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GERMAN GROUND RADAR EQUIPMENT

INTERIM REPORT ON MAIN DISPLAY UNIT TYPE NB.110 OF COAST WATCHER AND FREYA INSTALLATIONS

by

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SUMMARY

This Note describes the construction and operation of the Main Display Unit used in the Coast Watcher and Freya Installations. The unit is fitted with two cathode ray tubes, one covering the whole range of the station, up to 200 kilometres and the other expanding any chosen 15 kilometres of the main trace at the will of the operator. Both cathode ray tubes contain twin gun and deflection systems thus making possible the simultaneous display of radar and I.F.F. signals. Time base and tube circuits are distinguished by great simplicity obtained at the expense of performance, which, however, is probably adequate.

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1. Introduction

This apparatus was examined and re-built where necessary as part of a programme of reconstruction and installation of a Coast Watcher and a Freya Installation in Scotland. Owing to lack of material, only one main display unit could be reconstructed and had therefore to be used alternately between the two installations. While the apparatus was found generally in a good state of preservation, the control panels were much damaged and had to be reconstructed to such data as could be obtained from careful examination.

While the operation is described, as far as it can be surmised, there are some features, notably provision of "trace separation" (if such it is) on the main tube, for which no explanation can be found. Another unexplained feature is that outputs from the phase shifter of the time base circuits and 210 volt H.T. are made available at plug sockets "b3" and "b7".

A block schematic of the Display Unit is shown in Fig.14.

2. Purpose of Unit NB.110

This unit is the main operational feature of the Coast Watcher and Freya Installations and is mounted in one case with the receiver. It is probably used by the chief operator of the station for examination and direction finding of all echoes and also for obtaining a rough range which can be used to indicate to the operator of the precise range finder which echo requires his attention.

There are three controls accessible to the operator, "Brilliance" and "Focus" of the pictures on the cathode ray tubes and "Range", which moves a cursor over the lower tube and automatically causes an expanded picture of the echo covered by the cursor to appear on the upper tube, while the range is displayed in the small square window between the tubes.

In addition, the apparatus serves as a guide to the operator in tuning the receiver, which is mounted side by side with it; and being fitted with double cathode ray tubes, it is adaptable to display of I.F.F. signals on separate trace as in the British Mark III I.F.F.

The complete adjustment of this unit is a most difficult matter, there being no fewer than 24 points of adjustment to the electrical portion of the apparatus (see Fig.13) and not a few to the optical and mechanical equipment associated with the "Range" control. No information as to the means adopted to carry out these adjustments has come to hand, but it was noticed that one setting, the condenser 406 of the time base, was secured by paint, which may indicate a factory adjustment.

The German manual frequently alludes to controls being provided to compensate for change of valves or cathode ray tubes but gives no information whatever as to setting up procedure.

In the absence of any information as to how the apparatus was intended to be adjusted some suggestions are offered under "Operating Data", para.4.

3. Description of Unit NB.110 (See Figs.1 and 2)

This unit is intended to share a weatherproof box with the receiver, the whole forming "Gerät N" and coming under the care of one operator, who also rotates the cabin under the guidance of the display on Unit NB.110. Photographs of the unit itself are given in Figs. 1 and 2.

It will be seen that two cathode ray tubes are fitted which are intended to be observed through lenses in the outer cover, giving a threefold magnification. The three slotted discs on the lower front of the apparatus engage with control spindles passing through the outer cover to control knobs outside. Between the two cathode ray tubes a square window will be observed through which a range scale is optically projected by means of apparatus which has not become available as yet. The small panel below, bearing a mains switch and neon indicator lamp was a British addition for ease of operation; in the equipment as found a mechanical apparatus is fitted in its place to switch off automatically on opening the outer box.

Coming to the detailed mechanical construction of the unit, it will be seen that it has an open frame composed of many separate cast iron members which are screwed and pinned together in a manner that bears no relation to the electrical functions of the various parts. The frame must be regarded as having to be put together as a unit before any apparatus is fitted and cannot afterwards be taken apart for servicing the electrical side of the apparatus. Roughly it consists of a fairly deep cast bed plate, bearing "A" frames at front and back to support the two cathode ray tubes above the rest of the apparatus. Many small bars join these to add rigidity to the structure, which is already sufficiently heavy. Two carrying handles are provided, one at the front of the bed plate and a hinged one at the top, which folds down to enable the apparatus to be put in the outer box. The apparatus is fixed in this box by means of slide rails on the bottom bed plate which also carries two locating holes at the back end and was provided with a pair of captive screws in front, which are not to hand. A cast iron door, somewhat like that of a kitchen range, swings on a hinge to cover the cathode ray tubes and is made to carry the range cursor of the lower tube and some of the optical gear between the two tubes to show the range.

Most of the electrical apparatus, including such heavy items as the mains transformer, is mounted, not directly to the cast iron frame, but on bakelite fabric panels of fair thickness, which more or less fill up the iron skeleton and give an appearance of solidity to the whole. Here the mechanical layout very closely follows the electrical functions of the apparatus and can be roughly indicated as follows (see Figs.1 and 2).

(a) large bottom panel - power supply apparatus (except valves).

(b) small panel (at rear of (a)) - power supply valves.

(c) large panel in front of and higher than (b) - line amplifier and transformer shelf.

(d) vertical panel on right hand side of (c) - two valve time base for top tube.

(e) vertical panel on left hand side of (c) - three valve time base for bottom tube.

(f) a very large panel at top left hand side of apparatus which completely hides the cathode ray tubes from that side - D.C. apparatus of cathode ray tubes.

(g) small condenser panel at top right hand side of apparatus, - sweep voltages.

Additionally, the potentiometers for the control of the tubes are all mounted in a logical manner on 4 panels affixed to the front of the apparatus. In the case of the first five panels mentioned, these are all united by means of stout columns and angles to form a rigid cage-like structure which enables apparatus to be mounted on both sides of the panels but results in a very inaccessible construction. Although the various functions of the apparatus are thus more or less logically divided amongst the various panels, yet the interconnections between them are so numerous that it is not practicable to separate them for servicing and the accessibility must be considered as very bad.

Connection with the apparatus is automatically made on pushing it into the outer cover by means of 16 contacts on the back which correspond to others in the outer cover. Contacts Nos.1 to 8 are concerned with the time base and form a vertical line down the middle of one of the back vertical members of the frame while Nos.9 to 14 carry 50 cycle A.C. and are at the back of the bed plate. Nos. 15 and 16, which are concentric sockets on either side of these last, carry the video signals from the receiver direct to the cathode ray tubes. In the photographs an 8-way Jones Plug may be seen, which was fitted during reconstruction to carry certain currents as the outer box was not available. The same reason explains the fitting of the brass bracket at the back, which is substituted for concentric plugs 15 and 16.

Repairs and Replacements

All the front panels bearing potentiometers were broken up and had to be replaced by "home-made" ones, while the top cathode ray tube socket was broken in several pieces. As no substitute was available, it was carefully bound with cord and numerous 6 BA screws drilled and tapped into the various fragments. This has made a satisfactory repair. One of the vertical shift-controls was broken up and had to be replaced by a British component. Two condensers of panel "e" were missing, while condensers 325 of the power pack and 426 of the time base proved defective and were replaced by British equivalents. Owing to poor accessibility, neither of these condensers could be removed, so they were disconnected and the replacements connected to equivalent parts of the circuit.

3.1 Mechanical features of phase shifter 301

This phase shifter, which is the principal operational control of the unit NB.110, occupies the centre position below the two cathode ray tubes, and has the primary purpose of shifting the phase of the 500 cycle supply to the upper cathode ray tube and thereby causing it to display different sections of the main trace of the lower tube. Also mechanical arrangements are applied to the phase shifter, both to enable the operator to set it easily in order to magnify any given echo in which he is interested, and to display a rough indication of the range of that echo.

The phase shifter 301 is driven from outside the containing box by a spindle ending in a dog which engages a slotted disc on a short spindle carried by unit NB.110 itself. This disc is spring loaded and arranged to slip at a moderate torque to avoid damages to the trace wires etc. although the actual phase shifter is capable of continuous rotation in either direction. The rotor spindle carries a double pulley adjustable by a 120° slot and also a cam, which has not come to hand, and which used to abut on the adjustable stop seen projecting from the inside of the right hand control panel. This cam was intended to limit the movement of the phase shifter to cover only the useful part of the whole trace length and was adjustable by the mechanic in setting up the apparatus. The rear groove of the double pulley carried a trace wire which was led over small pulleys to a drum (not found) which rotated on the spigot seen projecting from the right hand middle side of the whole apparatus, roughly on a level between the two cathode ray tubes. This drum thus revolved at approximately the same speed as the phase shifter rotor and the range in kilometres was engraved on its circumference. A bold pointer was provided in front of the drum and just behind the door which covers the cathode ray tubes screws. This door is provided with 2 small lamps which intensely illuminate the drum and pointer and has an optical system on the basis of the periscope which gives an image of the drum in a little square window in the door between the two tube screens. The approximate range is thus indicated to the operator without his having to remove his eyes from the tubes.

The mechanism associated with the front pulley consists of a sliding block running on a rod fitted to the bottom of the door mentioned above and the necessary guide and jockey pulley to enable the door to be opened without disturbing the mechanical connection between the pulley and sliding block. The block formerly carried a transparent cursor which defined the part of the bottom trace which was being expanded on the top tube and thus enabled the operator to select the echo required without loss of time. The quadrant slot in the pulley is presumably for the use of the mechanic in setting up the apparatus to meet this requirement.

3.2 Power Supply Circuit of NB.110 (see Fig.3)

The whole power supply, with the exception of filament heating for the cathode ray tubes, is derived from the large transformer 307, which is mounted well down in the apparatus, as far as possible from the tubes. The current drawn from the main is given by an Avometer as 0.835 amps at 230 volts, but owing to the extreme distortion of the current wave (Fig.4) the actual power consumption is far below that indicated.

Fuses are provided in the mains supply and also in the time base H.T. and C.R. tube H.T. circuits, while a mechanical device breaks both poles of the supply and discharges the E.H.T. condensers whenever the containing box door is opened. This device was removed and replaced by a hand operated switch and neon signal lamp in the present case. The main time base H.T. supply of 110 mA is derived from a Telefunken EZ.12 valve, 303 connected to a 500-0-500 volt winding on the transformer. This, after passing the fuse 311, is smoothed by 2 paper condensers 320, 321 of 4 MF capacity and an iron core choke 329 before passing through the dropping resistance 324 to the Stabilovolt 304, the first three sections of which stabilise the voltage at 210 and 140 volts for time bases and at 70 volts for C.R. tube shift circuits. Large electrolytic condensers shunt all these outputs. The remaining gaseous section of the Stabilovolt is used in a remarkable way, being connected between earth and the centre point of the 500-0-500 volt winding which supplies the rectifier. The consequence of this is that conduction through the gas is intermittent, only taking place during the charging of the reservoir condenser (see Fig.4). A moving coil voltmeter connected across the Stabilovolt section thus reads an <u>average</u> value of the waveform, giving the apparent anomaly of a Stabilovolt section with only a 50 volt drop across it. These interruptions of current are smoothed out and the voltage further dropped by the 10,000 ohm resistor 318 with the result that the tag marked "-70 volts" is actually only 30 volts below earth. The reason for this very curious circuit is not known. The high voltage supply for the cathode ray tubes is provided by a Telefunken RFG 12 valve 302 which not being available, a British U.17 has been substituted with a 3 ohm resistance in series with its heater. In this unit the EHT current attains the large value of 15 mA, causing a serious drop in the smoothing resistances 312 and 313 which total 110,000 ohms. To offset this, the transformer winding supplying valve 302 is returned, not to earth, but to one side of the 500-0-500 volt winding of the transformer.

Apart from this the circuit of this portion is without interest, but it may be added that a mechanical device to discharge condensers 314 and 315 and break the main supply formerly existed. The transformer is made to supply a very heavy half wave load (15 mA at 2800 v), causing the extreme distortion of current wave already mentioned. This also has its effect on the time base H.T. supply, the input to the reservoir condenser 320 being much less in the half cycle, during which the E.H.T. rectifier is conducting than during the other half cycle when this load does not come on the transformer (Fig.4).

Transformer 307 additionally supplies separate L.T. voltages to the two time bases and also a 12 volt supply to the lamps used in the optical range indicator. All these supplies are balanced to earth and run in screened cables.

The small filament Transformer 308, which only supplies the cathode ray tube heaters, is mounted on the back member of the mains frame of the unit and has an electrostatic screen between the secondaries and the primary; a feature not found in the large transformer 307.

3.3 Time Base Circuits of NB.110

These consist of a distorting amplifier, which produces the high speed time base and blackout for the top tube (Fig.5) and a transitron oscillator, which is kept in synchronism with the 500 cycle master oscillator and supplies time base voltage and blackout to the lower tube via separate amplifiers. The chief features of interest are the use of only six valves for the two separate time bases and the unsatisfactory performance of the blackout obtained by undue economy of valves.

3.3.1 Phase Shifter

The 500 cycle tone controlling the two time bases comes from terminal "b1" on the back of the apparatus via a screened lead to the phasing network of condenser 423 and resistances 408 and 470. This gives approximately 30° control of phase without causing more than 20% variation in voltage level at grid of valve 334 and is operated by resistance 470 on the right hand control panel of apparatus NB.110. The valve 334, which is a fair sized output pentode, is almost hidden from sight between the two time base panels and its main function is to supply power to the phase shifter 301, or rather to its associated network. With a 1 volt input to terminal "b1" and average setting of phasing control 470, 66 volts are obtained at the anode of this valve and 14 volts at the secondary of the transformer 337. The phase splitting network used in connection with the phase shifter 301 is a very well known one and the vector diagram (Fig.6) shows, almost without further explanation, the distribution of currents and voltages, having been prepared from the results of actual measurements. It will be seen that while ideally the reactance of the condenser should be exactly double that of one of the coils, the variable resistances 411 and 142 allow a deviation to be made up at the expense of a reduction in power factor. In such a case, the phase angle of the load presented by the whole phase shifter adds itself to the mechanical setting of the rotor, but this can be allowed for in calibration.

