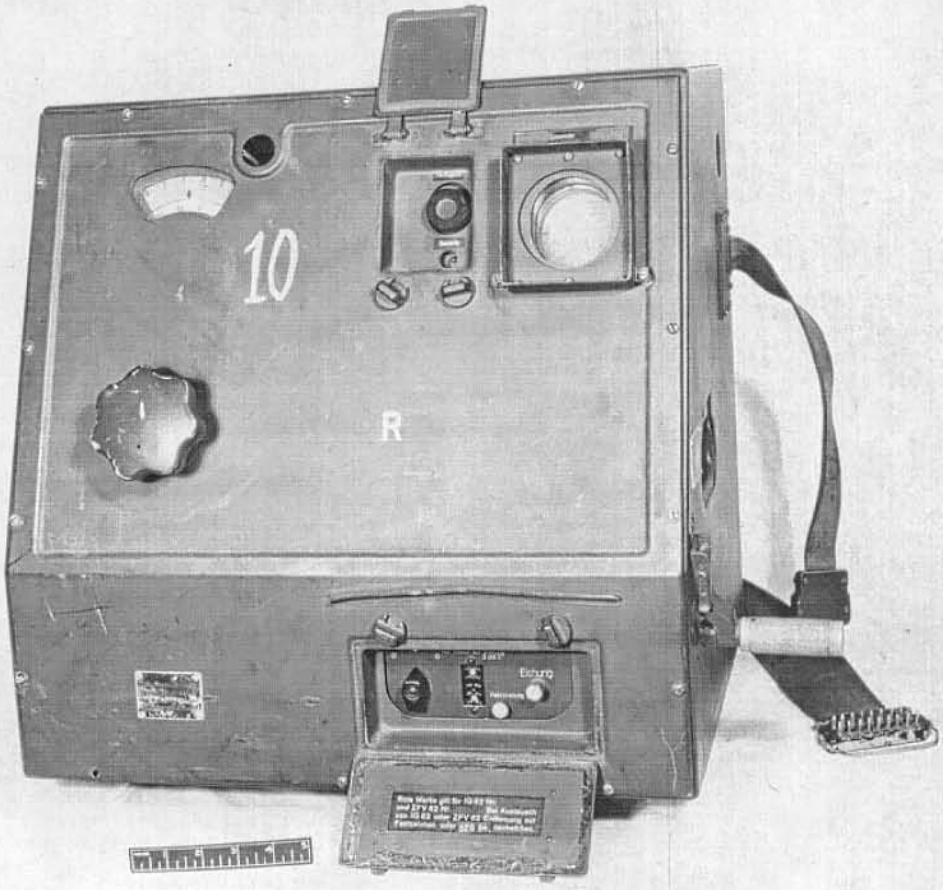
DISPLAY UNIT ANG. 62. I.F. OUTPUT UNIT. FIG. 6.



DISPLAY UNIT ANG 62. STROBE TIME - BASE UNIT. FIG. 7.

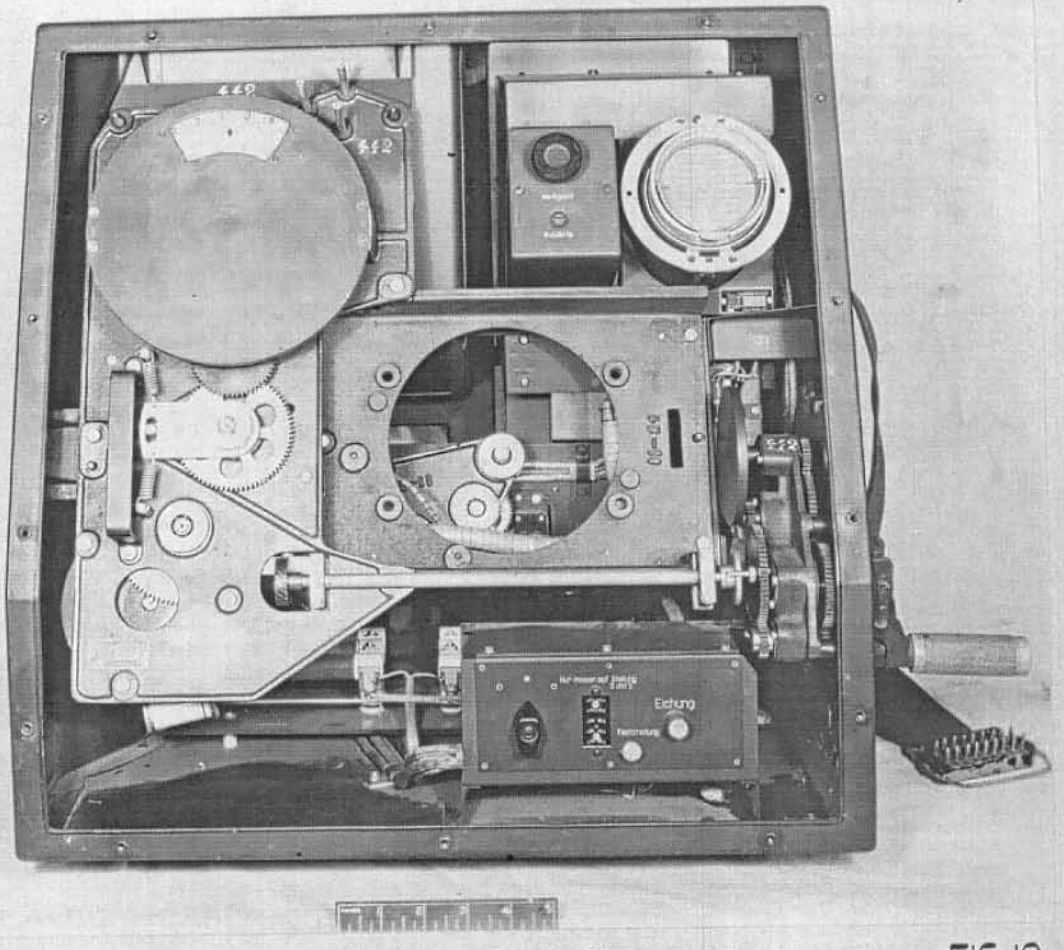


DISPLAY UNIT ANG 62. BLACK-OUT UNIT. FIG. 8



RANGE MEASURING UNIT EAG.62.
FRONT VIEW.

FIG.9.

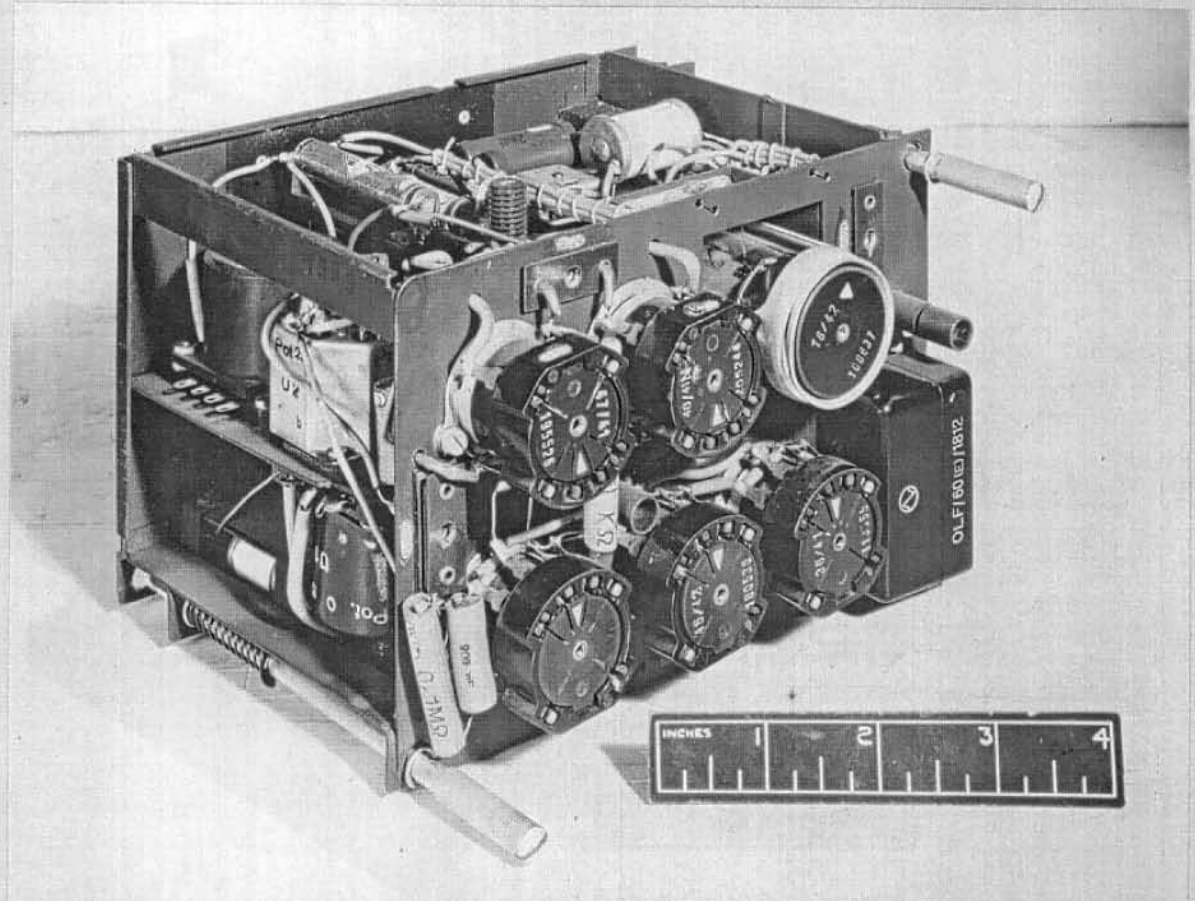


RANGE MEASURING UNIT EAG.62.
FRONT VIEW WITH COVER OFF.

FIG.10

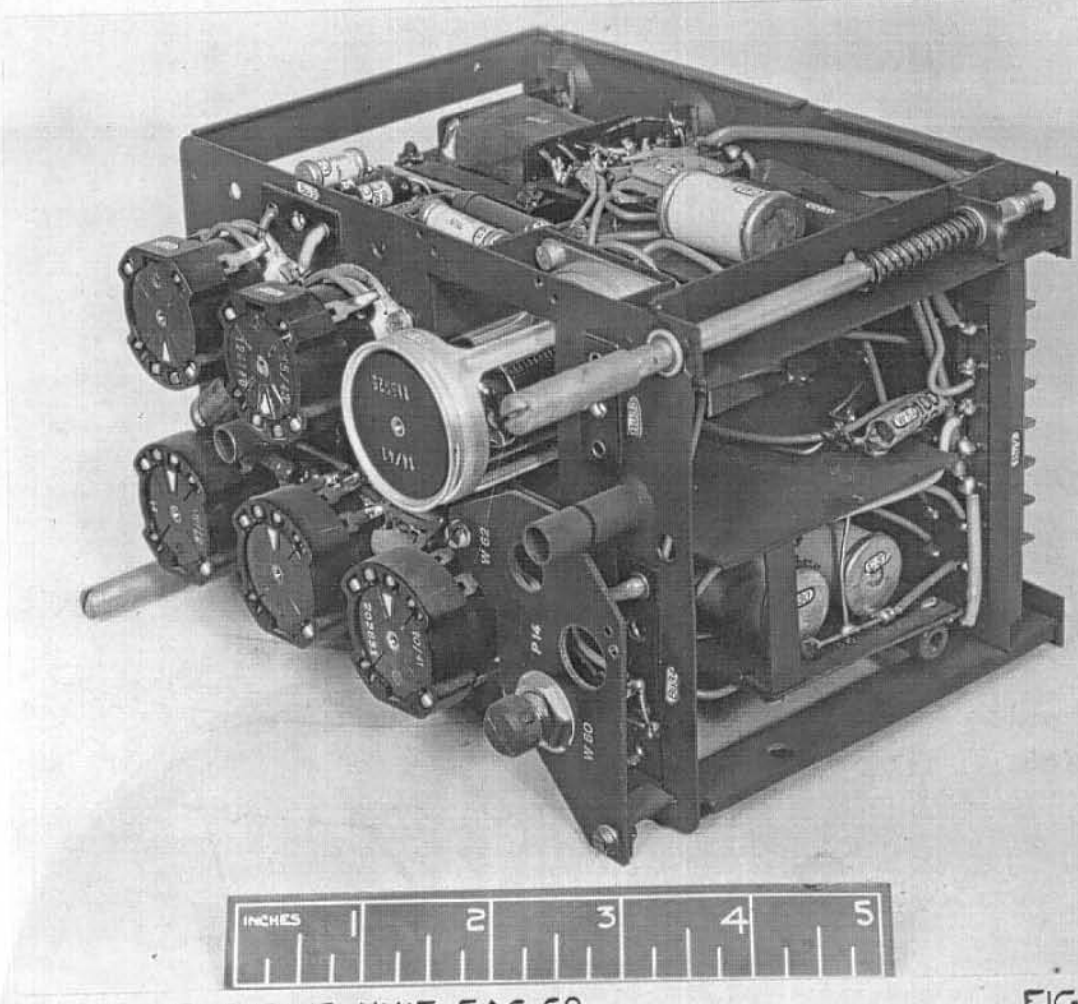
RANGE- MEASURING UNIT EAG 62.
BACK VIEW WITH COVER OFF.