3.3.2 Class A Amplifier

The output from the phase shifter is only about a tenth of a volt and is taken direct to valve 335, which is a class A amplifier, with tuned anode circuit across which about 22 volts are developed.

The tuned anode coil is a small inductance coil on transformer laminations and is housed in a sheet iron screening box just below the lower cathode ray tube and almost immediately over its corresponding valve panel to which it is connected by a screened lead. The very thorough decoupling by means of a 100,000 ohm resistance should be noted and is only rendered possible by the very small H.T. current of the miniature valve type RL 12P 2000.

3.3.3 Distorting Amplifier

The next valve is a distorting amplifier, which draws grid current and is consequently only lightly coupled to the tuned anode circuit by the 80 pF condenser 428, as well as being provided with a 120,000 ohm grid stopper 431. The small condenser used gives rise to a phase shift of almost 90° as well as reducing the voltage from 22 volts down to 1.2 volts, but there is no appreciable distortion of the sine wave till the grid of valve 336 is reached, where the positive going half of the wave is mutilated by the flow of grid current (see Fig.7). The anode wave form is rather similar to that of the grid as there is not enough swing to cause cut off on the negative going half cycle, and the positive going half cycle is already cut down by grid current. There is, however, an important feature to be noticed. The load presented by transformer 338 causes such a phase distortion of the harmonics introduced originally at the grid of valve 336 that one side of the anode voltage wave is steeper than the other and this steep side is chosen to form the working time base. One drawback of this is that the writing speed during flyback is less, not more, than during the working stroke, and if, as in this case, the blackout is not good, a very visible flyback results. This blackout voltage is derived by an integrating circuit of condenser 384 and resistance 385 from the anode of valve 336 and is again almost a pure sine wave, but of only 10 volts RMS value. The A.C. 500 cycle component of the anode voltage of valve 336 required to produce these 10 volts would be some 200 volts RMS, but measurements have not been attempted owing to the distortion at this point, which would render them of small value. It may be said of this system of blackout, that, though adequate for use in a dark cabin, the flyback easily becomes visible when the trace is turned up to a suitable level for daylight observation. Failure of the 500 cycle supply causes the production of a large bright spot in the middle of the screen for each system, though not enough to injure the screen of the tube.

3.3.4 The Transitron

The low timebase and blackout are derived from a transitron oscillator (see Appendix). In this particular apparatus the transitron is synchronised to the rest of the apparatus by applying a negative voltage to the control grid of the valve. The effect of this is, by reducing the total cathode current (all of which goes to the screen, while the time base is being drawn) to raise the screen potential sufficiently to enable the characteristic concerned to slip off the load line and put an end to the time base. The synchronising point is shown on the oscillogram (Fig.8). It will be seen that this synchronism at the end, instead of the beginning, of the time base, is the direct opposite of British practice and, by including the indeterminate charging, or flyback interval, between the point of synchronisation and the start of the time base, loses all claim to give accurate ranging. The same fact, that the valve is conducting during part of the measured interval, renders the trace extremely susceptible to hum-induced jitter, while the high mutual conductance and hence the voltage gain, between control and screen grids make it easy to cut short the duration of the time base below that necessary to display the full 200 kilometres, if the synchronising input is not kept well down.

In the present apparatus another objectionable feature is seen originating from the low H.T. voltage (210). At the commencement of the time base, the condenser 403 (Fig.5) is only charged to the difference between the minimum value of anode voltage and the H.T. potential of 210 volts. So low an initial charge does not allow a reasonable voltage excursion without the exponential nature of the discharge becoming evident (see Fig.8), and, to combat this, suitable values have been chosen for condenser 401 and resistance 396. While linearising the greater part of the time base, this leads to a slow start (see Fig.9) and consequently a bright non-linear portion at the beginning of the trace on the cathode ray tube. Owing to the lack of any means of adjusting the blackout timing, this cannot be got rid of and is a constant likelihood of error in setting up the apparatus, should the ground ray of the station be placed at the start of the trace. Coming to the practical details of the apparatus, valve 332 is the transitron oscillator, with condenser 400 coupling the screen and suppressor grids and condenser 406 supplying 500 cycle current to the grid. The positive half cycles are lost in grid current leaving the required negative pulses for synchronising. The suppressor grid (and hence the screen grid) of the transitron are coupled to the grid of valve 331, which is arranged to be cut off during the time base by the fall of potential on the transitron electrodes to which it is coupled (see Puckle diagram and Fig.9). The consequent rise of potential of the anode of valve 331 brightens the trace of the lower cathode ray tube. No means of adjustment to the blackout are available.

3.3.5 Time Base Amplifier

Valve 333, which is triode connected, is the actual time base amplifier. It will be seen that a 50,000 ohm resistor is connected across the primary of the output transformer, but no other precautions are taken to preserve linearity of response. The variable bias resistance, giving a range of control of half a volt, serves rather to introduce compensating distortion to that inherent in the time base generator. As the performance of the stage, considered as a pure audio amplifier, is somewhat remarkable, the attached Fig.10 is presented giving both the whole audio spectrum and the response over the part of more immediate interest. The excellent response down to low frequencies is of interest as it is usually accompanied by absence of phase distortion and indeed, input and output saw tooth waves are almost identical, except as to amplitude, unless the control 398 is used for correction. The input to the time base amplifier is derived from the potentiometer 396 which is fed from the anode of the transitron oscillator by condenser 401. Potentiometer 396 is mounted on the left hand control panel and in practice is used to adjust the length of the trace on the screen ofthe lower tube, while the bias may be adjusted to obtain as good linearity as possible. This is important as the cursor of the phase shifter 301 will not accurately define the part of the lower trace being expanded at any time unless the lower trace is strictly linear as well as being of the right length. It was noticed that adjustment of the synchronising control 406 greatly affects the trace length, thus acting as a width control as well as synchronising control. Condenser 406 is the only one of the numerous adjustments of the apparatus which appears to have been sealed with paint and is not improbably a factory adjustment, its value $1\frac{1}{2}$ to 6 pF being suitable to compensate for differences in capacity of the screened leads on the connection to valve 332.

3.3.6 Note on possible non-standard feature of time base

The enemy circuit shows a condenser 424 of 1000 uF and a resistance 420 of 500,000 ohms used as a phase advancing circuit between condenser 406 and the anode of valve 334. These had evidently been removed in this particular apparatus as the tags to accommodate them were still to be seen. As the phase shift thus removed is approximately equal to 33° (about 30 KM on the trace) and the precise phase shifter (which see) possesses a zero error of that amount, it is not improbable that, the timing circuits having developed a fault causing late firing of the transmitter, the expedient of removing condenser 424 and resistance 420 from the main display unit NB.110 was resorted to, instead of correcting the action of the timing circuits. The apparent zero error of some 30 KM on the precise range unit would be thus accounted for and could in any case be allowed for by the operator in reading the ranges.

3.4 Cathode Ray Tube Circuits of NB.110 (Figs.11 and 12)

These cathode ray tubes are of the double variety so that, practically, 4 complete cathode ray tubes have to be controlled in the one unit, thus giving an air of complexity to the circuits, although these as seen in Fig.12 are in reality extremely crude, being reduced to the bare minimum without any refinements whatever. It will be seen from Fig.11 that only the first and third anodes are common to the two systems, the other electrodes of each being supplied by an independent resistance chain in each case, thus accounting for the high E.H.T. consumption. It will further be seen that coming to the deflector plates, the signal presentation is single ended, although the time base is in push-pull connection. The application of shift voltage to the time base deflector plates is interesting. These plates are connected to earth via a 4 megohm resistance on the one hand and a 3 megohm resistance and a 1 megohm in series on the other, thus forming what would be a balanced load, were there no other connections. Actually, however, the shift voltage from the horizontal shift potential is fed in at the junction point of the two resistances, thereby more or less shortcircuiting any deflection potentials that may be developed across the 1 megohm resistance. The resistance between the deflector plate concerned and earth can never exceed $3\frac{1}{8}$ megohms and it would have been preferable to use a 4 megohm resistance on each side and connect it direct to the potentiometer slider as has been done in the case of the vertical shift, which presents no points of interest.

No attempt is made to obtain either push-pull application of the signal voltages, or astigmatism correction, and the whole equipment for placing the four traces consists of eight 500,000 ohm potentiometers shunted across the +70 and -70 outputs of the power supplies.

As seen in the large diagram, the same screen and blackout potentials are applied to both systems in each tube, so that in order that any signals displayed simultaneously on the two traces may come one over the other, it is necessary to choose the D.C. potentials applied to the other electrodes so that their sensitivities are as nearly as possible the same. This function is roughly performed by the mechanic in setting up the focus and brilliance controls and is a considerable embarrassment in getting a good trace on both systems at once. When adjustment is finished the sensitivity balance controls 349 and 326 of the two tubes enable any final matching up of the echoes at the expense of clearness of focus. These controls are only accessible to the mechanic.

The four focus controls on the left hand panel and the four brightness controls on the right hand panel have each a common control, accessible to the operator from outside the containing box, but the four controls in each group are geared together by means of bakelite spur gears, which can be slid out of engagement for independent adjustment to satisfy the condition mentioned above. The range of satisfactory adjustment when all four are geared together is limited but probably sufficient for the operator's needs. These two groups are each driven by a dog on an external spindle engaging in a slotted disc carried on one potentiometer spindle of each group. The discs are fitted with a spring loaded coupling which will slip before force enough to damage the gears can be applied and the brightness group has in addition a stop which may be set to limit the available brightness of the cathode ray tubes.

A very curious feature of the circuit is the provision of condenser 421 acting on the vertical shift of one system of the lower tube. This condenser is connected to terminal "b6" by means of screened wire and would appear to be provided for trace separation purposes, though there is nothing to show what object could thus be attained, as the rest of the apparatus in the two complete installations does not provide any time between working traces during which the separated trace could be displayed, nor has either installation any provision for suppressing its main transmitter and receiver. The production of a double trace by the use of two separate systems in each tube is, of course, not open to this objection, as main and I.F.F. systems can then function simultaneously.

An interesting point in the practical operation of the equipment is that, although the sensitivity of any cathode ray tube should depend solely on the potential drop from cathode to third anode, yet in this case focus and brilliance controls have an appreciable effect on sensitivity. This circumstance is very troublesome to the user, and seems to need further investigation.

4. Operating Data

The following operating data has been collected to date :

Resistance of components

No.	Designation	Primary Resistance	Secondary Resis.
301	Phase Shifter	400 + 400	750
337	Phase Shifter input Transformer	1250	330
338	Fast Time Base Transformer	1500	2500 + 2500
339	Slow Time Base Transformer	1500	2500 + 2500
307	Mains Transformer	$6\frac{1}{2}$ (with 308 in parellel)	HT 500 EHT 2500
422	Tuned Anode Coil	1700	
329	Smoothing Choke	380	

Currents measured at Fuses

No.	Function	Working Circuit	Rating
309	Mains Input	0.835 A	2 A
310	EHT Rectifier	15 mA	0.1 A
311	HT Reftifier	110 mA	?

Measured Voltages

	V.D.C.		V.A.C.
EHT (Valve 302 anode)	-2800	EHT sec.Transformer 307	1800
HT (fuse 311)	500	HT sec. Transformer 307	500-0-500
-70 volt tag of power pack	-30	500 cycle input from "Z" unit	1
across condenser 215	-1500	valve 334 anode	66
valves 335, 336 screens	70	transformer 337 secondary	14
valve 333 cathode	$7\frac{1}{2}$ to 8	terminal "b3"	approx.0.1
" 334 "	$4\frac{1}{2}$	valve 335 anode	22
" 335 "	3	across resistance 419	1.2
" 336 "	1	across condenser 384	10

NOTE: D.C. and A.C. 50 cycle voltages and currents by Avometer. 500 cycle voltages by valve voltmeter. Voltages at points directly connected to Stabilovolt electrodes are not given as in the absence of any fault they will have their nominal values.

5. Suggested Setting-up Procedure

Although no enemy instructions for setting up the apparatus are to hand, the following notes are offered as a suggested procedure, starting in the first case with the time bases, as setting of the cathode ray tube controls can only be done when some display is being shown, on account of the dependence of deflectional sensitivity on these controls. Starting with the phase shifter 301, it is recommended that the mechanical attachments be not fitted till after the phasing resistances 411 and 412 have been set. This will allow of the rotor being continually rotated by an assistant, while a suitable voltmeter connected across the anode coil 422 will show up any variations of phase shifter output while being rotated. Any such variations are to be removed by simultaneous adjustments of the two resistances 411 and 412. After this adjustment has been successfully completed the trace wires may be fitted to the phase shifter, but not finally clamped to the cursor and drum. The next step will be to roughly brighten one of the traces on each tube and with the aid of a squegger suitably locked to the 500 cycle source, or of the ground ray of the station, to find a suitable adjustment of the condenser 406, giving the most steady locking of the lower tubes time base to the 500 cycle source. The beginning of the trace will in any case be somewhat bright owing to its non-linear start, while its total length will depend markedly on the setting of condenser 406. The best setting of this condenser has been found to be halfway in (i.e. with screw driver slot horizontal). It must be appreciated that the shortening of the trace by increasing the value of condenser 406 is due to an actual reduction in time duration of the working stroke, and if it is carried to excess, the whole 200 kilometre range of the station cannot be displayed. Condenser 406 thus unsatisfactorily combines the functions of a "sync" and "width" control and it will be a great advantage if some form of calibrator panel is available at this stage.

Having secured a fairly good adjustment of condenser 406, the ground ray or squegger pip should now be placed at the beginning of the trace, but avoiding the bright, non-linear start of the trace, and phase shifter 301 turned to bring the ground ray or pip in the middle of the upper time base, when the "Range" drum on the side of the complete unit NB.140 can be clamped to display zero range at the small window between the cathode ray tubes and the cursor can be clamped at the start of its travel. The range should now be turned to 200 kilometres, when the movement of the cursor will indicate the required length of 200 KM on the bottom trace. As this will not necessarily be the actual length of trace, the ground ray or squegger pip should be shifted into the middle of the top tube trace, when its position on the lower trace can be made to coincide with the cursor by simultaneous adjustment of the "velocity" control 396 and the horizontal shift of the trace being used. It will be found that the "velocity" control affects both ends of the trace and this calls for compensating adjustments to the horizontal shift whenever it is used, in order that the start of the trace may remain in its place. The "linearity" control 398 is fortunately without serious effect on the trace length and can be adjusted either in the well known manner if a suitable calibrator panel is available, or else by carefully going over a number of intermediate ranges in the way just described for 200 kilometres.

Owing to the requirements of equal deflectional sensitivity of the two systems in each cathode ray tube, it will be necessary to join the inputs in parallel at plugs "b15" and "b16" and to display simultaneously on the traces either a pip at the extreme end of the slow trace or a proper calibrator display, depending on the apparatus available. If the pips are reasonably wide, one of them can be displayed in the upper tube and will suffice by itself for the purpose of comparing the sensitivity of the two sections of that tube. Before starting adjustments, the time bases should be stopped by removing the 500 cycle input and by turning the velocity control 396 to zero. The various brightness and focus controls should also be individually set to zero (noting that, on account of the spur gearing, alternate ones will turn clockwise and anticlockwise) and the sensitivity balance controls 326 and 349 placed in the middle of their travel. The brightness controls should now be turned up till a suitably bright spot appears in all four instances and these focussed as well as possible, without uncoupling the gearing between the controls. When reasonably focussed, the four spots should be placed horizontally in the exact centre of their tubes by means of the horizontal shift controls 452 and 455. Their vertical setting by means of potentiometers 464 to 467 will correspond to the desired trace separation. After this adjustment, the time bases can be brought into action by applying the 500 cycle tone and turning up the velocity control to its original setting. The squegger or calibrator display should now be applied and individual adjustments made to the focus and brilliance controls of each tube to improve the brightness and definition, subject to the condition that the two pictures of the blip in the top tube remain of equal size and the two bottom traces of equal length, as denoted by the fact that they commence together and the blips at their ends are over each other. Any slight final matching up of pictures after meshing the gear wheels must be by the sensitivity balance controls 326 and 349.

When this meshing of the gear wheels has been effected, a check on the lower time base will probably be necessary, the beginnings of the two traces being so placed that a ground ray or squegger pip displayed in the centre of the top time base at zero or small range is covered on the lower trace by the cursor and the velocity control 396 being then adjusted to give the same state of affairs at the long range end of the trace. Several repetitions of this and final linearising of the trace will be needed to obtain a good effect.

6. Conclusions

The chief feature of interest in the apparatus, as in the rest of the installations in which it is used, is in the provision of ingenious mechanical and structural features combined with remarkably crude electrical design. An example of this may be seen in the provision of two complete systems in each cathode ray tube, with the accompanying great difficulties of adjustment of apparatus and tube construction, rather than the use of trace separation circuits with a normal tube or, alternatively a double beam tube of the Cossor type. The mechanical attachments of phase shifter 301 are another case in point and it is doubtful if the whole arrangement of small tubes with trace expansion presents any advantage over the use of a single 12 inch tube with graduated scale along the trace. Considering that the operator is responsible for searching and for turning the cabin to give optimum response, it is certainly a bad feature that he cannot clearly examine an echo till he has covered it with the transparent cursor and thus displayed it in the top tube.

On the electrical side, the use of small diameter cathode ray tubes, worked at low anode voltages, greatly reduces the time base requirements and, at the same time, permits the use of very crude means of shifting the picture. This has been taken full advantage of by the designers both in the primitive shift controls provided and in the absence of any astigmatism controls.

The time bases, which in these circumstances are not called upon to provide any great output, are remarkable for the low anode dissipation of the valves used and the low H.T. voltage. The excellent time base output transformers (338 and 339 Fig.5) are largely responsible for this, but as will be seen from the description of the action of the time base circuits, many compromises have had to be made and special circuit features incorporated to enable a satisfactory performance to be obtained. Even so, objectionable features remain, especially as to blackout on both tubes, and locking of the bottom time base to the rest of the apparatus. With the system adopted of taking range by placing the required echo in the centre of the top tube, this is rather an inconvenience to the operator than a source of inaccuracy, but in any case, would have been better avoided. The setting up of the time base circuits and cathode ray tubes has been dealt with under "Operating Data" and will be seen to be quite complex.

The accessibility of the various parts is extremely poor, owing to the adoption of a skeleton form of construction for the equipment instead of a chassis and, already in two cases where replacements were necessary, it was impossible to remove the defective component and it has had to be disconnected and left in place. The fitting of the two trace wires, though fairly difficult, does not call for any comment.

Finally, it may be said that the apparatus is chiefly interesting in its points of difference from British practice and does not present any features which could usefully be copied.

7. Parts List

No.	Component	Description
301	Phase Shifter	Primary 400 + 400 ohms, Secondary 750 ohms
302	Rectifier Valve	V.U.17 (British)
303	" "	EZ.12 (Telefunken)
304	Stabilovolt	STV.280/80 (British)
305	Cathode Ray Tube	HR2/100/1.5A (Telefunken)

No.	Component	Description
306	Cathode Ray Tube	HRP2/100/1.5A (Telefunken)
307	Mains Transformer	220/6.3 + 1800 : 2 x 6.3 : 2 x 6.5 : 2 x 6.3 : 2 x 500
308	" "	220/4:4:4:4
309	Indicating fuse	2A
310	" "	0.1A
311	" "	0.1A
312	Vitreous Resistance	75K ± 5%; 35 watt
313	" "	35K ± 5%; 35 watt
314	Condenser	1 µF ±10%; 2-6 KV. DC.
315	"	1 µF ±10%; 2-6 KV. DC.
318	Resistance	10 K ±5%; 0.25 watt
320	Condenser	4 µF ±10%; 500 V. D.C.
321	"	4 µF ±10%; 500 V. D.C.
322	Electrolytic Condensers	10µF +50% - 20%; 100 V. D.C.
323	Choke	15 henries
324	Vitreous Resistance	2.5K ±10%; 35 watt
325	Electrolytic Condenser	16 µF; 250 V. D.C.
326)	Resistance	200K ± 5%; 0.5 watt
326)	Potentiometer	30 K; 2 watt
327	Electrolytic Condenser	16 µF; 250 V. D.C.
328	" "	10 uF +50% -20%; 100 V. D.C.
329	Resistance	1M ± 5%; 0.5 watt
330	"	1M ± 5%; 0.5 watt
331	Pentode Valve	RL.12P.2000 (Telefunken)
332	" "	RL.12P.2000 (")
333	" "	RL.12P.2000 (")
334	" "	RL.12P.10 (")
335	" "	RL.12P.2000 (")
336	" "	RL.12P.2000 (")
337	Coupling Transformer	
338	" "	
339	" "	
340	Condenser	0.01 µF ±10%; 500 V. D.C.
341	Potentiometer	30 K; 2 watt
342	Resistance	100 K, ±5%; 1 watt
343	Potentiometer	100K, 2 watt
344	Resistance	100 K, ± 5%; 1 watt
345	Resistance	200 K, ± 5%; 2 watt
347	"	200 K, ±5%; 0.5 watt
348	Electrolytic Condenser	10 µF +50% -20%; 100 V. D.C.
349	Potentiometer	30K; 2 watt
350	Condenser	0.01 µF ±10%; 500 V. D.C.
351	Potentiometer	30 K; 2 watt
352	Resistance	100 K ± 5%; 1 watt
353	Potentiometer	100 K; 2 watt
354	Resistance	100 K ± 5%; 1 watt
355	"	200 K ± 5%; 2 watt
357	"	200 K ± 5%; 0.5 watt
358	Electrolytic Condenser	10 µF +50% -20%; 100 V. D.C.
360	Condenser	0.01 µF ±10%; 500 V. D.C.
361	Potentiometer	30 K; 2 watt
362	Resistance	100 K ± 5%; 1 watt
363	Potentiometer	100 K; 2 watt
364	Resistance	100 K ± 5%; 1 watt
365	"	200 K ± 5%; 2 watt
366	"	200 K ± 5%; 0.5 watt
368	Electrolytic Condenser	10 µF +50% -20%; 100 V. D.C.
370	Condenser	0.01 µF ±10%; 500 V. D.C.
371	Potentiometers	30 K; 2 watt

No.	Component	Description
372	Resistance	100 K ± 5%; 1 watt
373	Potentiometer	100 K; 2 watt
374	Resistance	100 K ± 5%; 1 watt
375	Resistance	200 K ± 5%; 2 watt
376	Resistance	200 K ± 5%; 0.5 watt
378	Electrolytic Condenser	10 μF +50% -20%; 100 V. D.C.
379	Resistance	300 K ± 5%; 1 watt
380	"	400 K ± 5%; 1 watt
381	"	400 K ± 5%; 1 watt
382	"	500 K ± 5%; 0.5 watt
384	Condenser	10.000 pF ±10%; 500 V. D.C.
385	Resistance	600 K ± 5%; 0.5 watt
386	"	200 K ± 5%; 0.5 watt
390	"	20 K ± 5%; 0.5 watt
392	"	1 M ± 5%; 0.25 watt
393	"	1 M ± 5%; 0.25 watt
394	"	1 M ± 5%; 0.25 watt
396	Potentiometer	500 K, 2 watt
398)	"	2.5 K; 2 watt
398)	Resistance	5 K ± 5%; 0.25 watt
399	Condensers	0.01 μF ±10%; 500 V. D.C.
400	"	0.03 μF ±10%; 500 V. D.C.
401	"	0.01 μF ±10%; 500 V. D.C.
402	Electrolytic Condenser	10 μF +50% -20%; 160 V. D.C.
403	Condenser	0.03 μF ±10%; 500 V. D.C.
406	Variable Condenser	1.5-6 pF ceramic type
407	Resistance	1 K ± 5%; 0.5 watt
408	"	200 K ± 5%; 0.25 watt
410	"	150 ohm; 0.5 watt
411	Potentiometer	120 ohm; 0.5 watt
412	"	120 ohm; 0.5 watt
413	Resistance	100 ohm ±5%; 0.25 watt
414	"	100 ohm ± 5%; 0.25 watt
415	"	3 K ± 5%; 0.25 watt
416	"	80 K ± 5%; 0.25 watt
417	Condenser	3000 pF ±10%; 500 V. D.C.
418	Resistance	100 K ± 5%; 1 watt
419	"	300 K ± 5%; 0.25 watt
421	Condenser	0.01 μF ±10%; 500 V. D.C.
421	Choke	
423	Condenser	2000 pF ±10%; 500 V.D.C.
425	"	0.16 μF ±10%; 500 V.D.C.
426	"	0.5 μF ±10%; 500 V. D.C.
427	"	1 μF ±10%; 500 V. D.C.
428	"	80 pF ±10%; 500 V. D.C.
429	Electrolytic Condenser	10 μF +50% -20%; 100 V. D.C.
430	" "	60 μF; 100 V. D.C.
432	Resistance	3 M ± 5%; 0.5 watt
433	"	1 M ± 5%; 0.5 watt
434	"	4 M ± 5%; 0.5 watt
435	"	3 M ± 5%; 0.5 watt
436	"	1 M ± 5%; 0.5 watt
437	"	4 M ± 5%; 0.5 watt
438	Condenser	10,000 pF ±10%; 500 V. D.C.
439	"	10,000 pF ±10%; 500 V. D.C.
440	"	10,000 pF ± 10%;500 V. D.C.
442	Resistance	3 M ± 5%; 0.5 watt
443	"	1 M ± 5%; 0.5 watt
444	"	4 M ± 5%; 0.5 watt
445	"	3 M ± 5%; 0.5 watt
446	"	1 M ± 5%; 0.5 watt
447	"	4 M ± 5%; 0.5 watt

No.	Component	Description
448	Condenser	10,000 pF ±10%; 500 V. D.C.
449	"	10,000 pF ±10%; 500 V. D.C.
450	"	10,000 pF ±10%; 500 V. D.C.
451	"	10,000 pF ±10%; 500 V. D.C.
452	Potentiometer	500 K; 0.5 watt
453	"	500 K; 0.5 watt
454	"	500 K; 0.5 watt
455	"	500 K; 0.5 watt
460	Resistance	1 M ± 5%; 0.5 watt
461	"	1 M ± 5%; 0.5 watt
462	"	1 M ± 5%; 0.5 watt
463	"	1 M ± 5%; 0.5 watt
464	Potentiometer	500 K; 0.5 watt
465	"	500 K; 0.5 watt
466	"	500 K; 0.5 watt
467	"	500 K; 0.5 watt
470	"	1 M; 2 watt
471	Resistance	50 K ± 5%; 0.25watt
474	"	200 ohm ± 5%; 0.25 watt

---

8. References

The following are, or will be, R.A.E. Technical Notes dealing with German radar equipment :-

8.1	Freya Transmitter T.106	No.Rad.156	
8.2	FuSE 62 Mechanical Aspects and Turning Gear	" 151	
8.3	FuSE 62 Display Unit OSZ.62	" 178	
8.4	FuSE 62 Low Tension Circuits	" 189	
8.5	Examination of German Valves manufactured between 1938 and 1943	" 114	
8.6	German Valve type LD.2	" 127	
8.7	German Valve type LG.1	" 149	
8.8	Examination of German Valves and C.R.Ts		In preparation
8.9	FuSE 62 Pulse Generators IG.62 & IG.62A		In preparation
8.10	FuSE 62 Monitoring Receiver Units KD.62 and KD.64		In preparation
8.11	FuSE 62 D type Display System		In preparation
8.12	FuSE 62 Examination of Aerial Feeder System and R.F. Circuits		In preparation
8.13	Coast Watcher and Freya Installations - Main Display Unit NB.110		In preparation

Circulation

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

R.A.E. Ref : Rad/S.4761/TB/126

APPENDIX

The Transitron

The transitron oscillator depends on the fact that, in a pentode, an increase in suppressor grid potential tends to divert current from the screen to the anode and hence raise the screen potential, if the screen should be fed through a resistance. This fact enables a form of relaxation oscillation to be obtained by coupling screen and suppressor grid by a condenser. Owing to the fact that several actions are taking place simultaneously, it is difficult to give a simple yet accurate description of the action of a transitron oscillator in words, but by the use of a peculiar form of characteristic due to Puckle a very clear idea can be obtained, both of the action of this form of time base and of its unavoidable points of inferiority to British practice (see Fig.8).