FIG. 11.



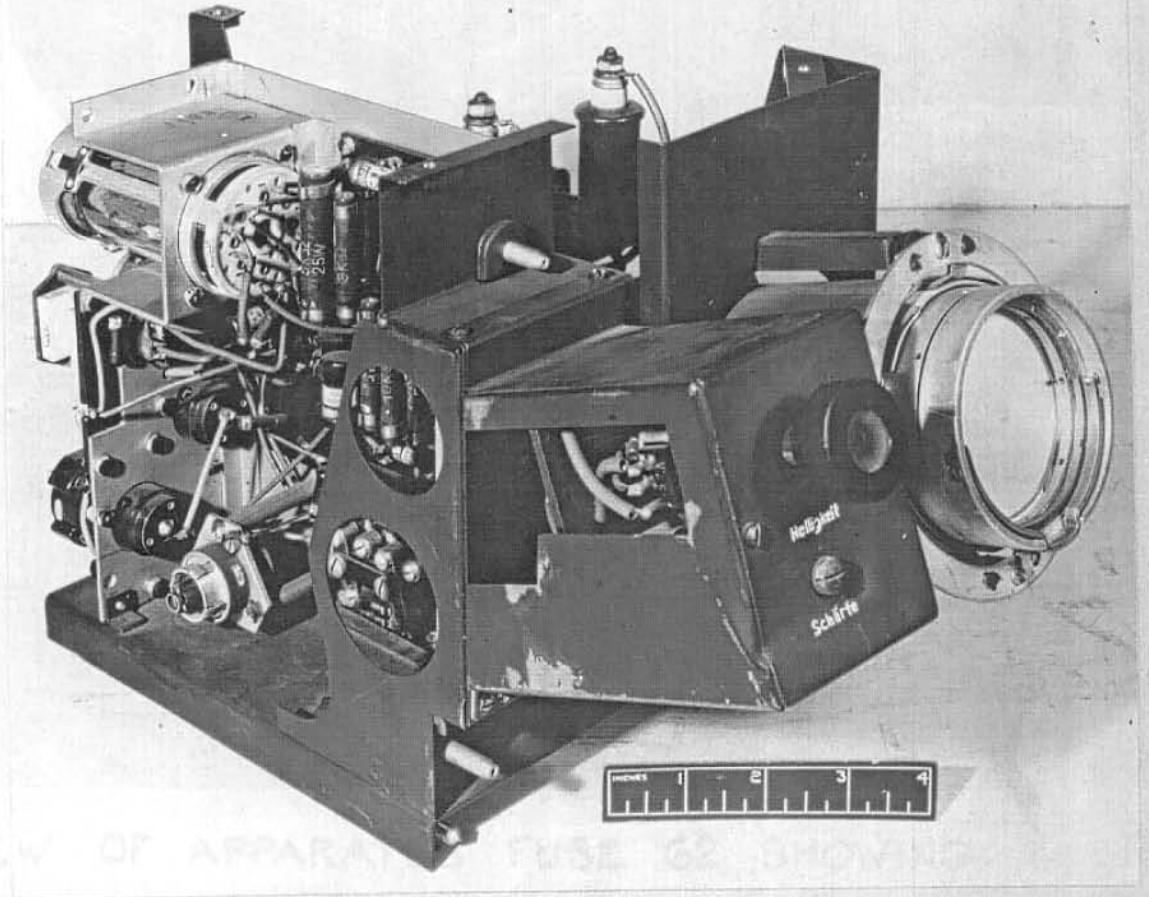
RANGE MEASURING UNIT EAG 62.
MASTER OSCILLATOR UNIT.

FIG. 12.



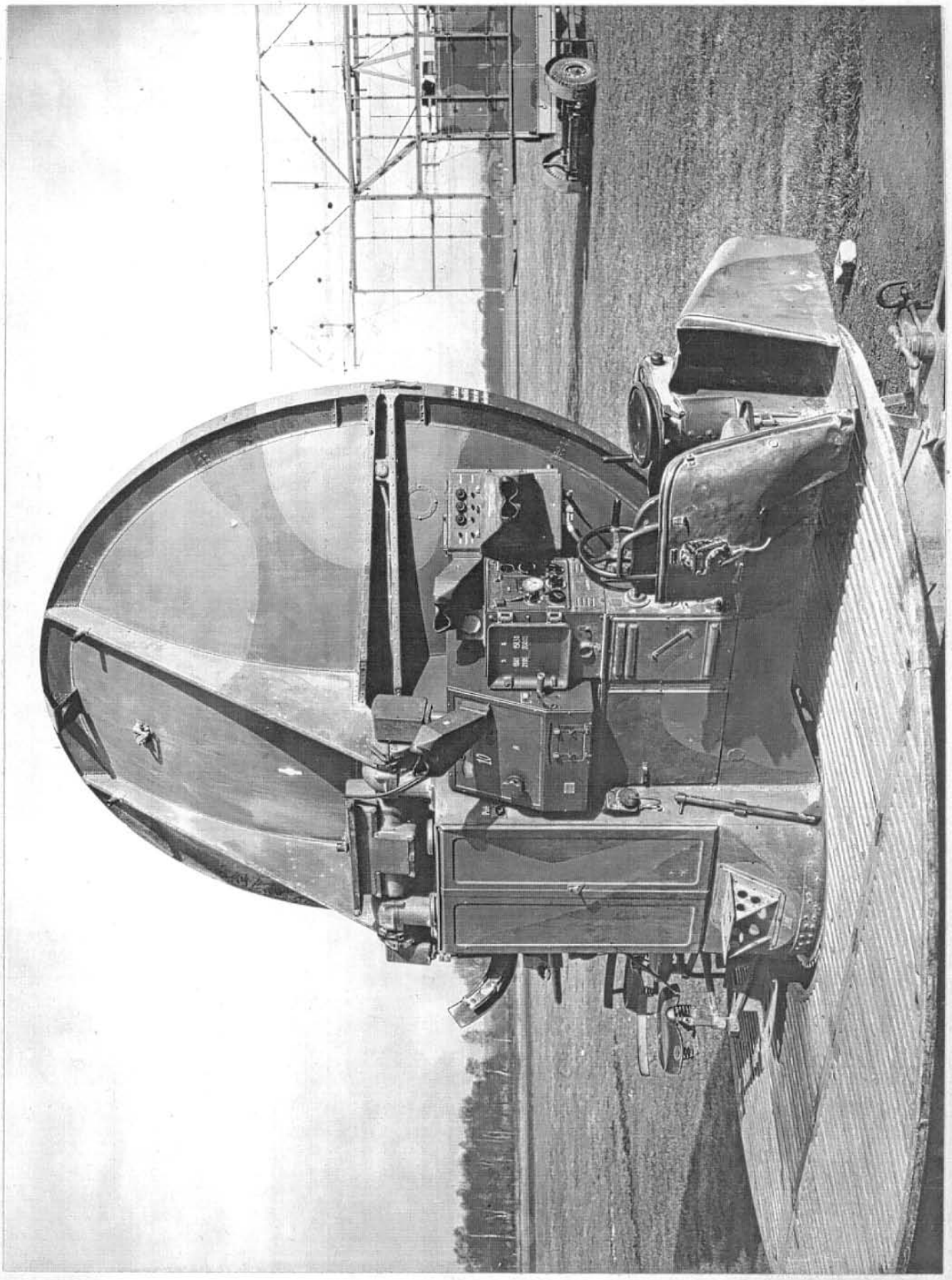
RANGE-MEASURING UNIT EAG 62.
BLACK-OUT AND TIME BASE UNIT.

FIG. 13.



RANGE MEASURING UNIT EAG 62.
I.F. OUTPUT AND RANGE TUBE UNIT.

FIG 14.



VIEW OF APPARATUS FUSE 62. SHOWING DISPLAY AND RANGE MEASURING UNITS.

FIG. 15.

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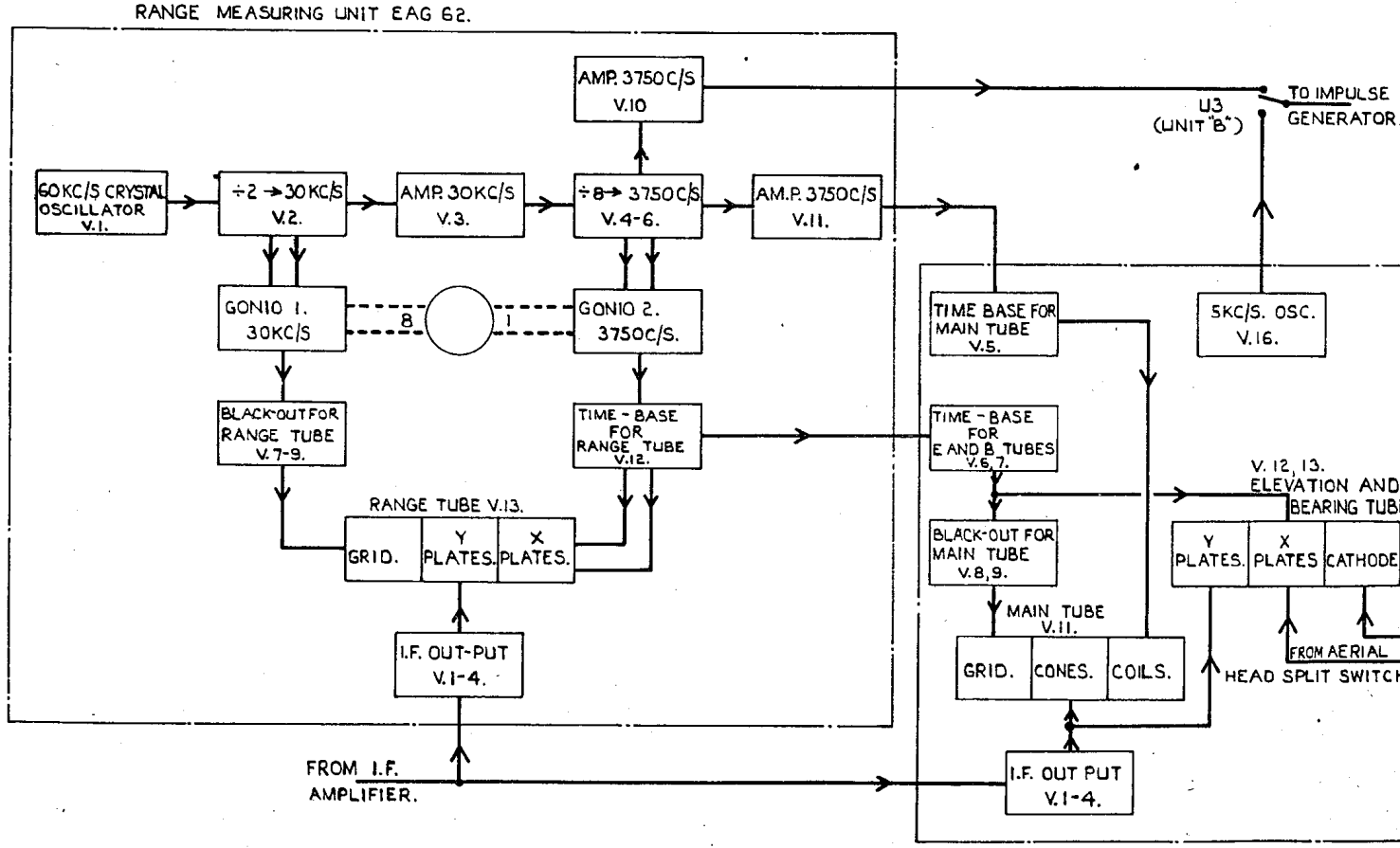
GERMAN GROUND RADAR EQUIPMENT. SECRET.

APPARATUS FUSE 62. (WÜRZBURG.)

BLOCK SCHEMATIC OF DISPLAY SYSTEM TYPE 'D'.



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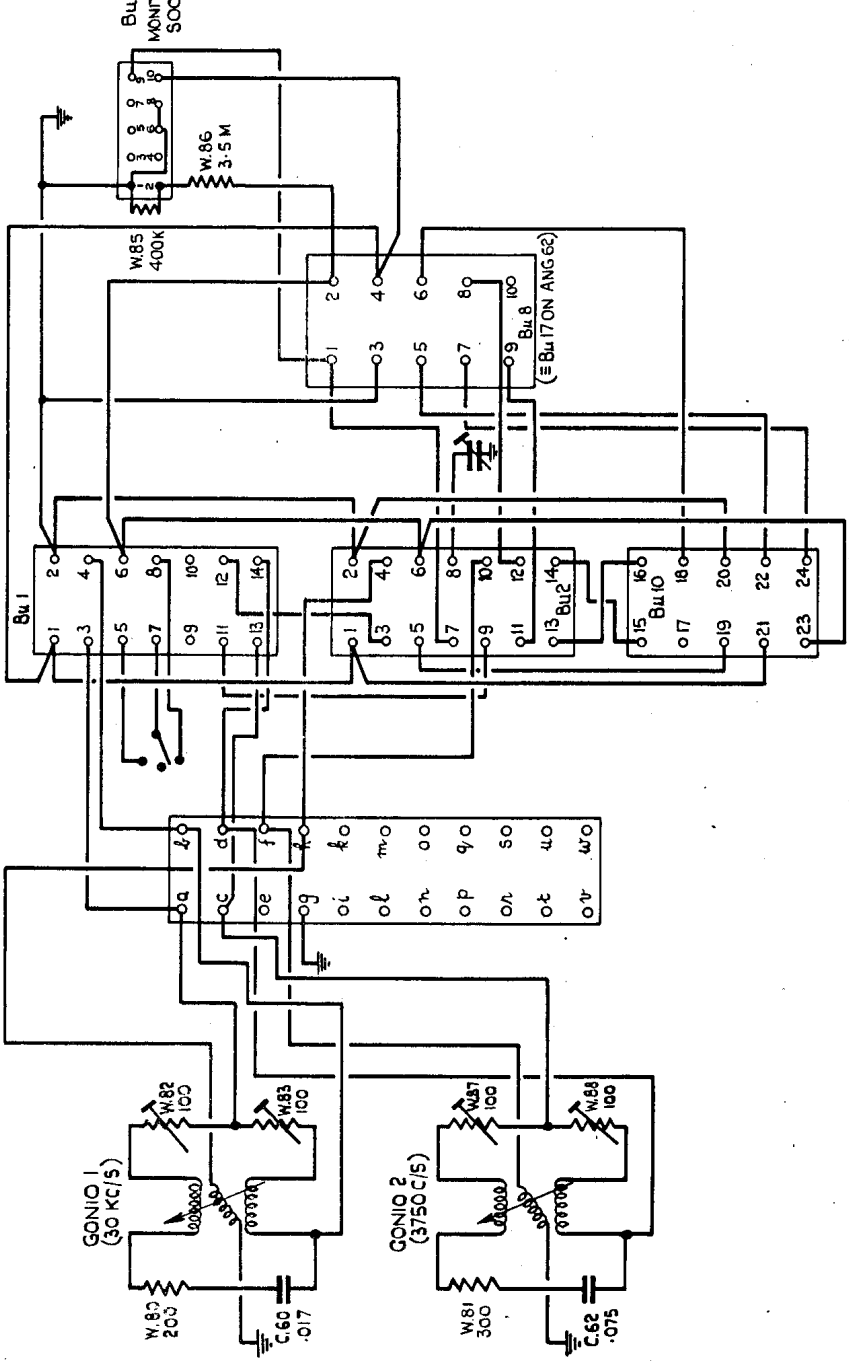

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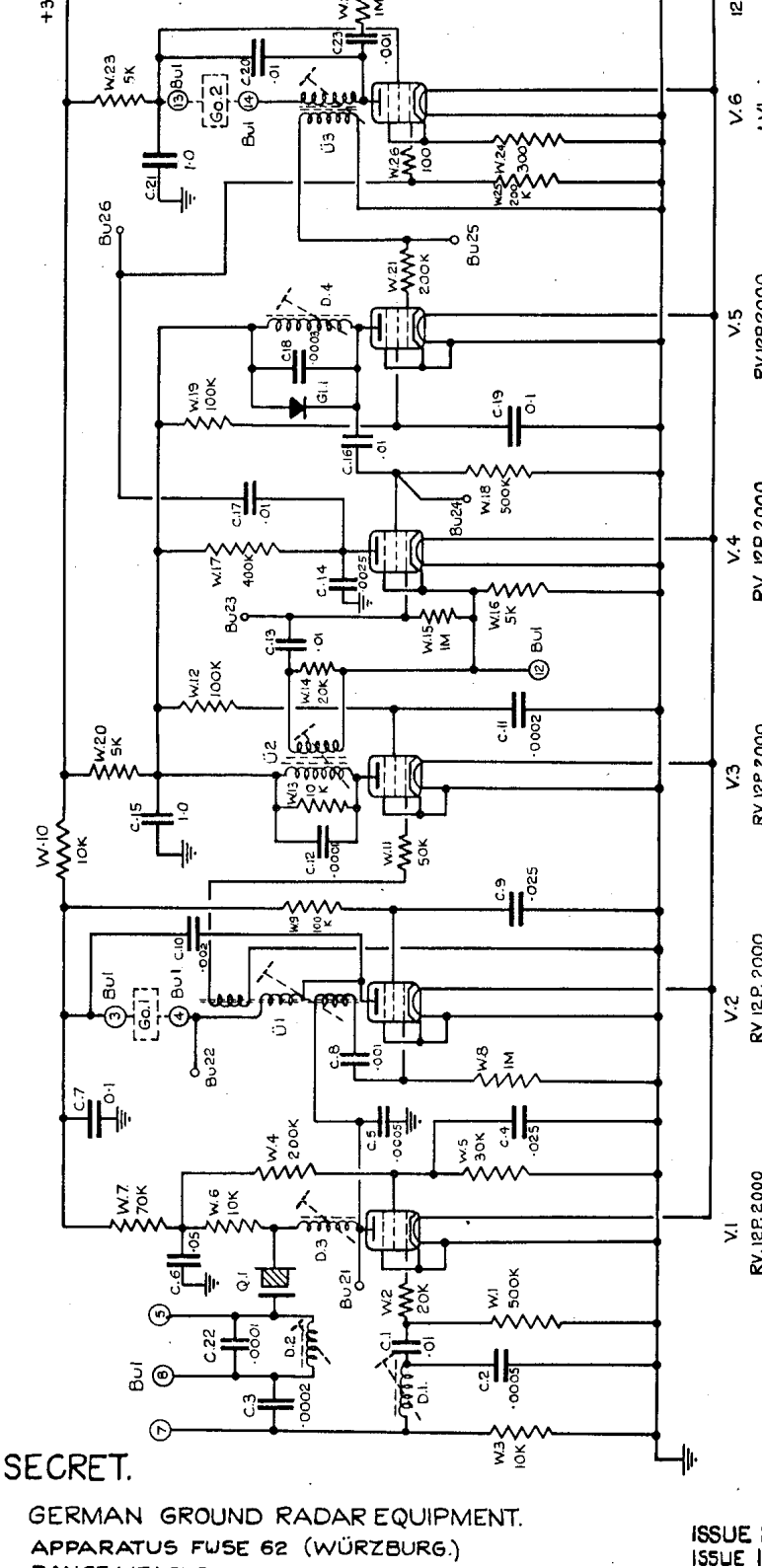
GERMAN GROUND RADAR EQUIPMENT
APPARATUS FUSE 62 (WÜRZBURG)
RANGE MEASURING UNIT EAG 62.
INTERNAL WIRING OF CHASSIS.

ISSUE I. 15-12-43.

DIAG. Nº 9266 B.



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GERMAN GROUND RADAR EQUIPMENT.
APPARATUS FUSE 62 (WÜRZBURG.)

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ISSUE 1. 15-12-43

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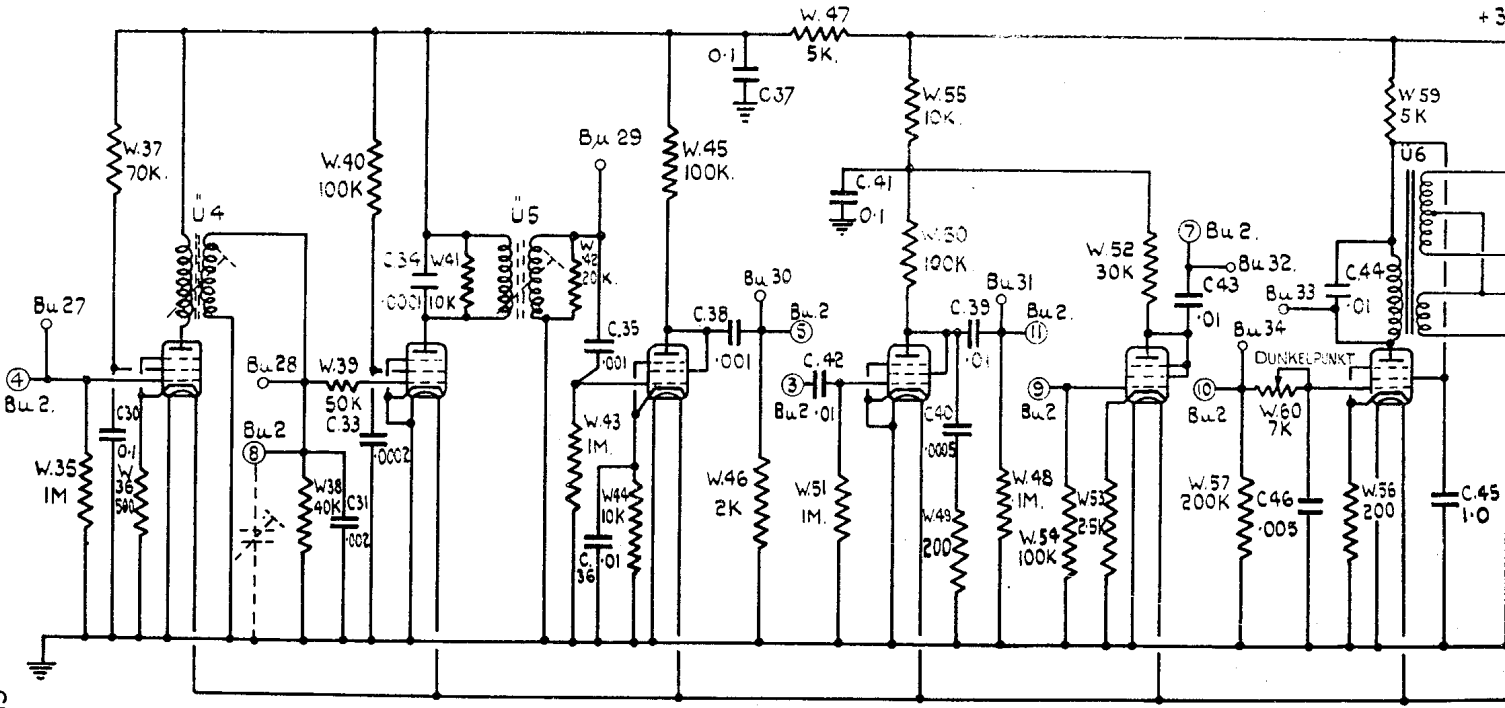
GERMAN GROUND RADAR EQUIPMENT.