The Puckle diagram consists of a series of characteristic curves connecting screen voltage (fed through the coupling resistance) with suppressor grid voltage, the other electrodes having their correct potentials as when the transitron is running. It will be seen that there is different curve for every value of anode voltage and the family of curves are readily plotted by fixing the anode voltage by a battery of suitable EMF. In the present case, only those corresponding to the maximum and minimum values of anode voltage reached in the oscillograms are needed. It will be seen that when the suppressor grid is sufficiently negative, neither it nor the anode have influence on the screen grid and all the characteristics merge into a straight horizontal line.

Having obtained the characteristics for the minimum and maximum anode voltages, two load lines of slope $\frac{dE_{g2}}{dE_{g3}} = 1$ (i.e. expressing perfect coupling of screen and suppressor grids by the condenser 400) are drawn tangential to the two characteristics at x and y , thus giving a cyclogram. This cyclogram expresses a continuous process of alternate charging of the two condensers by the valve and discharge through resistances, each of which processes goes on till the load lines concerned can no longer intersect any of the characteristics. When this happens (at the tengential points x and y) there is a convulsive jump to the other process. It will be seen that this is essentially a continuous process with two condensers taking part simultan ously, and is not simply explainable in words as are the older relaxation oscillators. The Puckle diagram with attached waveforms, perhaps gives the best view of the action.

During the time base working stroke, the discharge of condenser 403 through resistance 388 causes the anode potential to rise to its maximum working value, while at the same time the discharge of condenser 400 through resistance 393 causes the load line to move to the right. As long as intersection is possible between the characteristics corresponding to the anode potential and the load line, the discharging of the two condensers goes on steadily and the change of potential across 403 produces the time base. As soon as intersection becomes impossible, at the tangential point x , a jump occurs to a point where the curves again intersect and this being in the positive part of the curve, both suppressor grid and anode draw current and charge the condensers at a rate depending on the capabilities of the valve (dotted lines). This again causes the load line and the characteristic to separate and they lose touch at the tangential point y , when a second jump is made to the beginning of the time base.

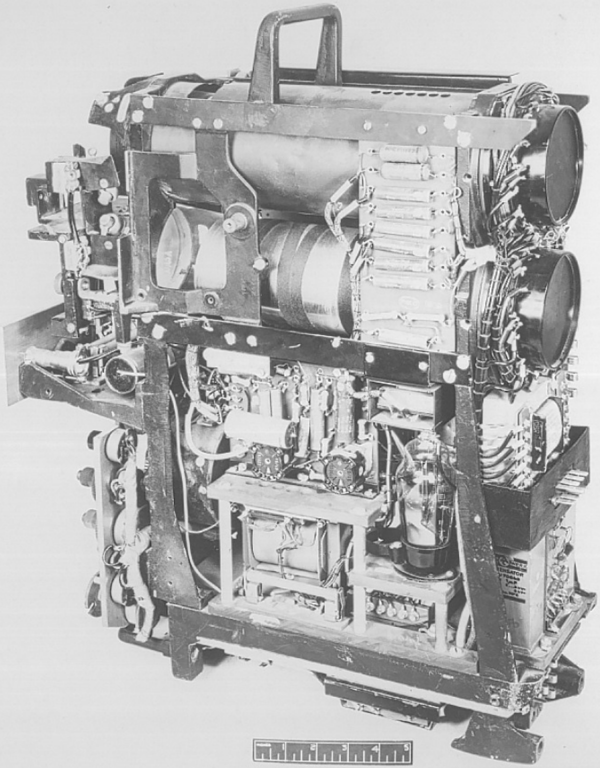


FIG. 2.

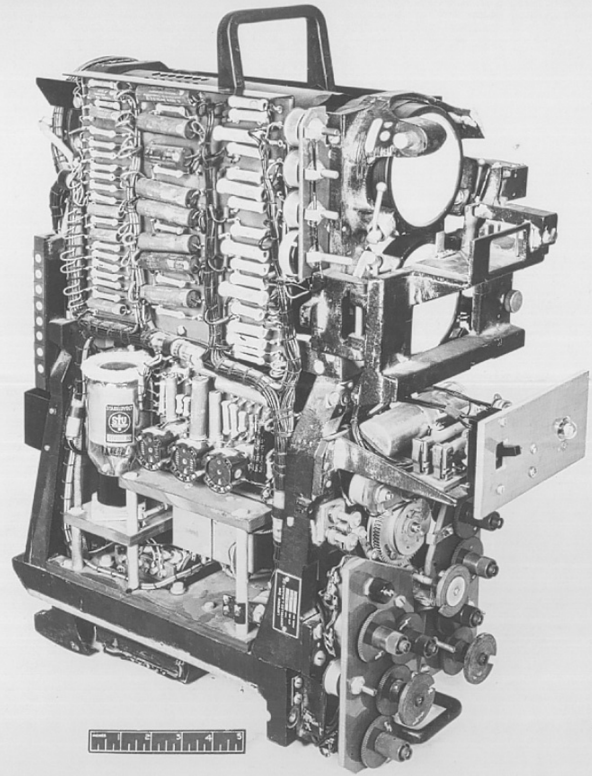
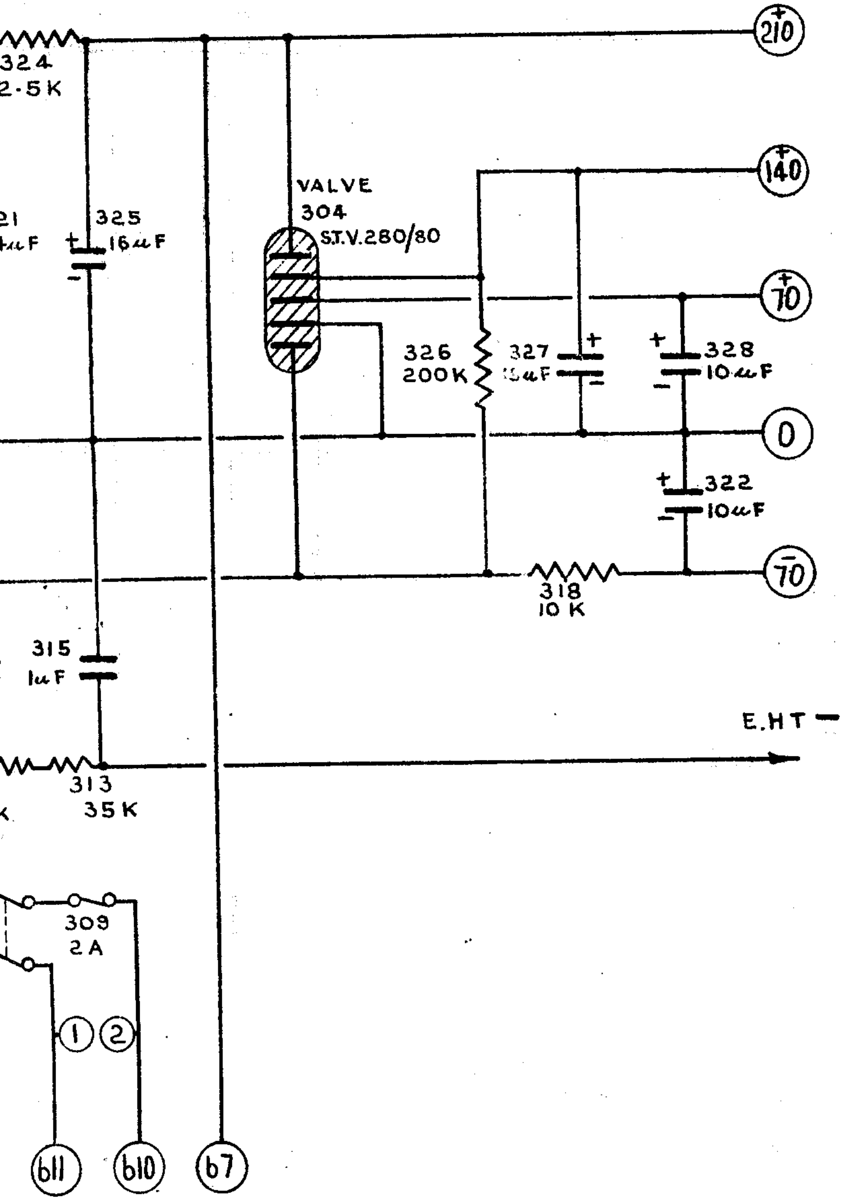


FIG.1.

Unclassified

DISPLAY UNIT TYPE NB 110.

FIGS 1 & 2

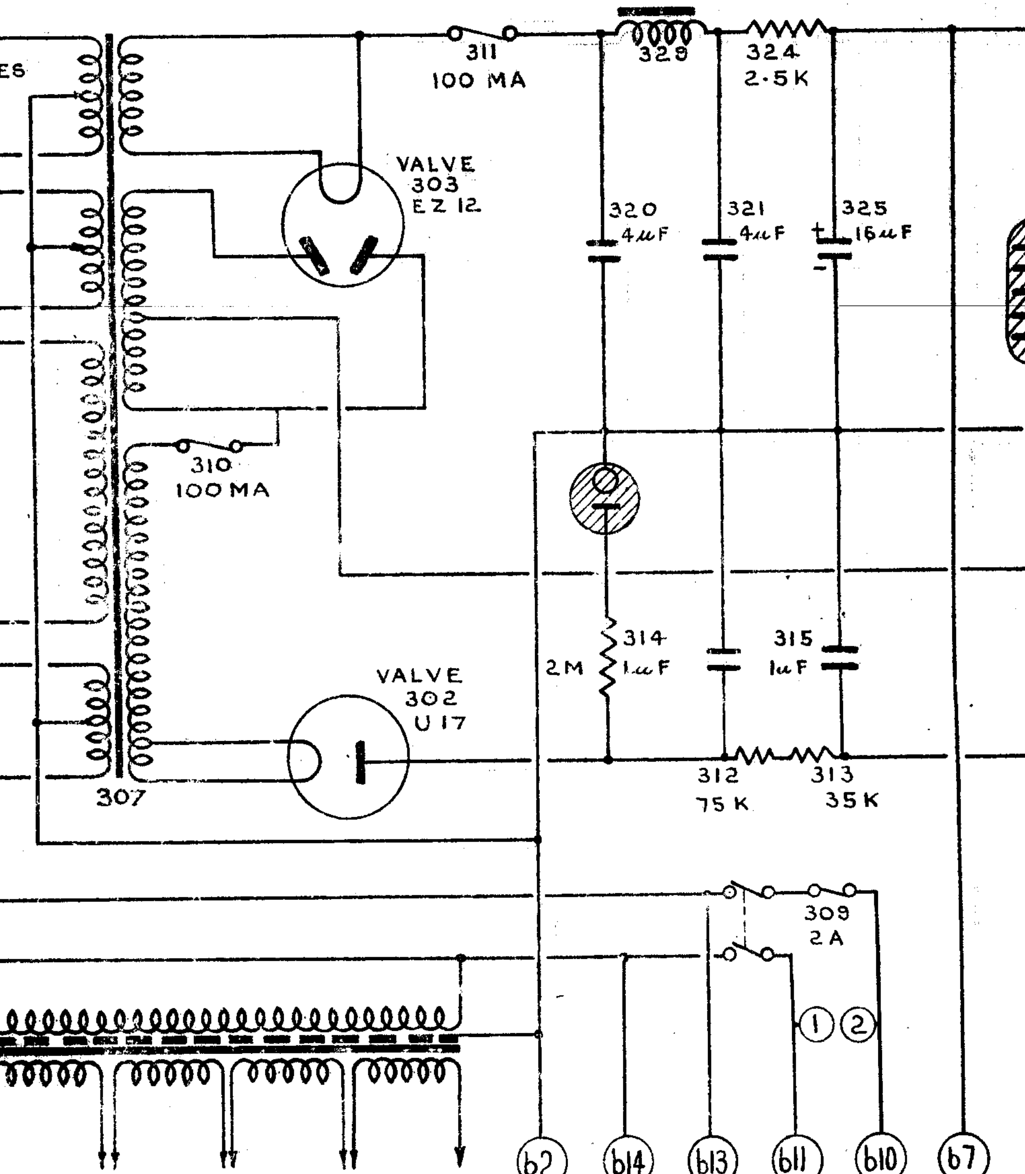


H UNIT N.B.110. (CIRCUIT DIAGRAM)

ENT.

&B) (FREYA.)

FIG. 3.
DIAG^M N^o 9916/B.