APPARATUS FUSE 62. (WÜRZBURG)



V7 RV. 12P. 2000 | V.8 RV.12P. 2000 | V.9 R.V. 12P. 2000 | V.10 RV.12P 2000 | V.11 RV. 12P. 2000 | V.12 L V.1

SOCKETS SHOWN THUS —o Bu 28 ARE FOR MONITORING PURPOSES ONLY.

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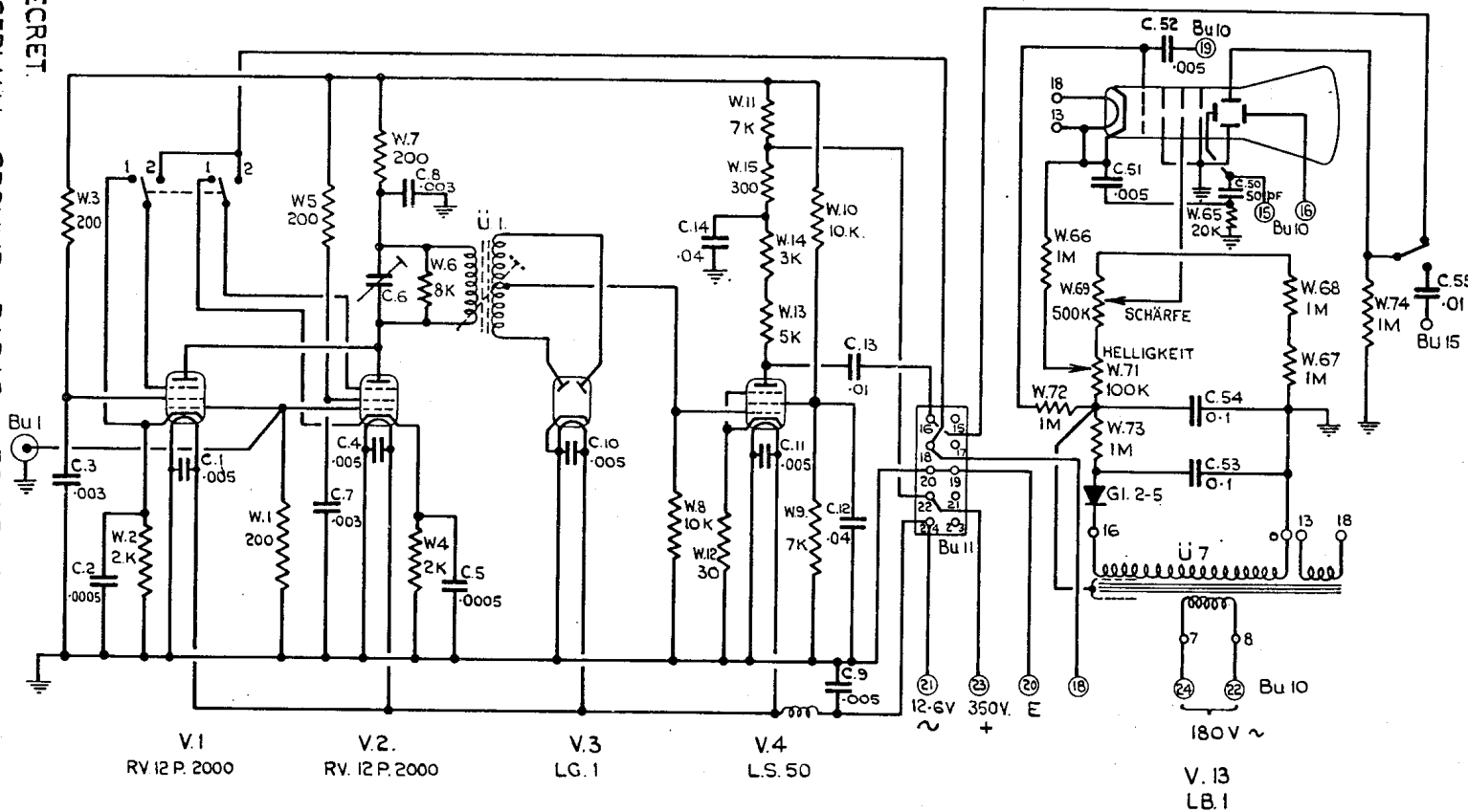
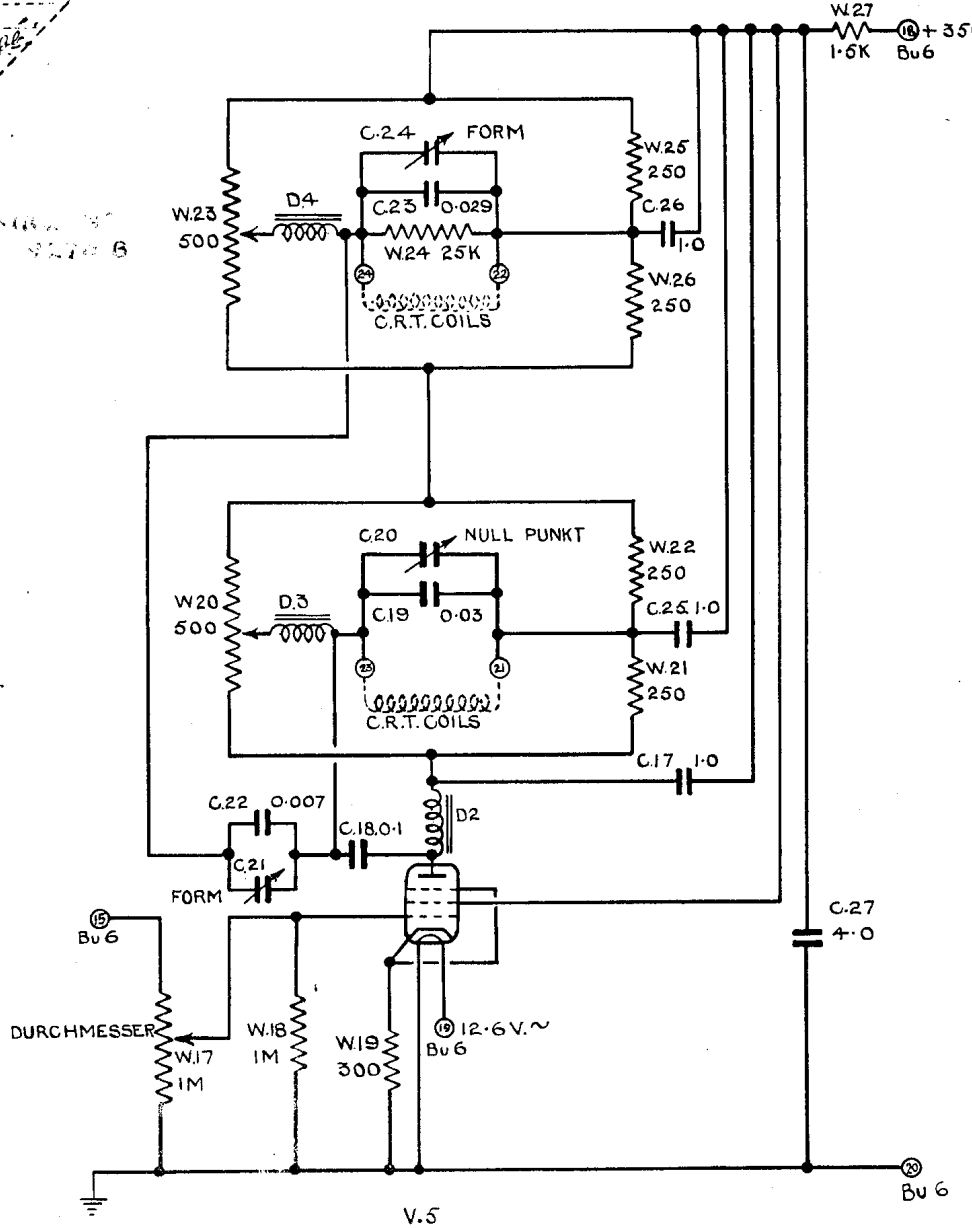
GERMAN GROUND RADAR EQUIPMENT.

APPARATUS FUSE 62 (WÜRZBURG)





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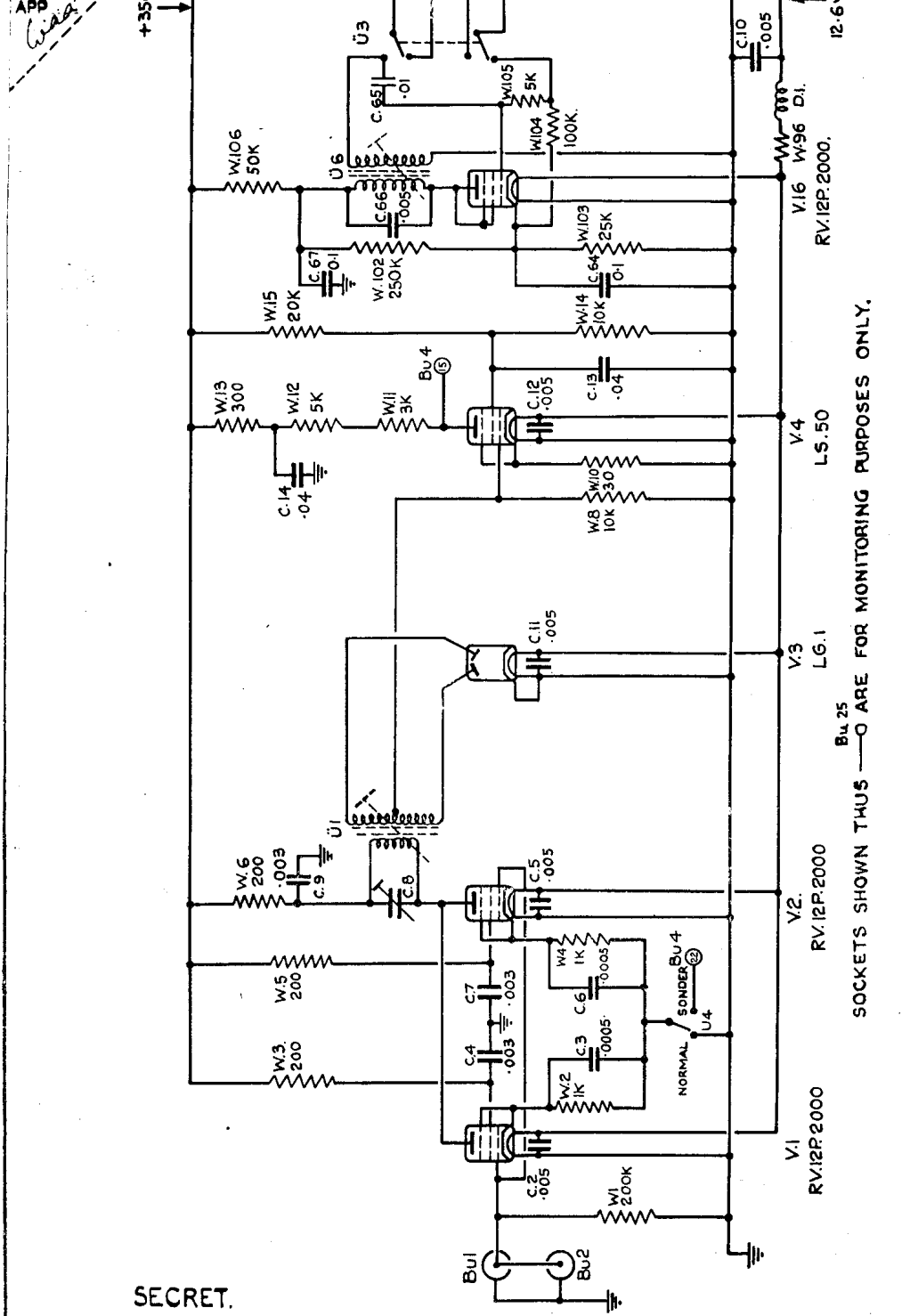
LS.50

GERMAN GROUND RADAR EQUIPMENT.
APPARATUS FUSE 62 (WÜRZBURG).
DISPLAY UNIT ANG 62 UNIT 'A'.

SECRET.



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GERMAN GROUND RADAR EQUIPMENT.

2. 17-4-44 APPARATUS FUSE 62 (WÜRZBURG)
ISSUE 3. 24·5·44 DISPLAY UNIT ANG 62 UNIT 'B'.

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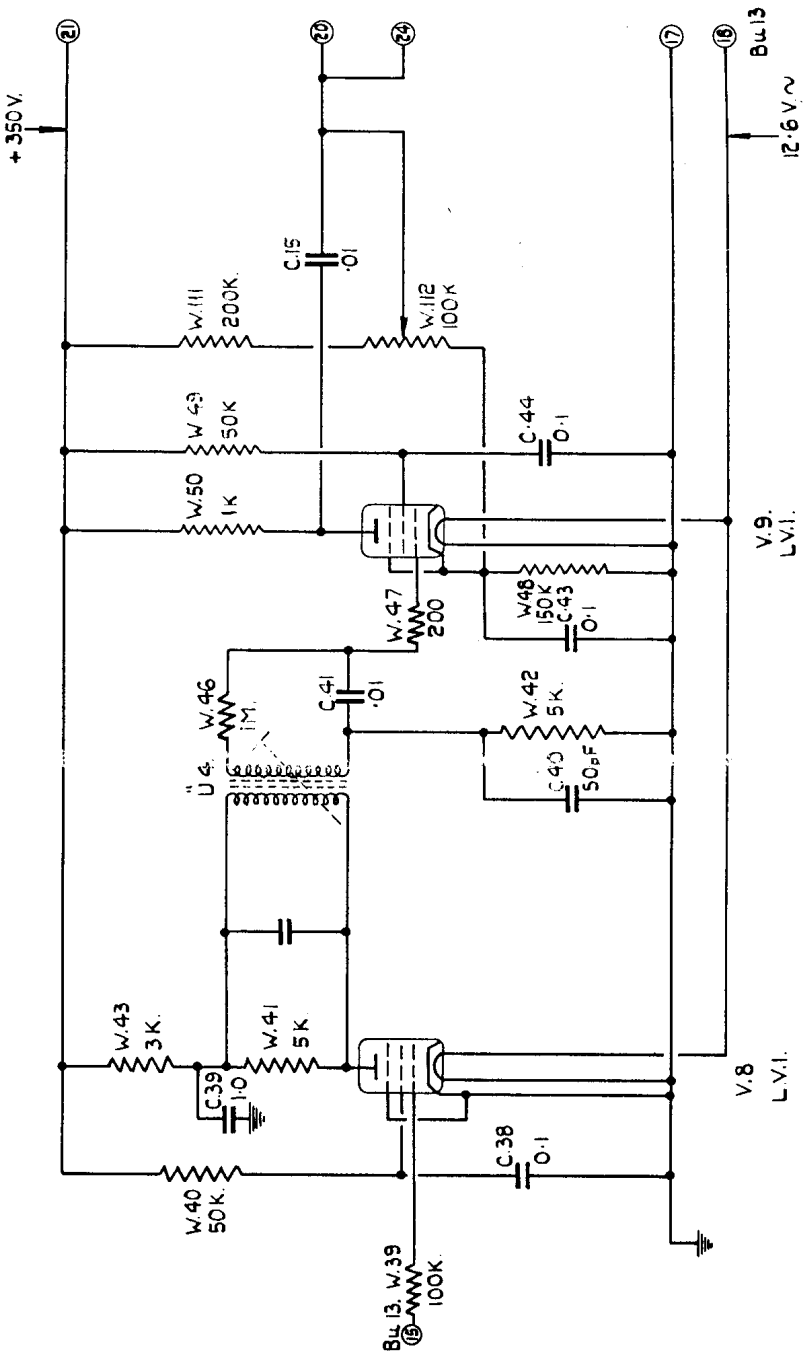
GERMAN GROUND RADAR EQUIPMENT.
APPARATUS FUSE 62. (WÜRZBURG).
DISPLAY UNIT ANG 62. UNIT 'C'.



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GERMAN GROUND RADAR EQUIPMENT.

APPARATUS FUSE 62. (WÜRZBURG)

DISPLAY UNIT. ANG. 62. UNIT 'D'.

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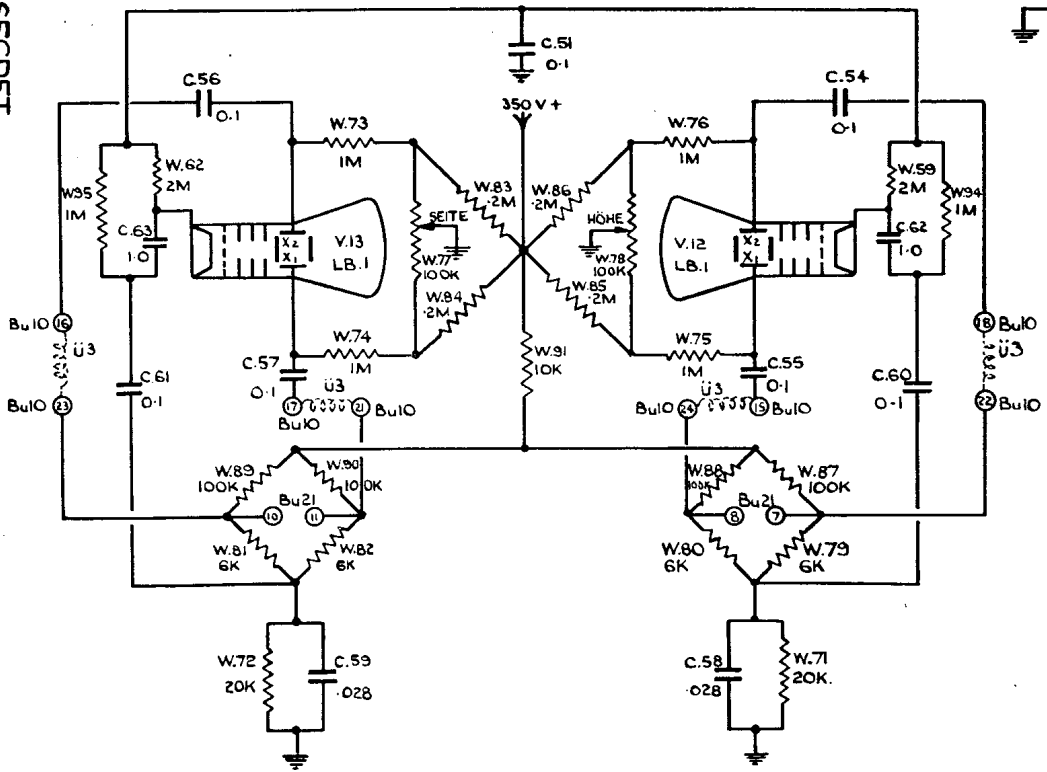
GERMAN GROUND RADAR EQUIPMENT

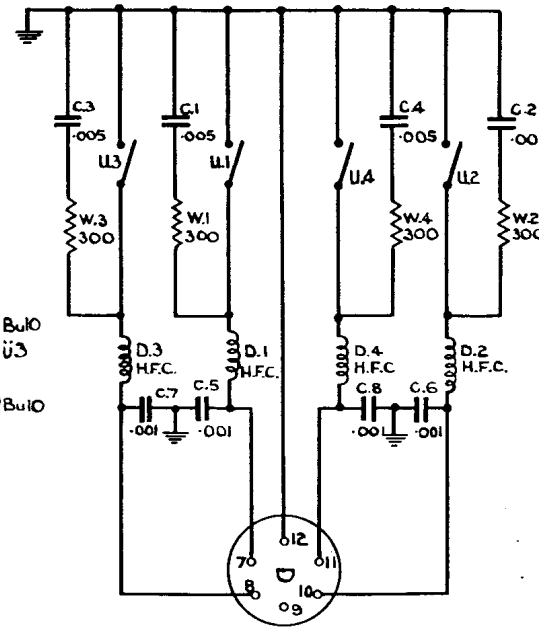
DIAG Nº 9274 B



U3 IN UNIT 'C', ANG 62.

Bu10 ≡ Bu8, UNIT 'C'.

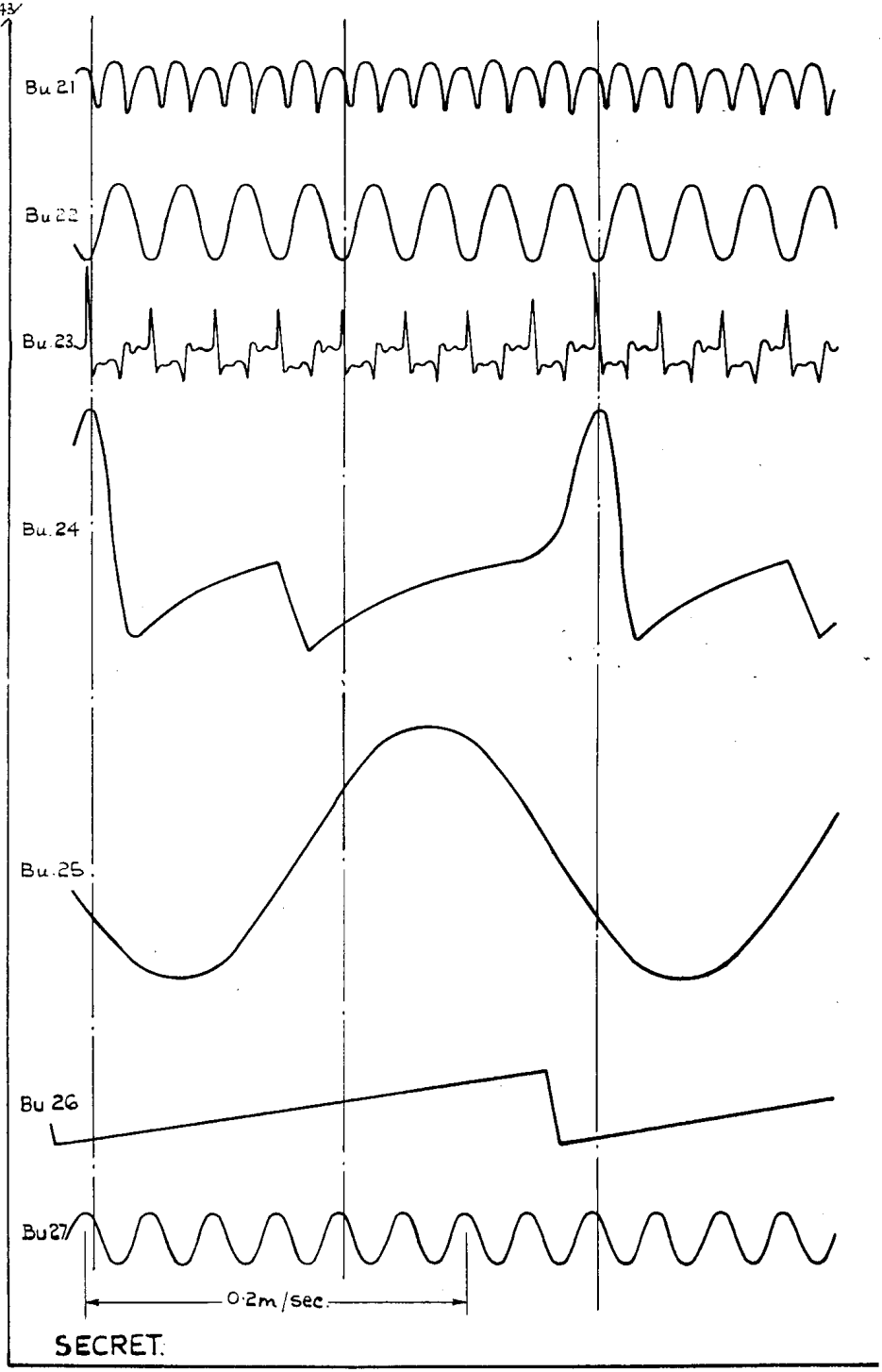
DIPOLE HEAD CAM SWITCHES.