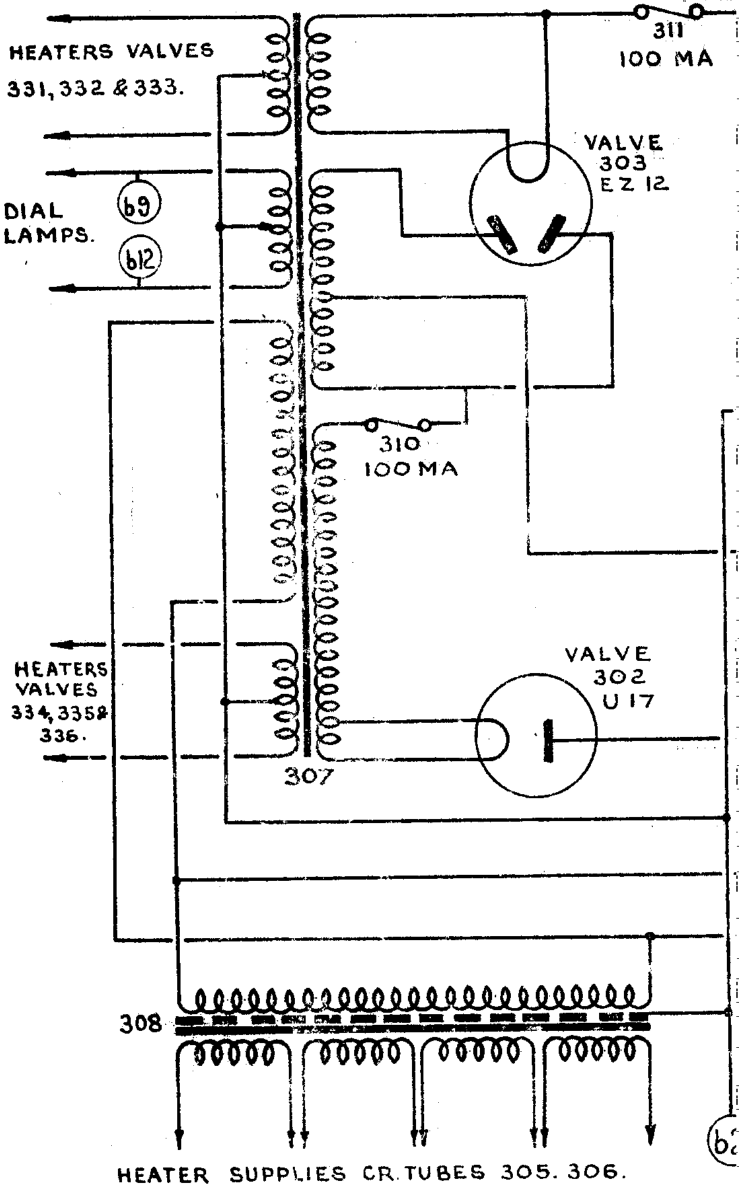
R SUPPLIES CR. TUBES 305. 306.

POWER PACK FOR MAIN PRESENTATION UNIT N.B. 110. (CIR

GERMAN GROUND RADAR EQUIPMENT.

FU. M.G (FLUM) 40G (fB) (FREYA.)

UE 1.
E:- 1-3-44.
E. 2.

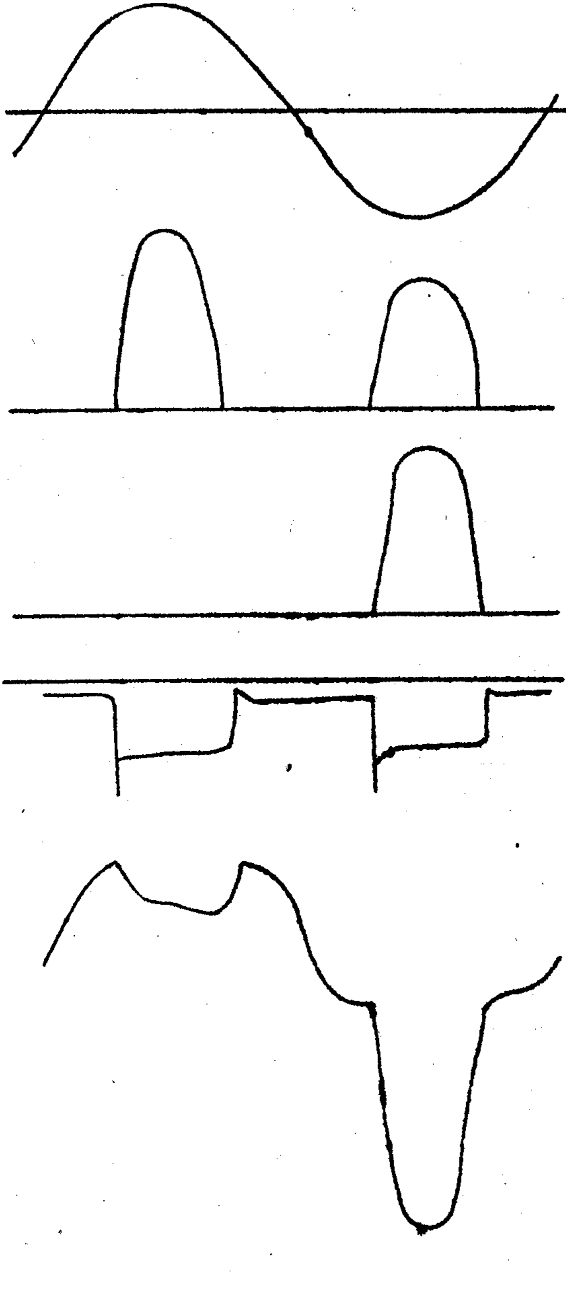


POWER PACK FOR MAIN P

GERMAN GROUND RAD

FU. M.G (

ISSUE 1.
DATE:- 1-3-44.
ISSUE . 2.

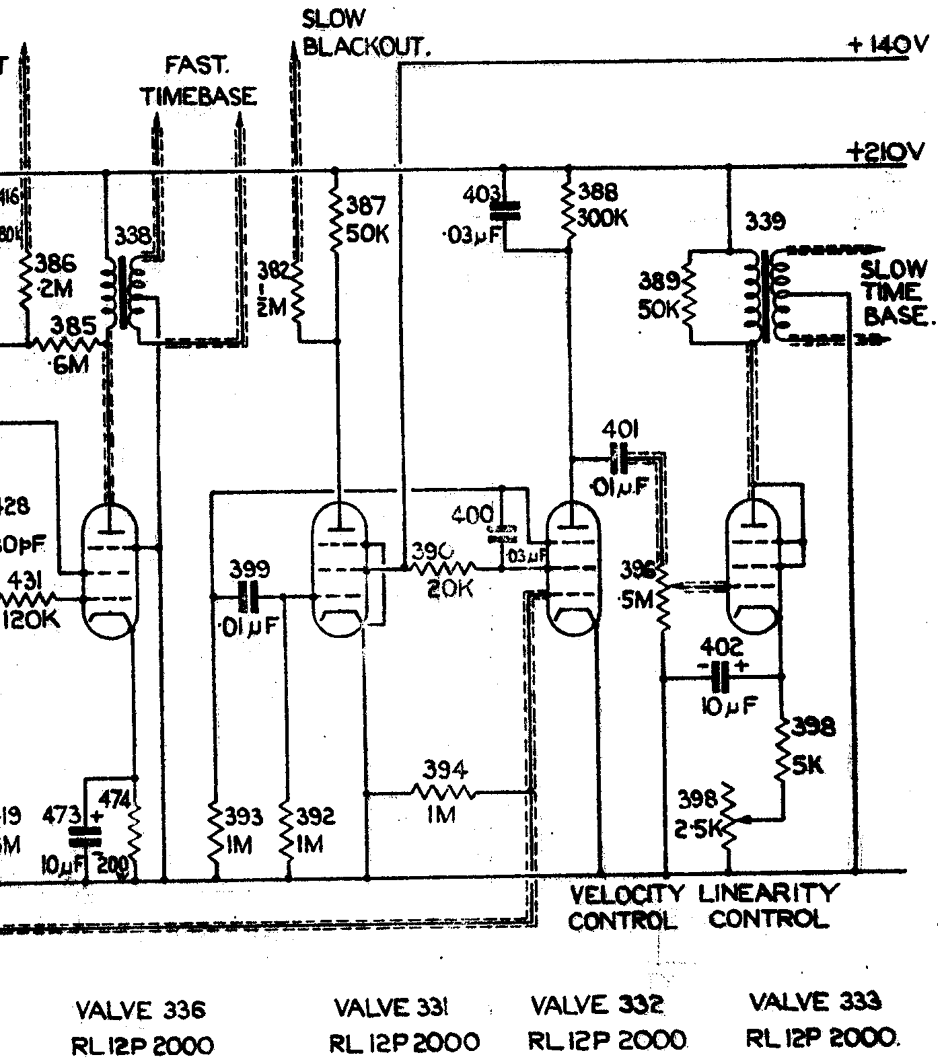


GERMAN GROUND RADAR EQUIPMENT
F.U MG: (FLUM) 40G (f8) FREYA
MAIN PRESENTATION UNIT NB 110

50 CYCLE WAVEFORMS

ISSUE Nº 1.
DATE 6/4/44
ISSUE Nº 2

FIG 4



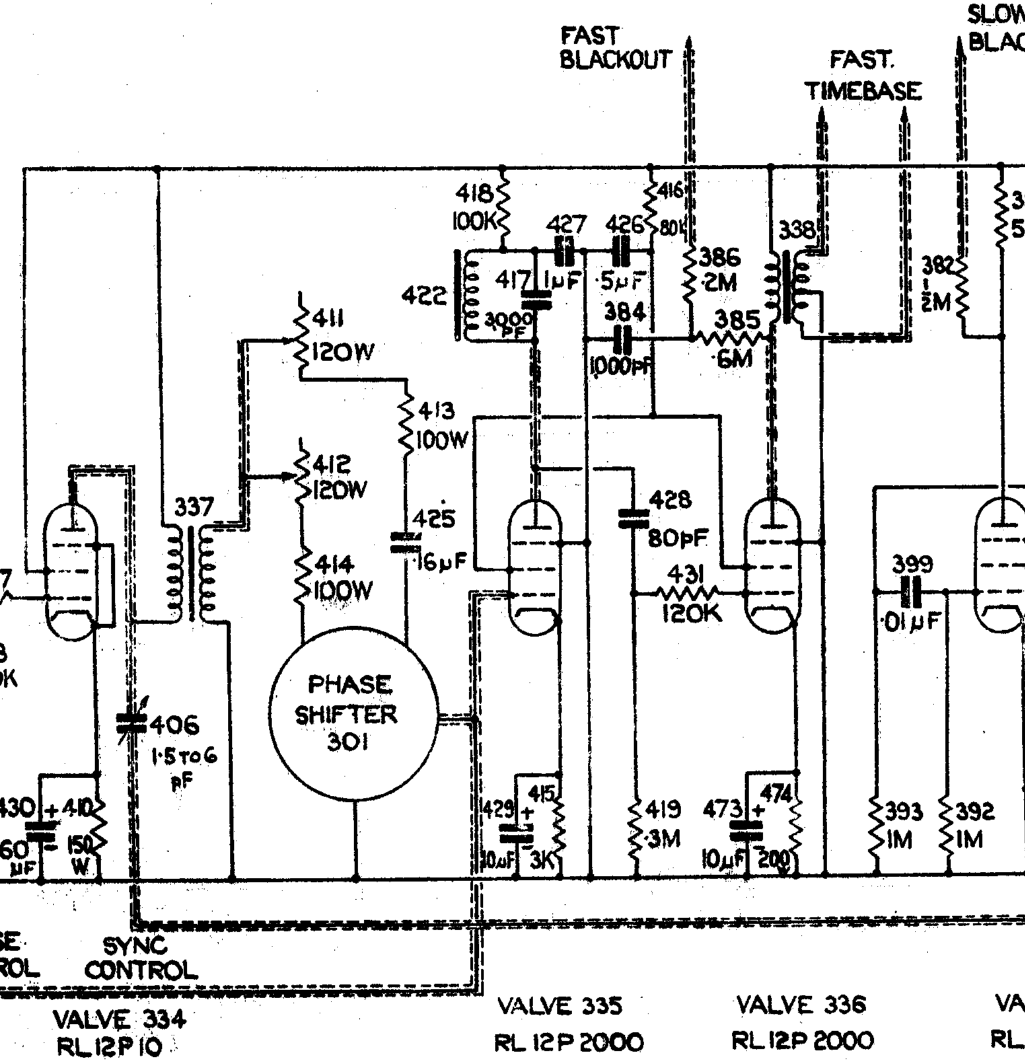
(F B) (FREYA).

DAR EQUIPMENT.

MAIN PRESENTATION UNIT. CIRCUIT DIAGRAM.

FIG. 5.

DIAG. Nº 9910/8



FU. M.G. (FLUM) 40 G (F B) (FREYA).

GERMAN GROUND RADAR EQUIPMENT.

DEFLECTION AMPLIFIER OF MAIN PRESENTATION UNIT

DR. J.S. OVER
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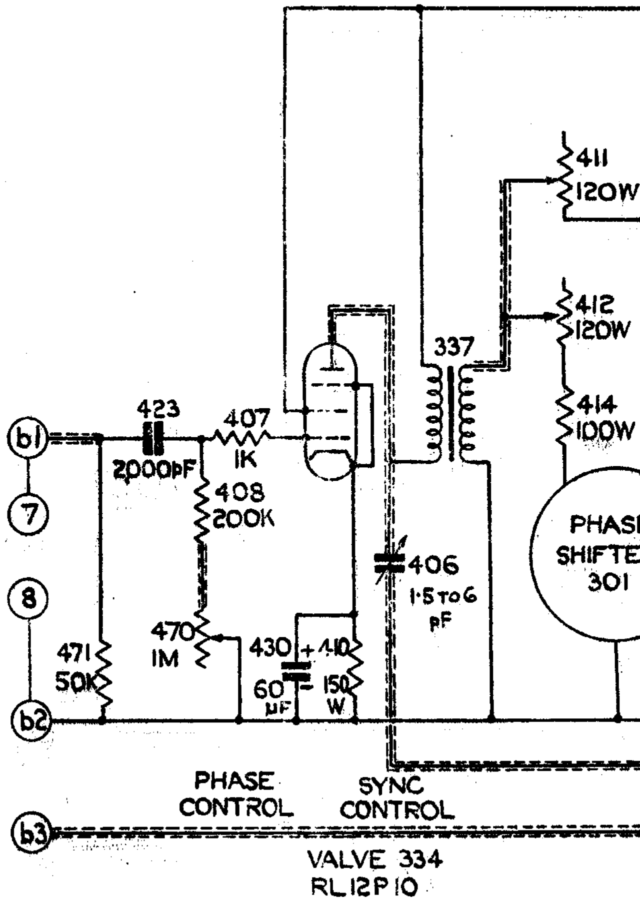
APP.



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DEFLECTIO

ISSUE 1.
DATE 1-3-44.
ISSUE 2.
DATE. 21-4-'44.

DIAG. Nº 9962/B.

TR 15.3.44

APP.

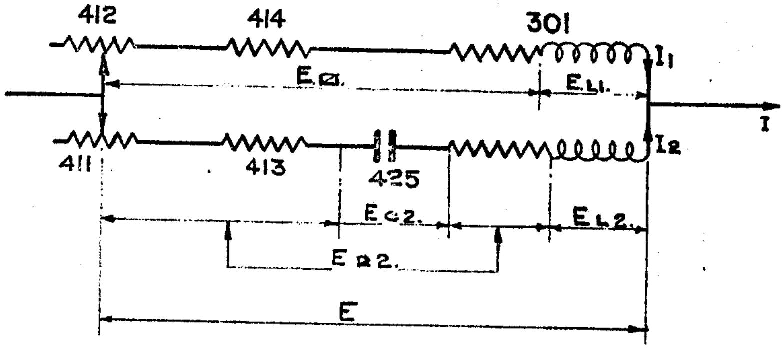
THIS DRG. IS TO BE READ IN CONJUNCTION WITH SPEC: D.C.D. W.T. 1000.

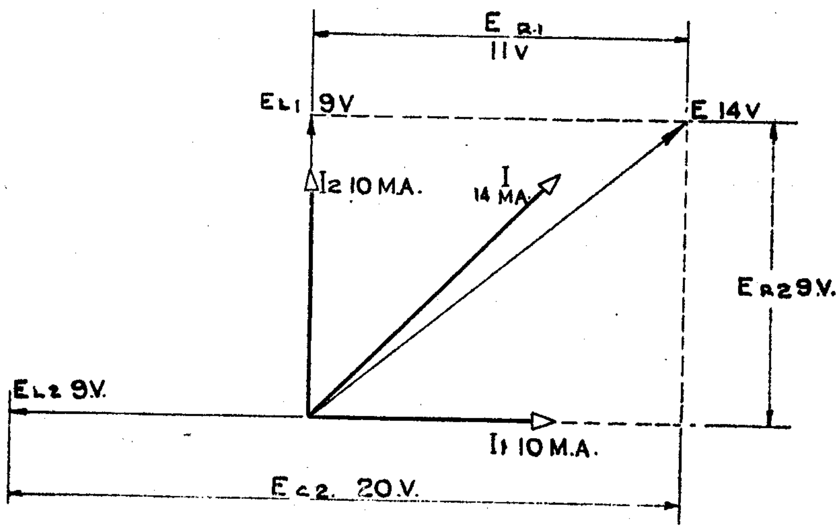
COIL 301 = ·283 H X_L = 890 Ω

COND: 425 = ·16 pF X_C = 2000 Ω

∴ R 1 = 1110 Ω

R 2 = 890 Ω



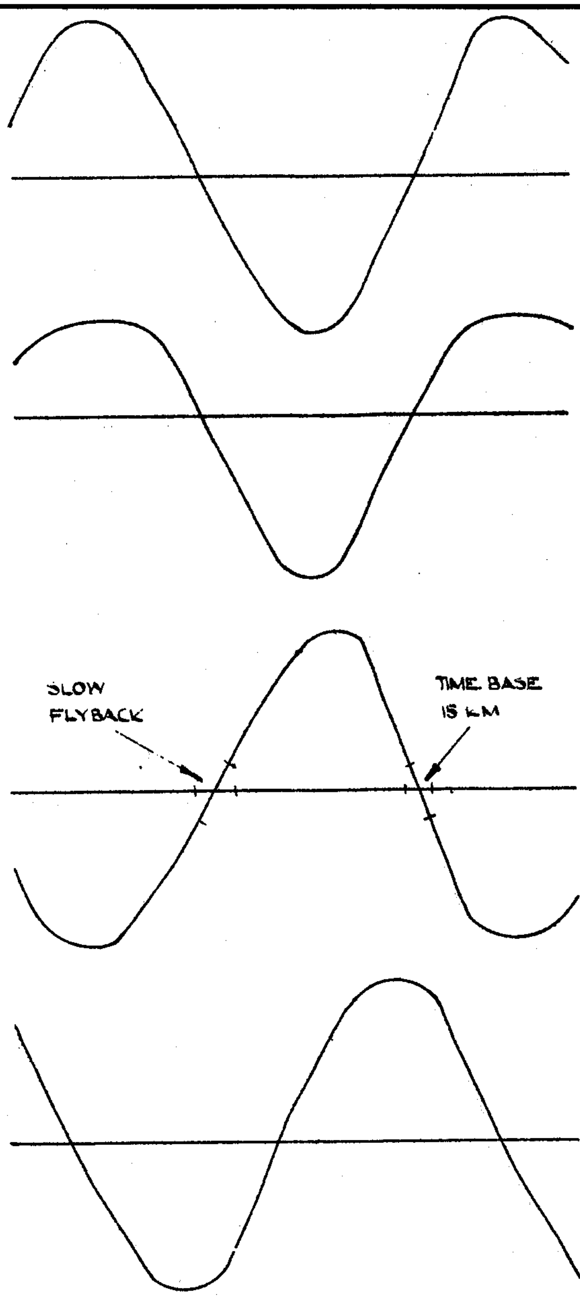


DEFLECTION AMPLIFIER OF MAIN PRESENTATION UNIT Nº 110

F.U MG (FLUM) 40 G (f B) FREYA

GERMAN GROUND RADAR EQUIPMENT.

VECTOR DIAGRAM OF PHASE SHIFTER CIRCUIT.



GERMAN GROUND RADAR EQUIPMENT
F.U MG (FLUM) 40 G (FB) FREYA)
MAIN PRESENTATION UNIT NB 113.

FAST TIMEBASE WAVEFORMS.

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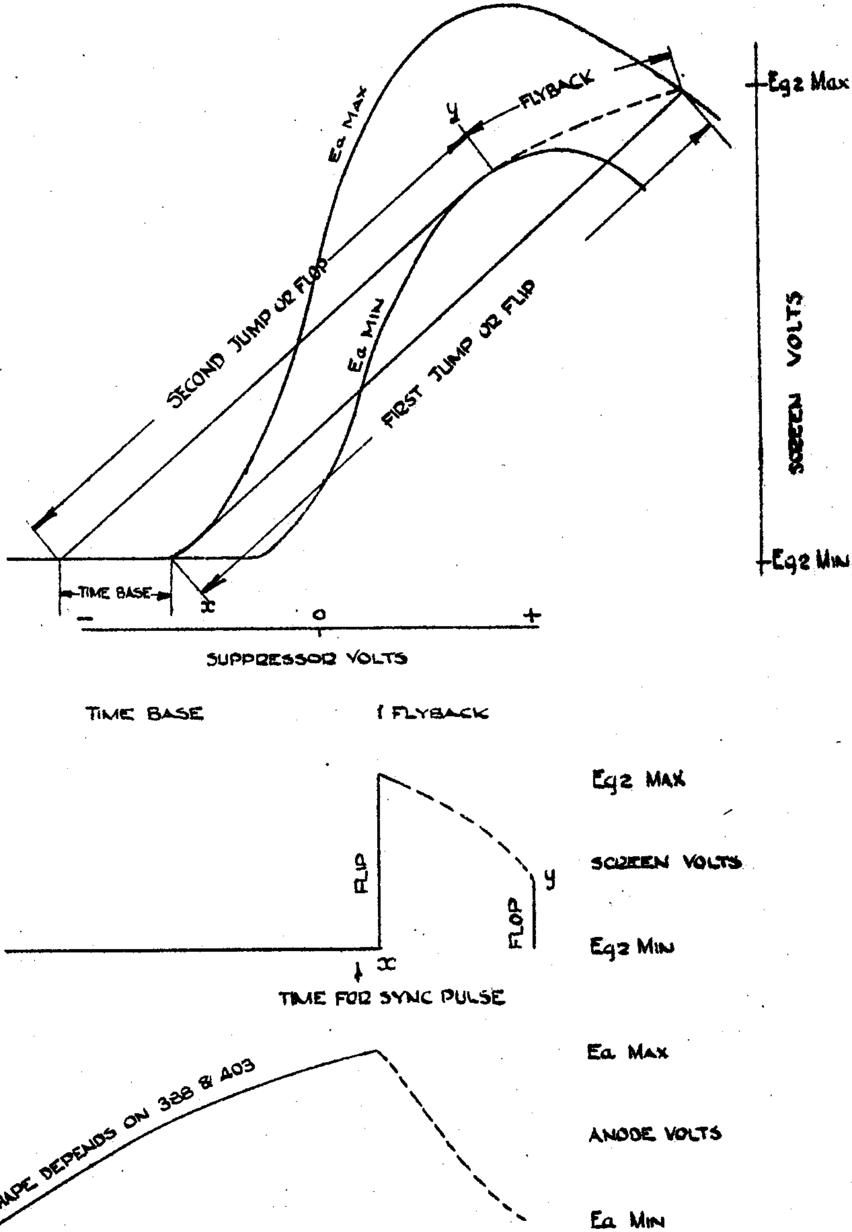
DATE 6 4 44
ISSUE Nº 2
DATE 21. 4. '44

FIG. 7.



COND. 400 DISCH. VIA RES. 393 " 403 " " 388 LOADLINE & CHAR. LOSE TOUCH AT x	400 CH. BY SUP^{R} 403 " " ANODE LOADLINE & CHAR LOSE TOUCH AT y

GERMAN GROUND RADAR EQUIPMENT

F.U.M.G (FLUM) 40G (fB) (FREYA)

MAIN PRESENTATION UNIT NB 110.

PUCKLE DIAGRAM.

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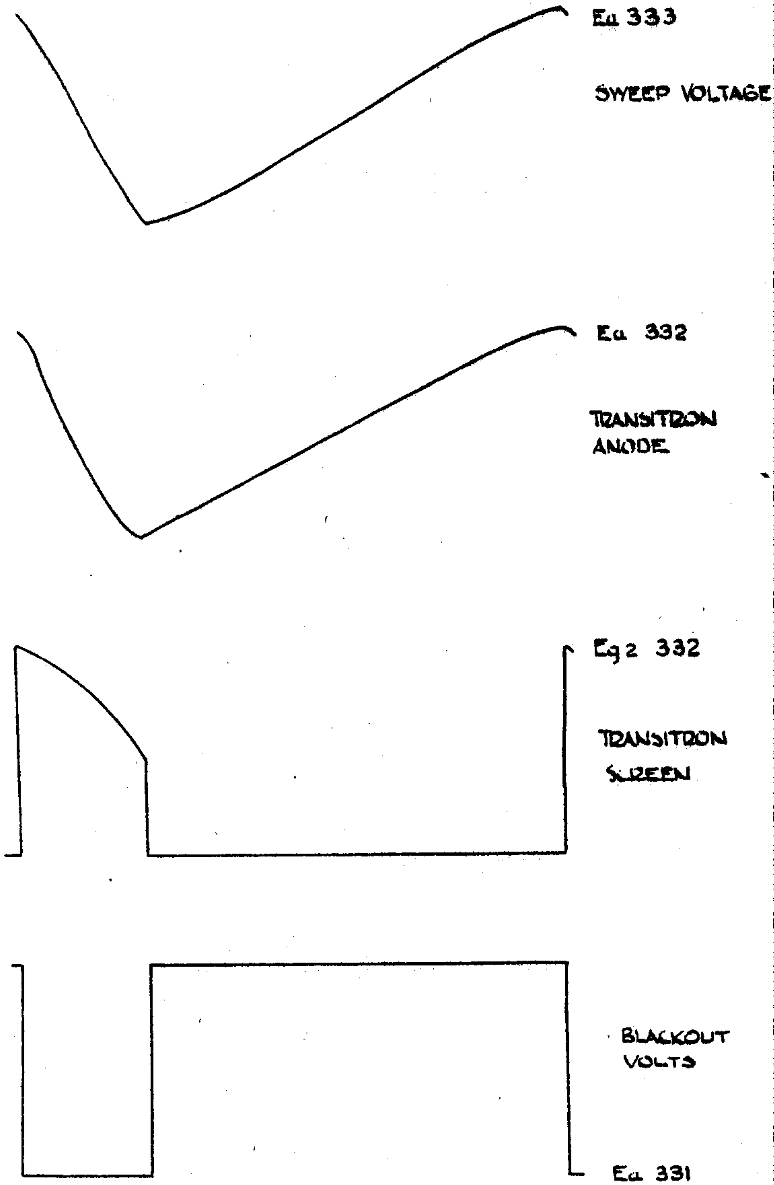
ISSUE Nº 2
DATE. 21. 4. '44

FIG. 8



GERMAN GROUND RADAR EQUIPMENT
F.U. MG. (FLUM) 40G (f8) FREYA.
MAIN PRESENTATION UNIT NB 110.

SLOW TIMEBASE WAVEFORMS.

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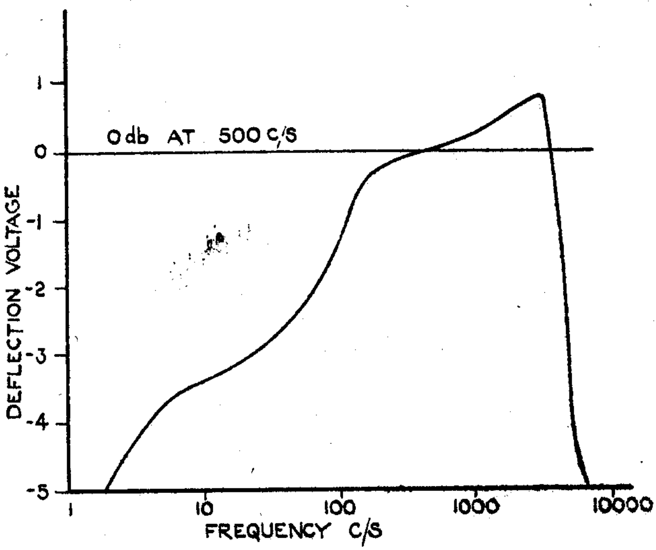
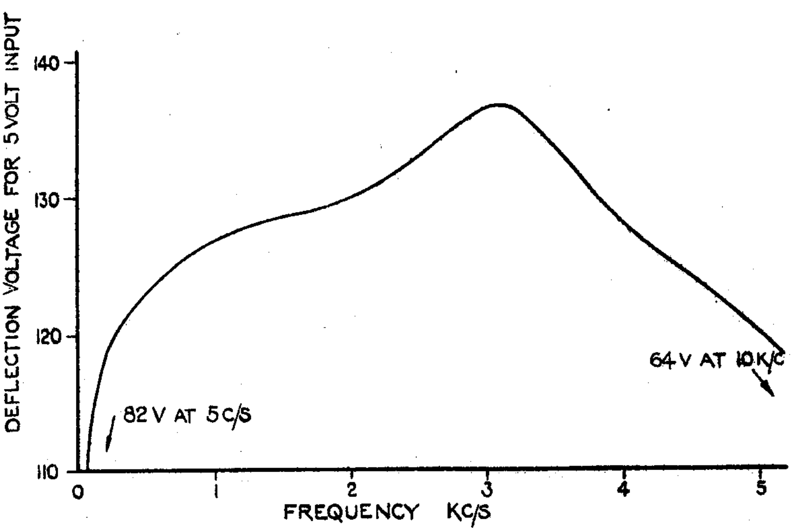
DATE 21-4-'44.