Bu1 ≡ Bu 21, ANG 62 CHASSI

DIPOLE POSITION.	SWITCH CLOSED
BOTTOM	U.1
RIGHT	U.2
TOP	U.3
LEFT	U.4

GONIOMETER READING 29·4 KM.



GERMAN GROUND RADAR EQUIPMENT.
APPARATUS FUSE 62 (WÜRZBURG.)
WAVEFORMS IN RANGE MEASURING UNIT EAG.62.(I)

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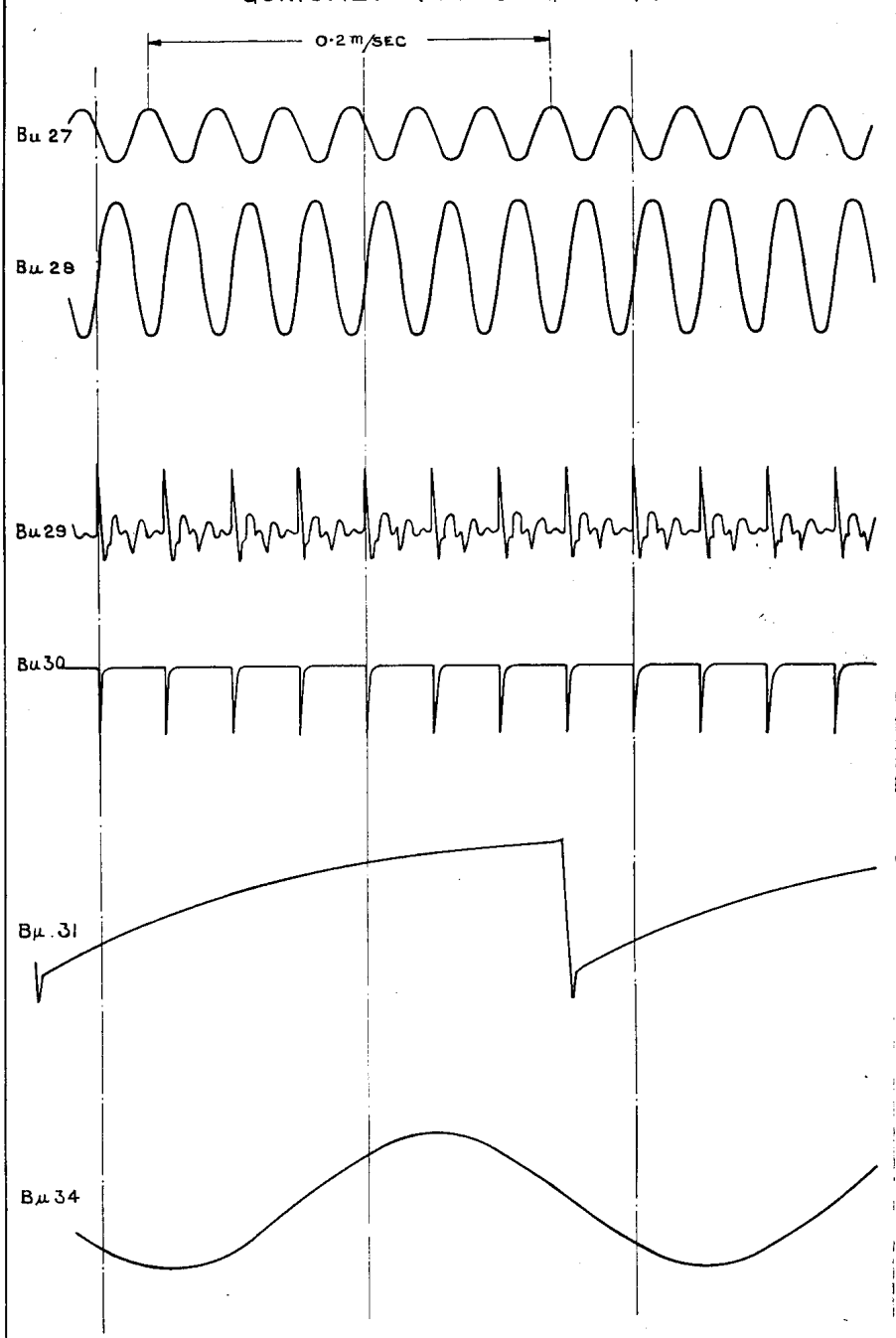

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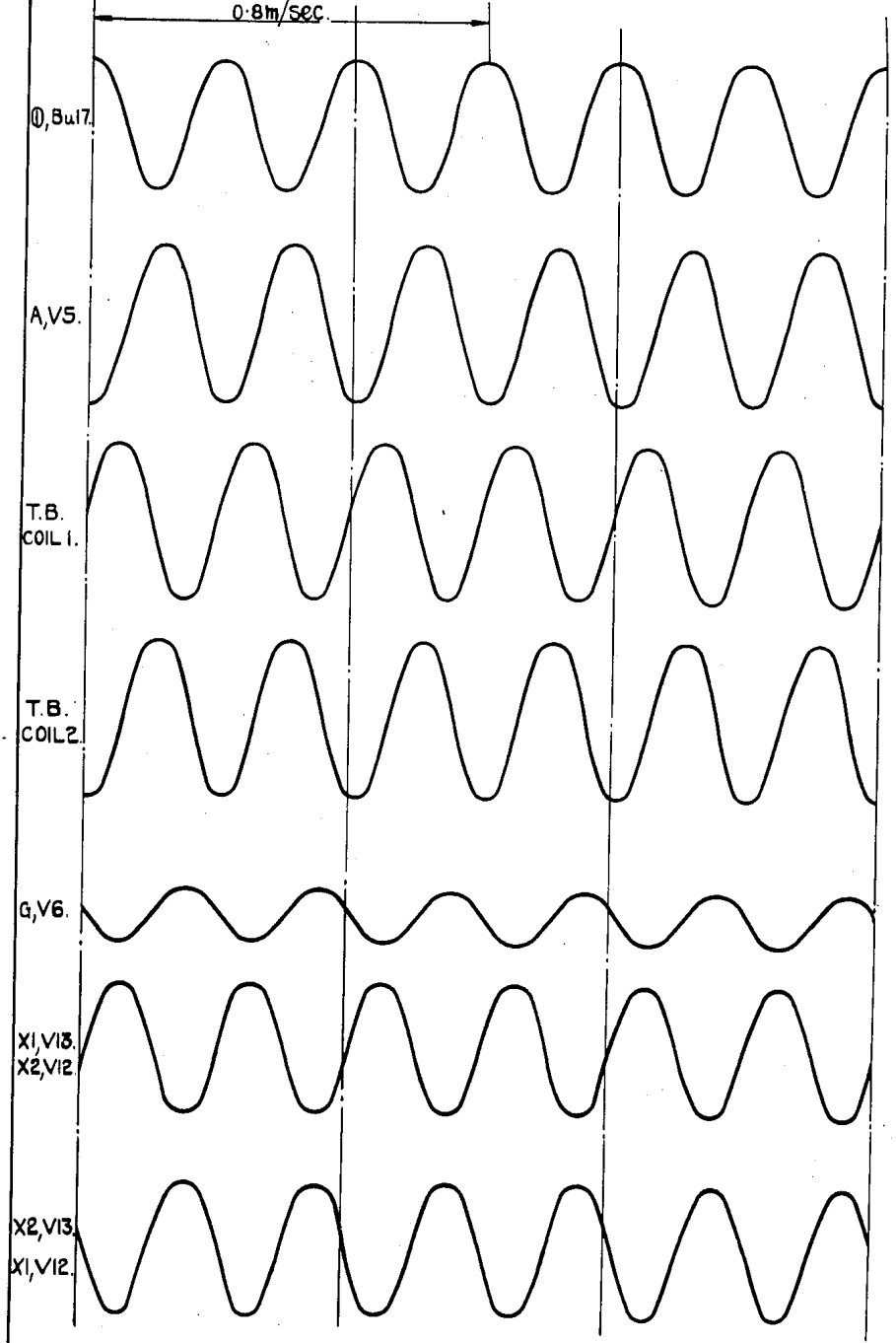
GERMAN GROUND RADAR EQUIPMENT
APPARATUS FUSE 62 (WÜRZBURG.)



GERMAN GROUND RADAR EQUIPMENT.

APPARATUS FUSE 6Z. (WÜRZBURG)
WAVEFORMS IN DISPLAY UNIT ANG.62. (I)

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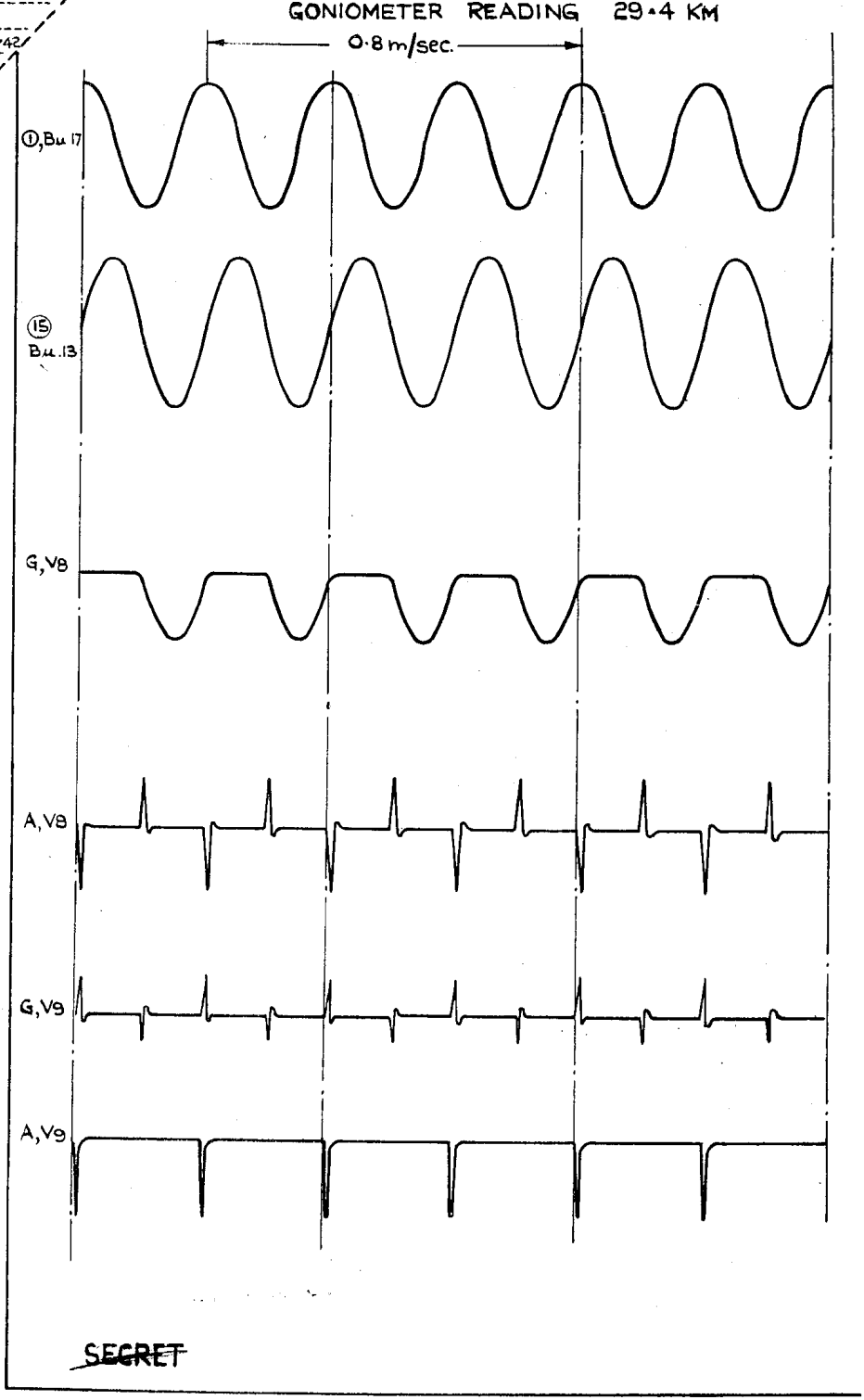