FIG. 9

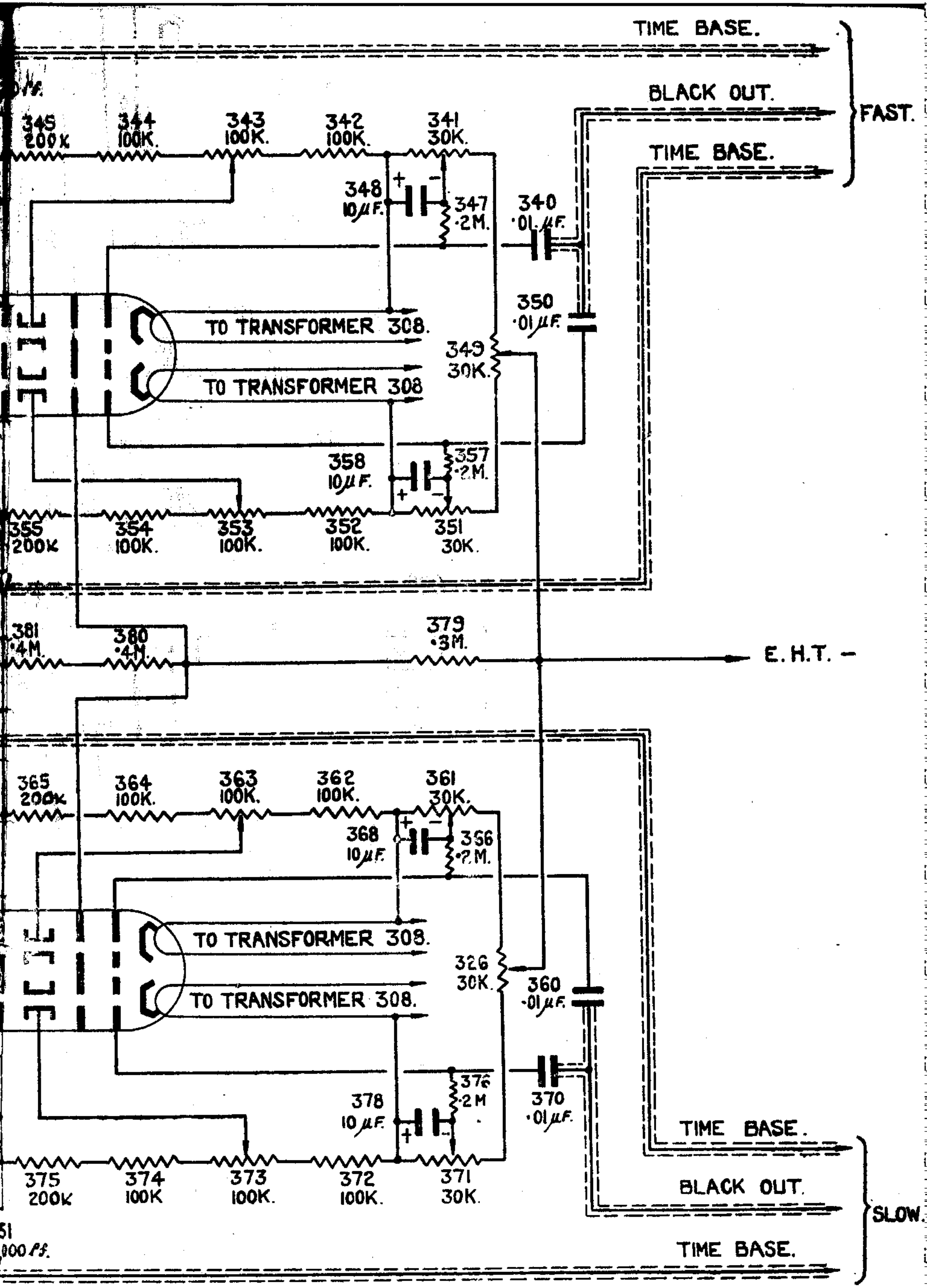




DEFLECTION AMPLIFIER OF MAIN PRESENTATION UNIT NB.11(
FU M.G. (FLUM) 40G (fB) (FREYA)
GERMAN GROUND RADAR EQUIPMENT.
PERFORMANCE OF TRANSFORMER 339 AND
ASSOCIATED COMPONENTS.

FIG. 10
DIAG. Nº 10046/6

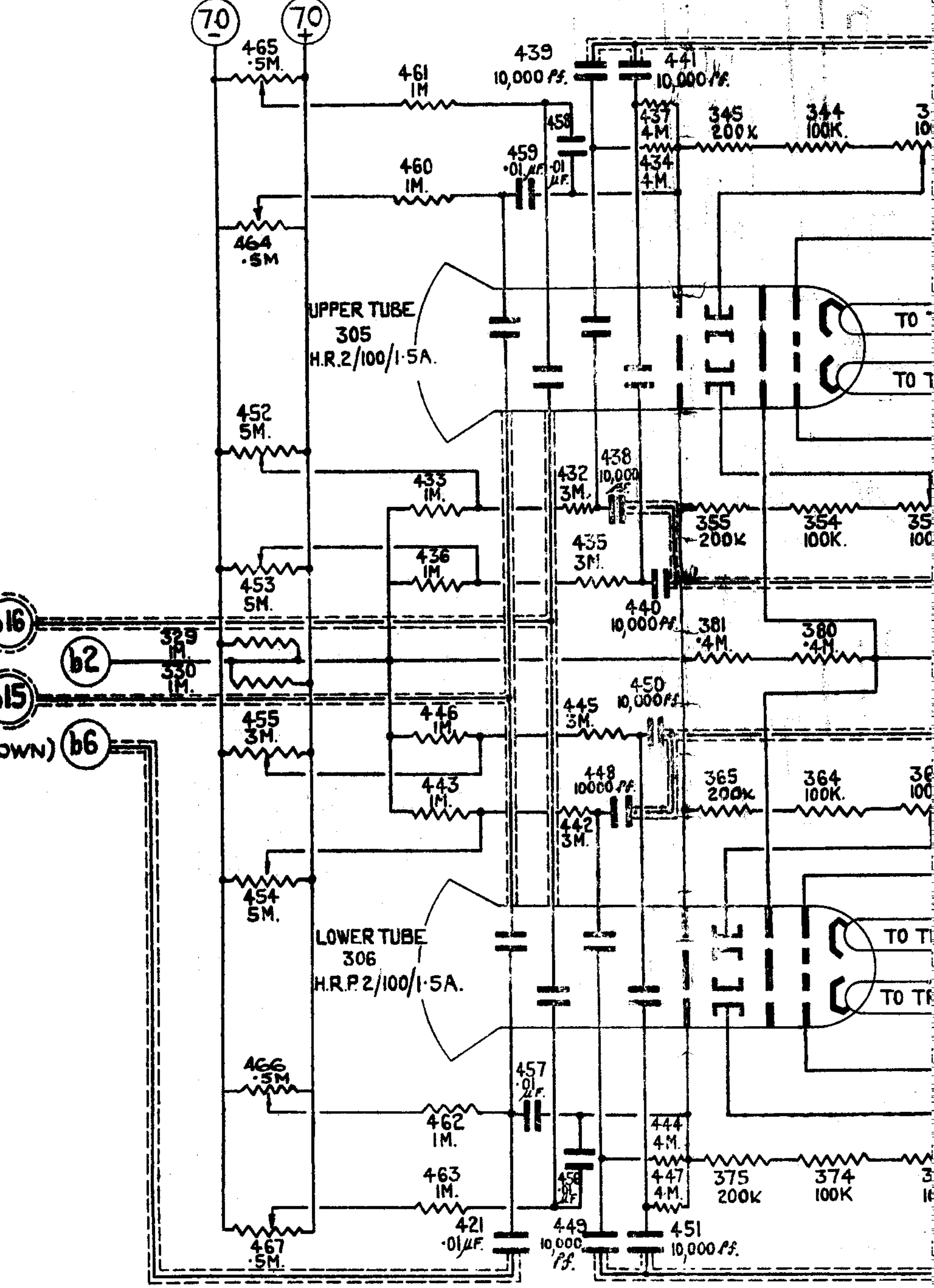
ISSUE Nº 1
DATE 22·3·44
ISSUE Nº 2.



AIN PRESENTATION UNIT N.B.110.
D RADAR EQUIPMENT.
UM) 40G (fB) FREYA.

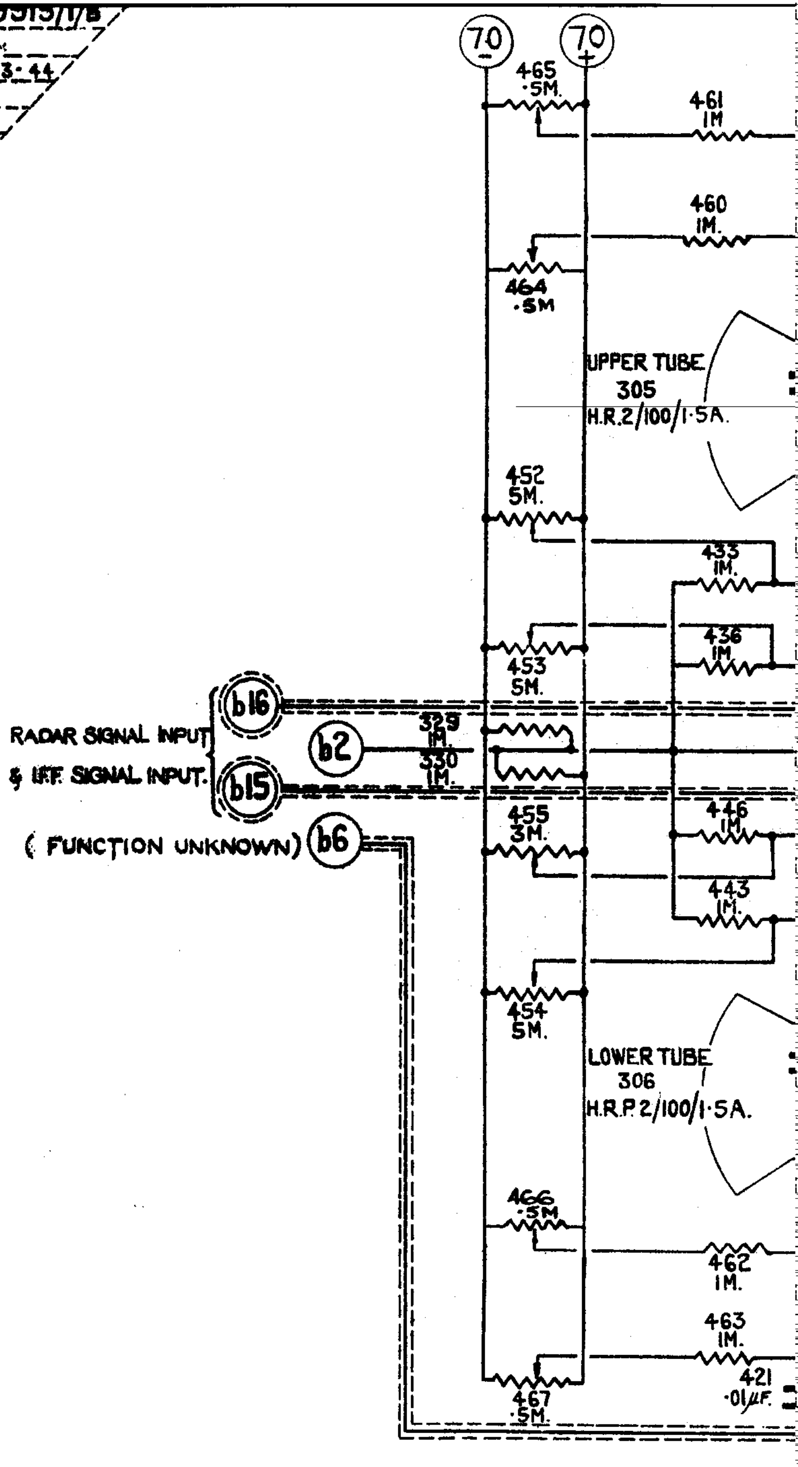
FIG. 11.

DIAG. No 9915/B. SHT.