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GERMAN GROUND RADAR EQUIPMENT.
APPARATUS FUSE 62. (WÜRZBURG.)

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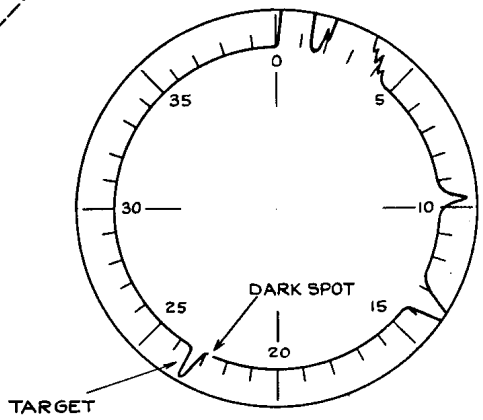
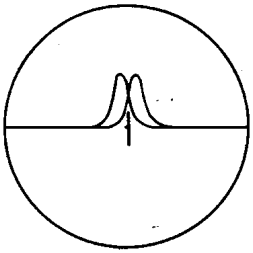
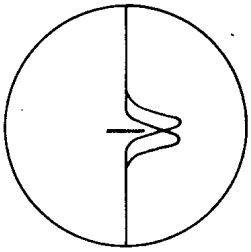


MAIN SEARCH TUBE

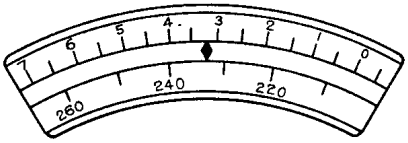


AZIMUTH SPLIT TUBE

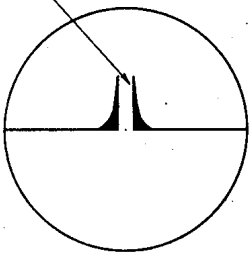
ELEVATION SPLIT TUBE.



FINE RANGE DARK SPOT.



RANGE DIAL
READING 23·32 KM.



FINE RANGE TUBE.

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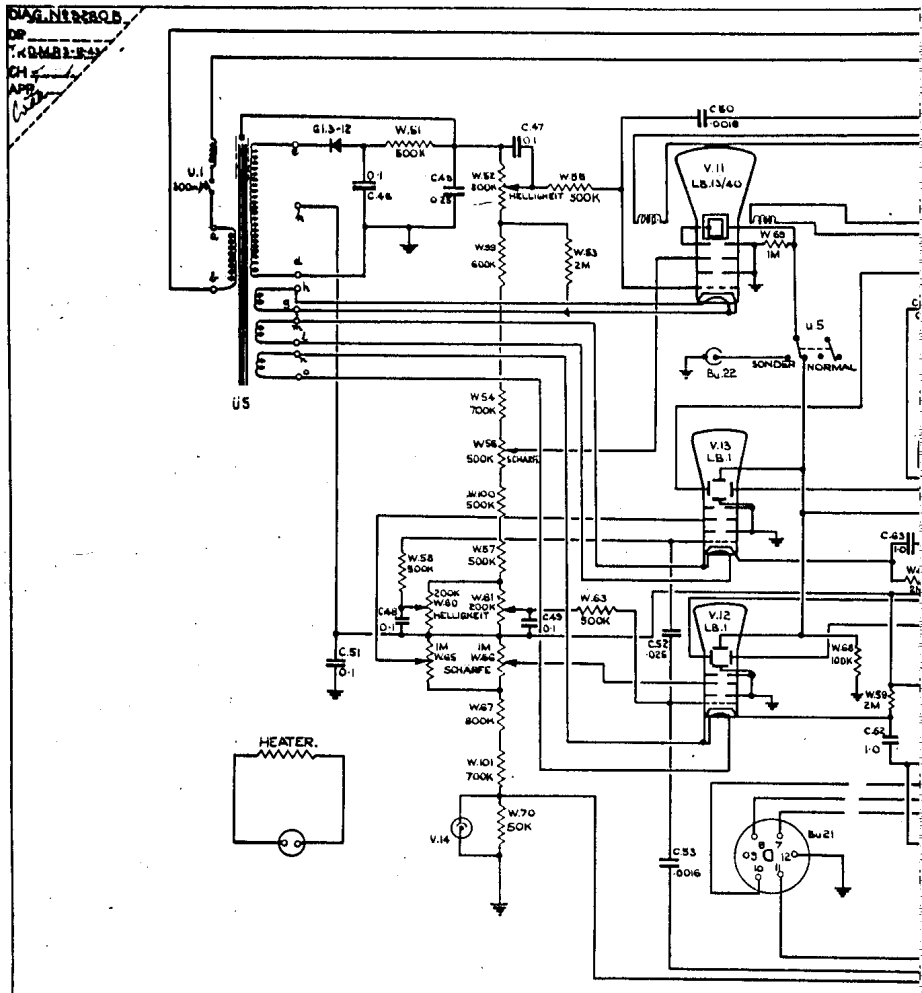
GERMAN GROUND RADAR EQUIPMENT.
APPARATUS FUSE 62 (WÜRZBURG.)
TYPICAL TRACES ON 39T/D DISPLAY SYSTEM.



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GERMAN GROU
APPARATUS FUSE
DISPLAY UNIT A
INTERNAL WIRING

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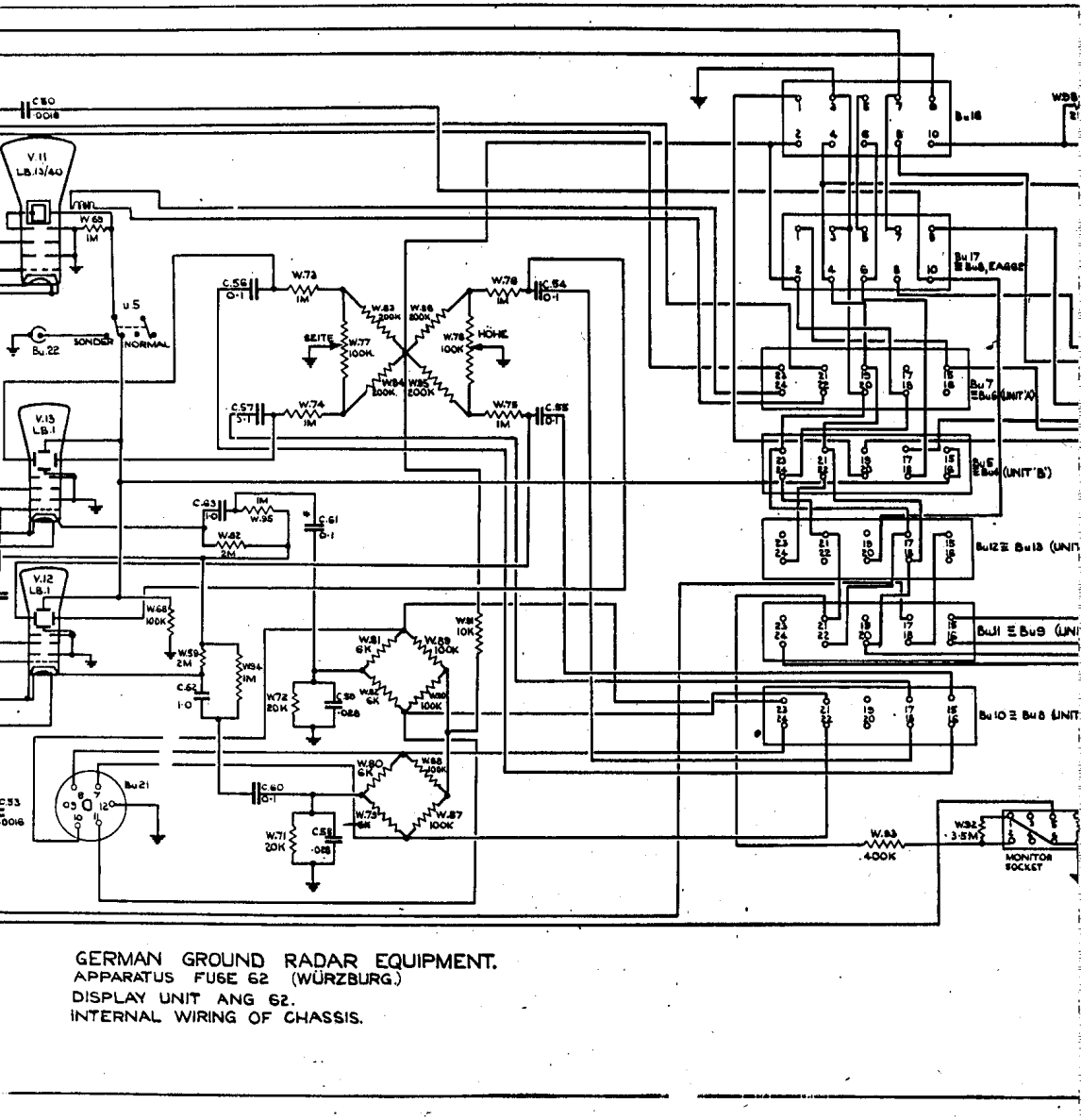
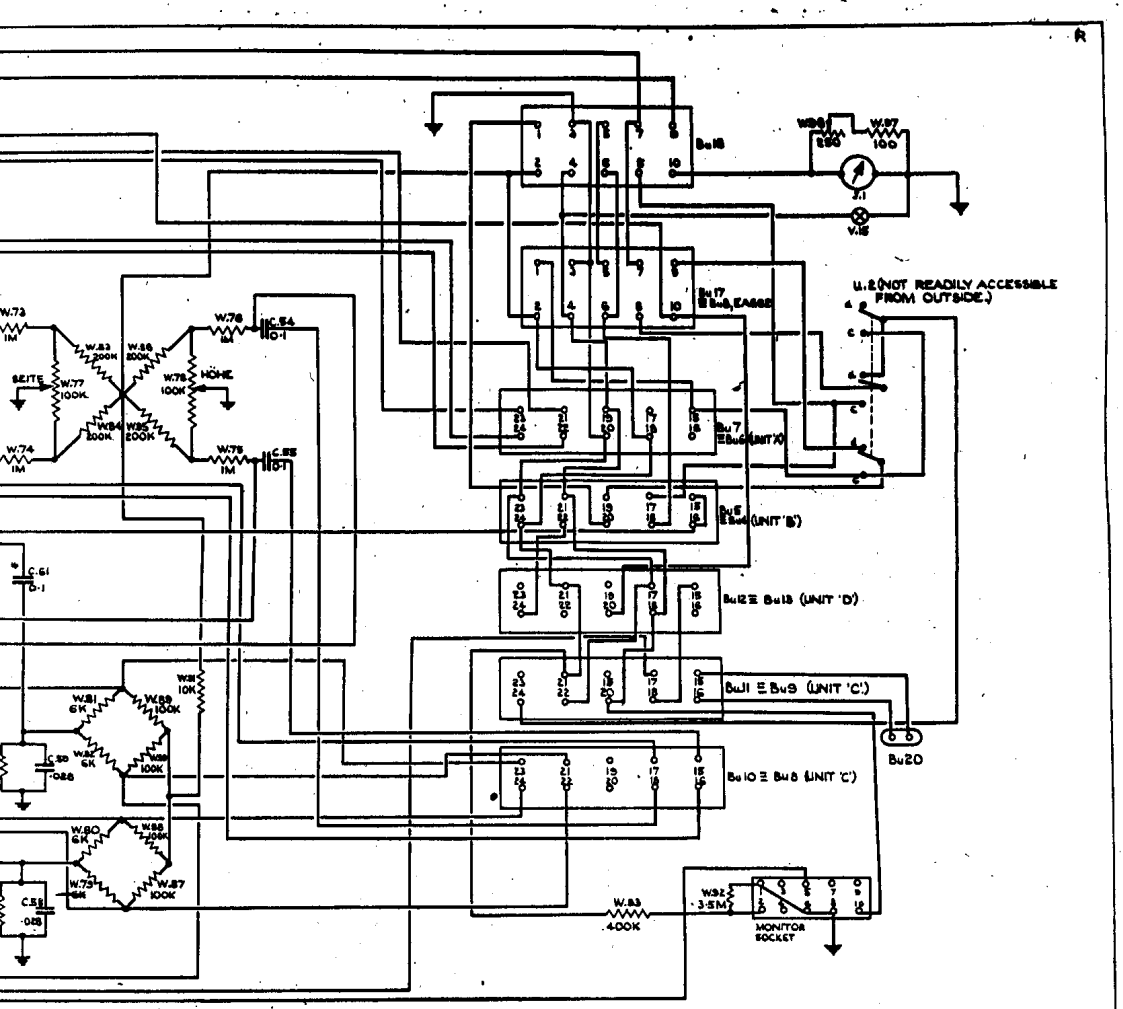


GERMAN GROUND RADAR EQUIPMENT.
APPARATUS FUSE 62 (WÜRZBURG.)
DISPLAY UNIT ANG 62.
INTERNAL WIRING OF CHASSIS.



RADAR EQUIPMENT.
(WÜRZBURG.)

CHASSIS.

DIAG. Nº 9280 B.

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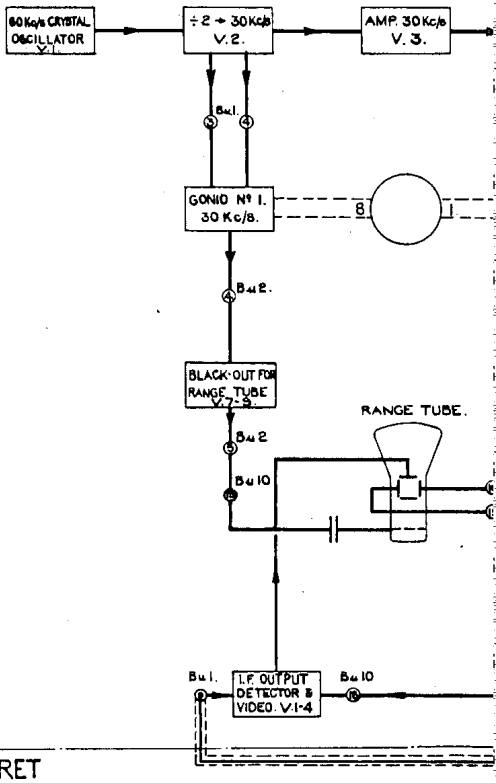
RANGE-MEASURING UNIT E.A.G. 6



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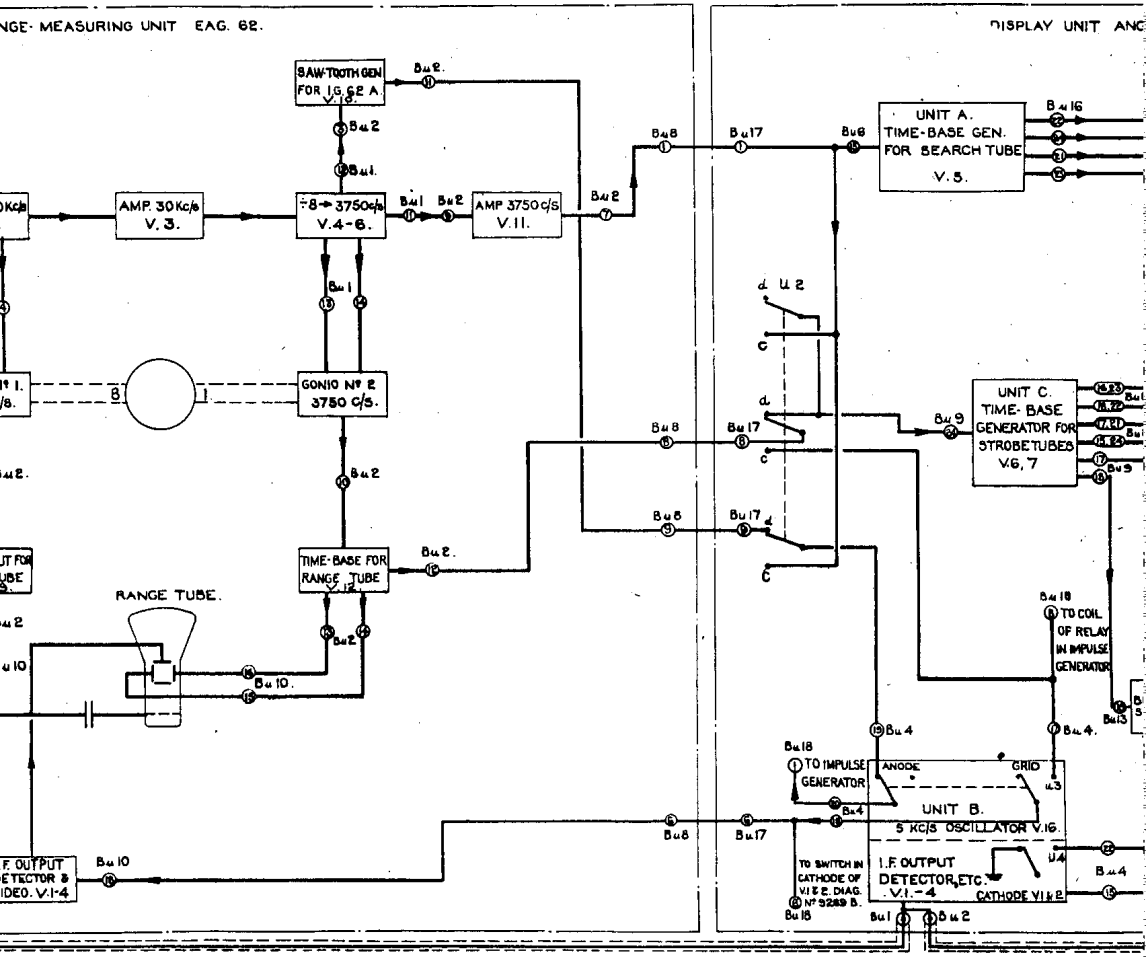
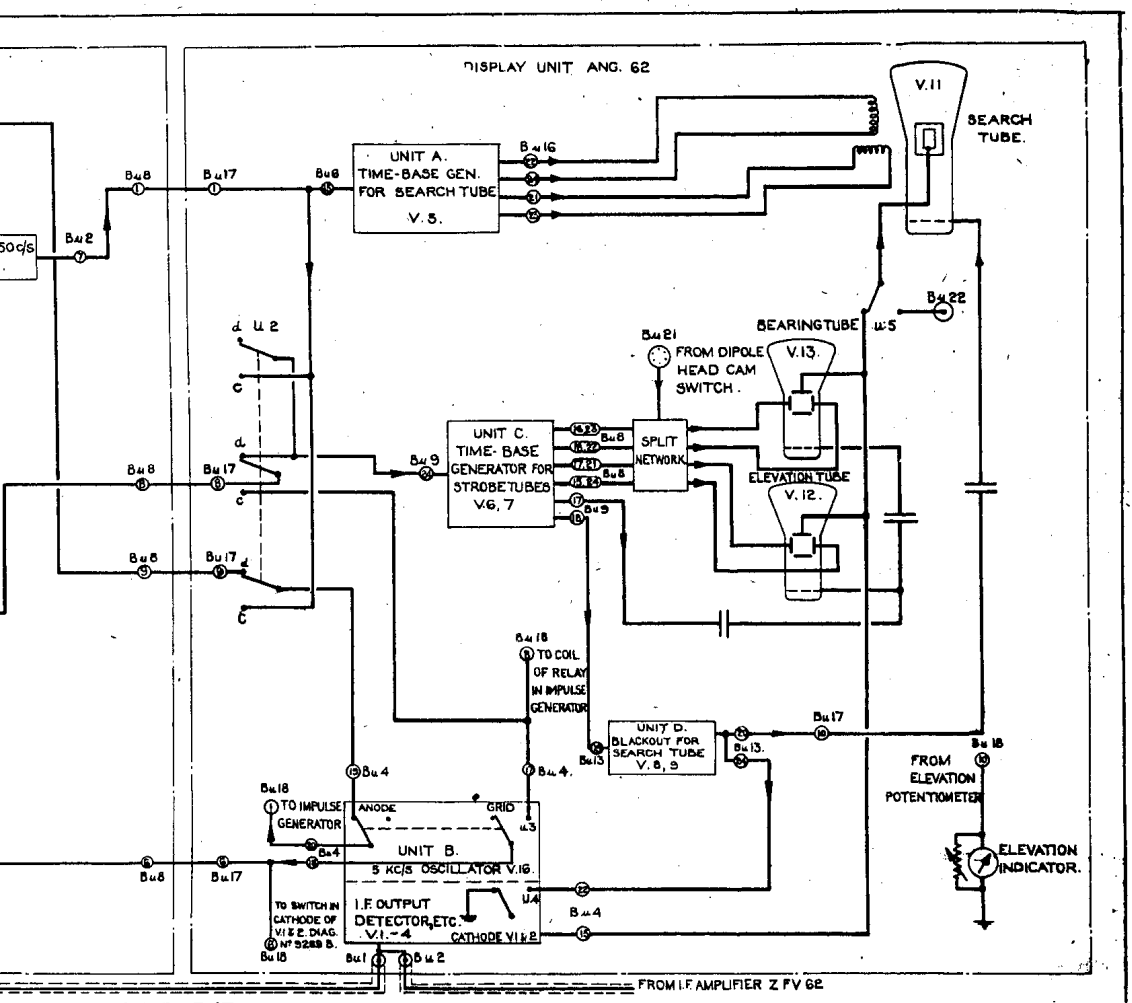
ISSUE No 1.
DATE. 5.6.44.



GERMAN GROUND RADAR EQUIPMENT
APPARATUS FuSE 62 (WÜRZBURG)
DETAILED SCHEMATIC OF DISPLAY SYSTEM TYPE "D"



RADAR EQUIPMENT
62 (WÜRZBURG)
TIC OF DISPLAY SYSTEM TYPE 'D'

DIAG. Nº 10259/B.