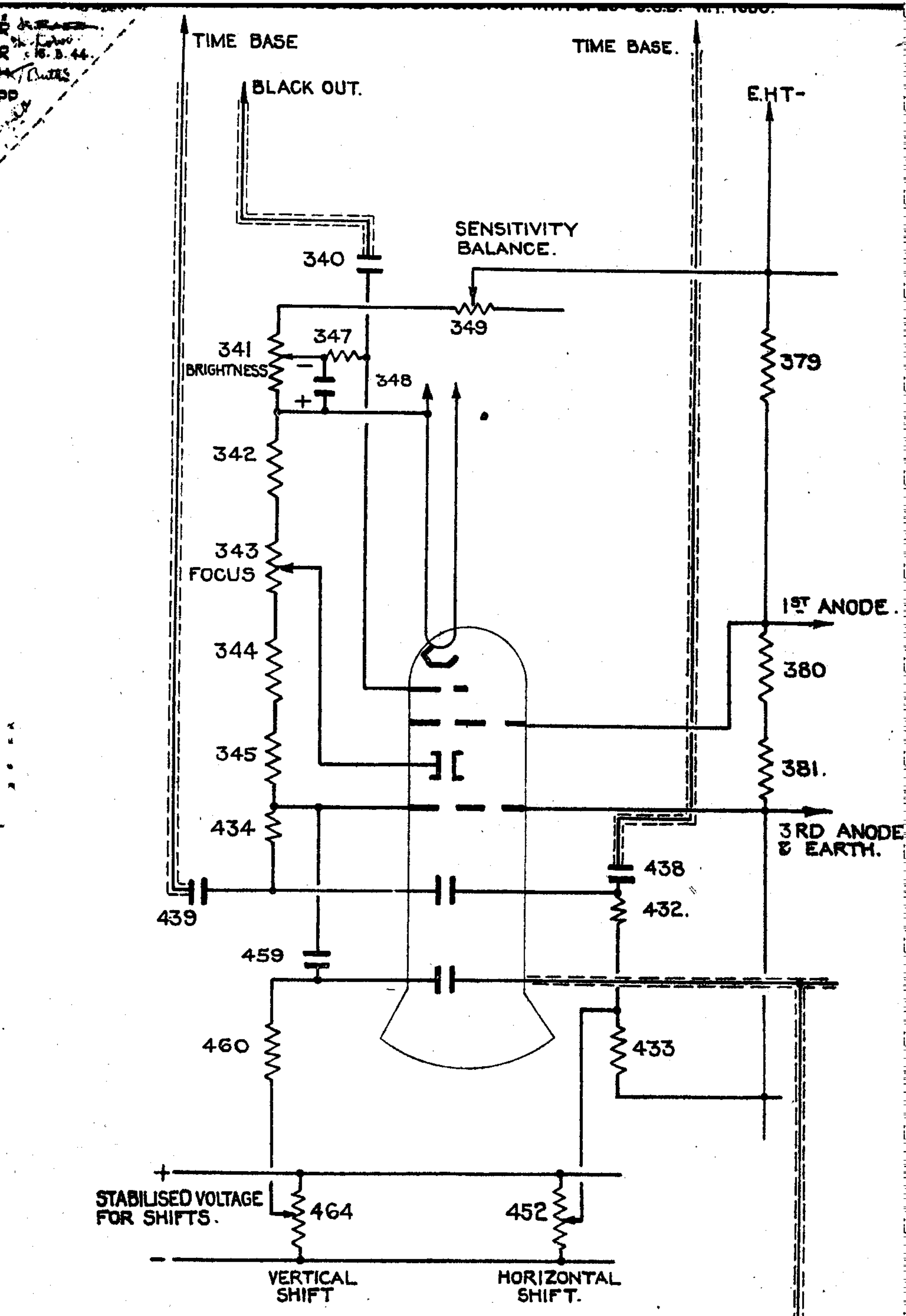
C.R.T. CIRCUIT OF MAIN PRESENTATION
GERMAN GROUND RADAR EQUIPME
F.U. MG. (FLUM) 40G (fB) FRE

DWG. Nº 5515/1/B
DR. G.[illegible]
CR. A.M. 2-3-44
CH. D.D.
APP. W[illegible]



ISSUE Nº 1.
DATE:- 29-2-44.
ISSUE Nº 2

C.R.T.
G



C.R.T. CIRCUIT OF MAIN PRESENTATION UNIT N.B.110.
F.U. M.G. (FLUM) 40 G. (f B) FREYA.
GERMAN GROUND RADAR EQUIPMENT.

Nº	TYPE.	MIN CONTACT.	SLIDER	MAX CONTACT.
349	30K TIN BACK PLATE.	MIN CONTACT OF 341.	379 F	MAX CONTACT OF 351.
353	100K TIN BACK PLATE.	352 F	A	354 F
343	100K TIN BACK PLATE.	344 F	B	342 F
396	500K BAKELITE BACK.	EARTH	E	G
373	100K TIN BACK PLATE.	372 F	C	374 F
363	100K TIN BACK PLATE.	364 F	D	362 F
326	30K BAKELITE BACK.	MIN CONTACT OF 361	379F	MAX CONTACT OF 371.
351	30K 358 F.	358 F	358B	MAX CONTACT OF 349
341	30K TIN BACK PLATE.	MIN CONTACT OF 349	348B	348 F.
470	1 M BAKELITE BACK.	F	EARTH	——
371	30K TIN BACK PLATE.	378 F	378B	MAX CONTACT OF 326
361	30K TIN BACK PLATE	MIN CONTACT OF 326	368 B	368 F.
452	·5M BAKELITE BACK.	329 F.	432 F	330 F
453	·5M BAKELITE BACK.	329 F	435F	330F
454	·5M BAKELITE BACK.	329 F	442F	330F
455	·5M BAKELITE BACK.	329 F	445 F	330 F
464	·5M BAKELITE BACK.	329F	460F	330F
465	·5M BAKELITE BACK.	329 F	461 F	330 F
466	·5M BAKELITE BACK.	329F	462 F	330 F
467	·5M BAKELITE BACK.	329F	463F	330F
398	2·5K BAKELITE BACK.	EARTH	398/5K	——
411	120 Ω 1/10 WATT.	413 F	337	——
412	120 Ω 1/10 WATT.	414B	337	——

NOTES.

(1) F = FRONT END OF COMPONENTS } ALL THESE COMPONENTS ARE ON THE LARG
B = BACK END OF COMPONENTS } PANEL AT TOP OF LEFT SIDE OF APPARATUS

(2) 398 IS BELOW LEFT HAND VALVE PANEL.

(3) 411. 412. ARE ON RIGHT HAND VALVE PANEL.

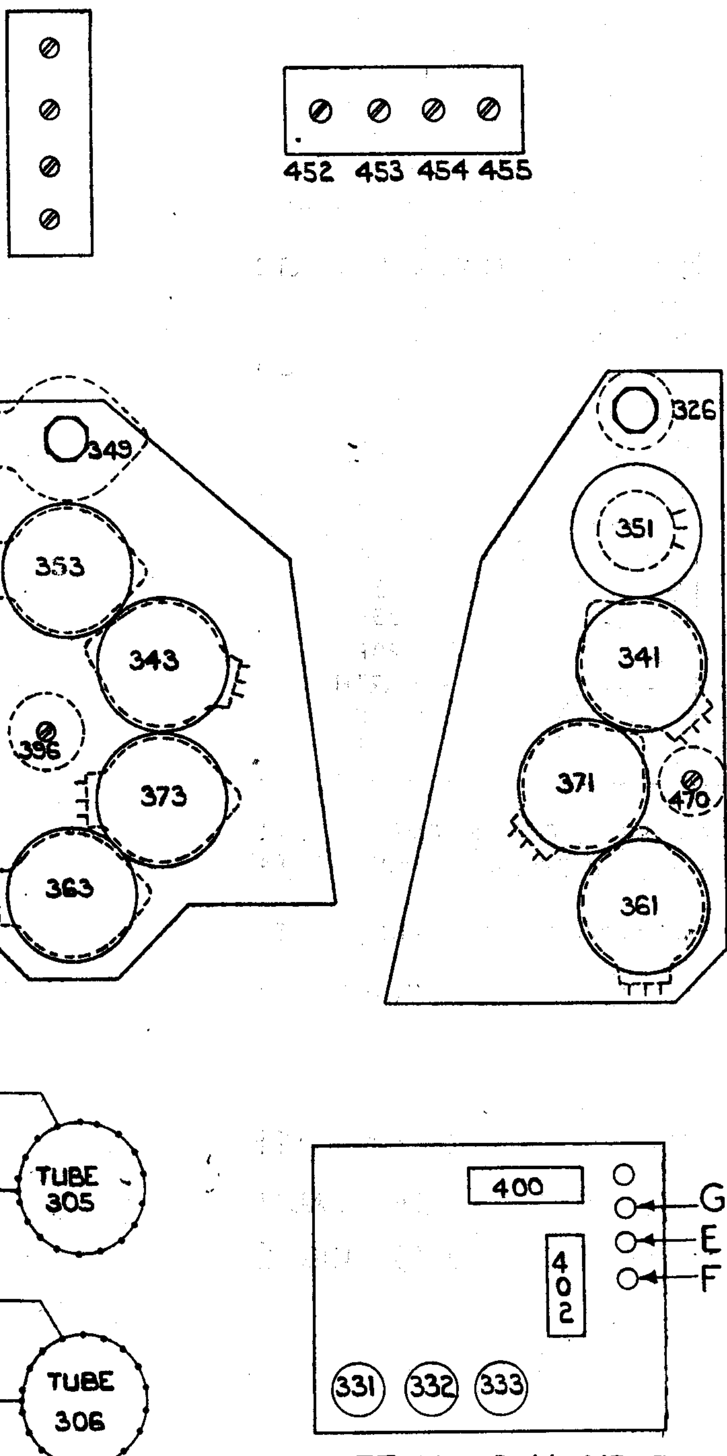
POTENTIOMETERS OF MAIN PRESENTATION UNIT N.B.110.

GERMAN GROUND RADAR EQUIPMENT

FU. MG. (FLUM) 40G (f B) FREYA.

FIG. 13.

DWG. Nº 9961/8



LEFT HAND VALVE PANEL.

Nº	TYPE
349	30K TIN
353	100K TIN
343	100K TIN
396	500K BA
373	100K TIN
363	100K TIN
326	30K BAK
351	30K 358
341	30K TIN
470	1 M BA
371	30K TIN
361	30K TIN
452	·5M BAK
453	·5M BAK
454	·5M BAK
455	·5M BAK
464	·5M BAK
465	·5M BAK
466	·5M BAK
467	·5M BAK
398	2·5K BAK
411	120 Ω ½c
412	120 Ω ½c

NOTES.

(1) F = FRONT
B = BACK

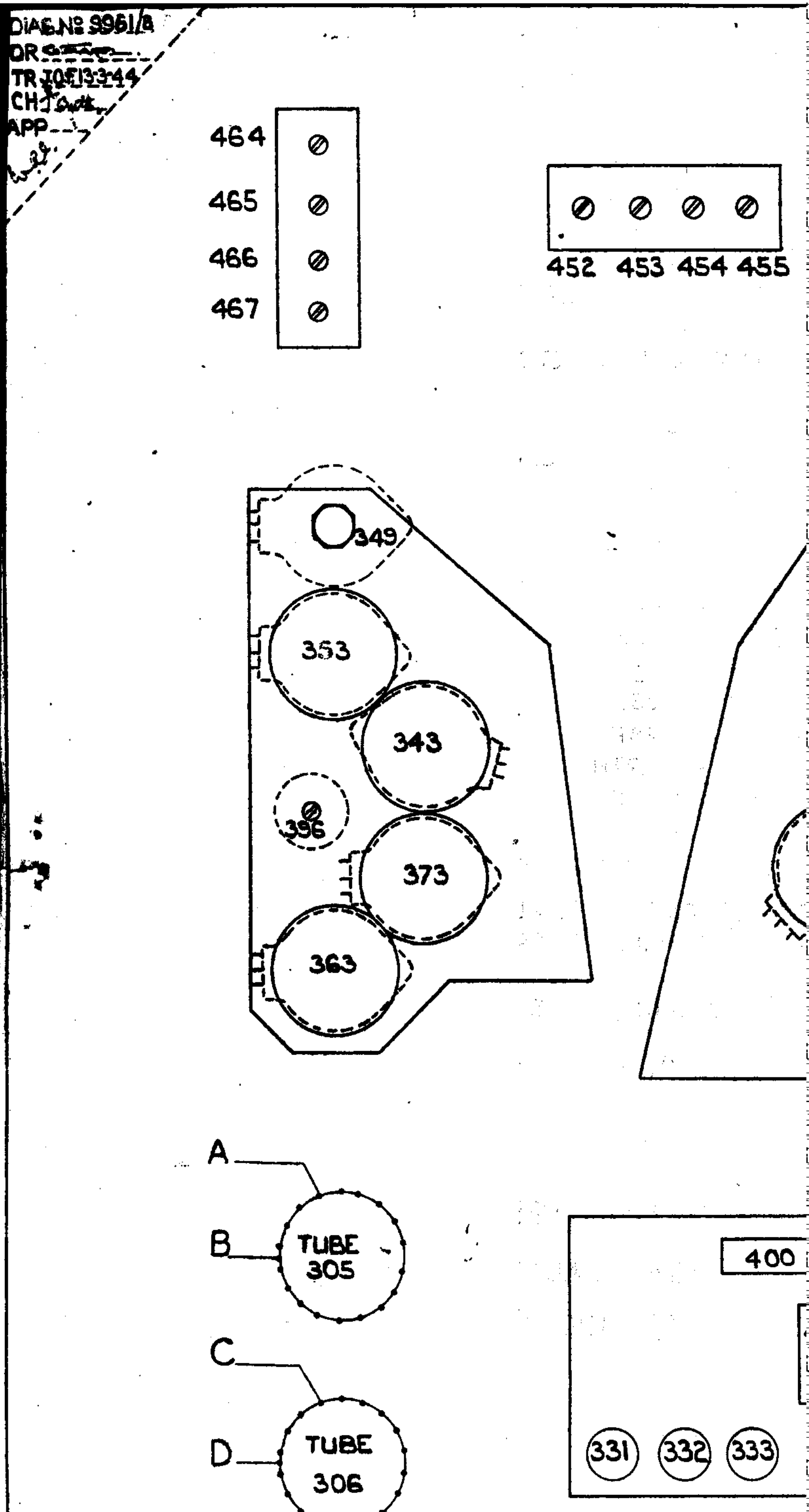
(2) 398 IS BE

(3) 411. 412. A

POTENTIOM

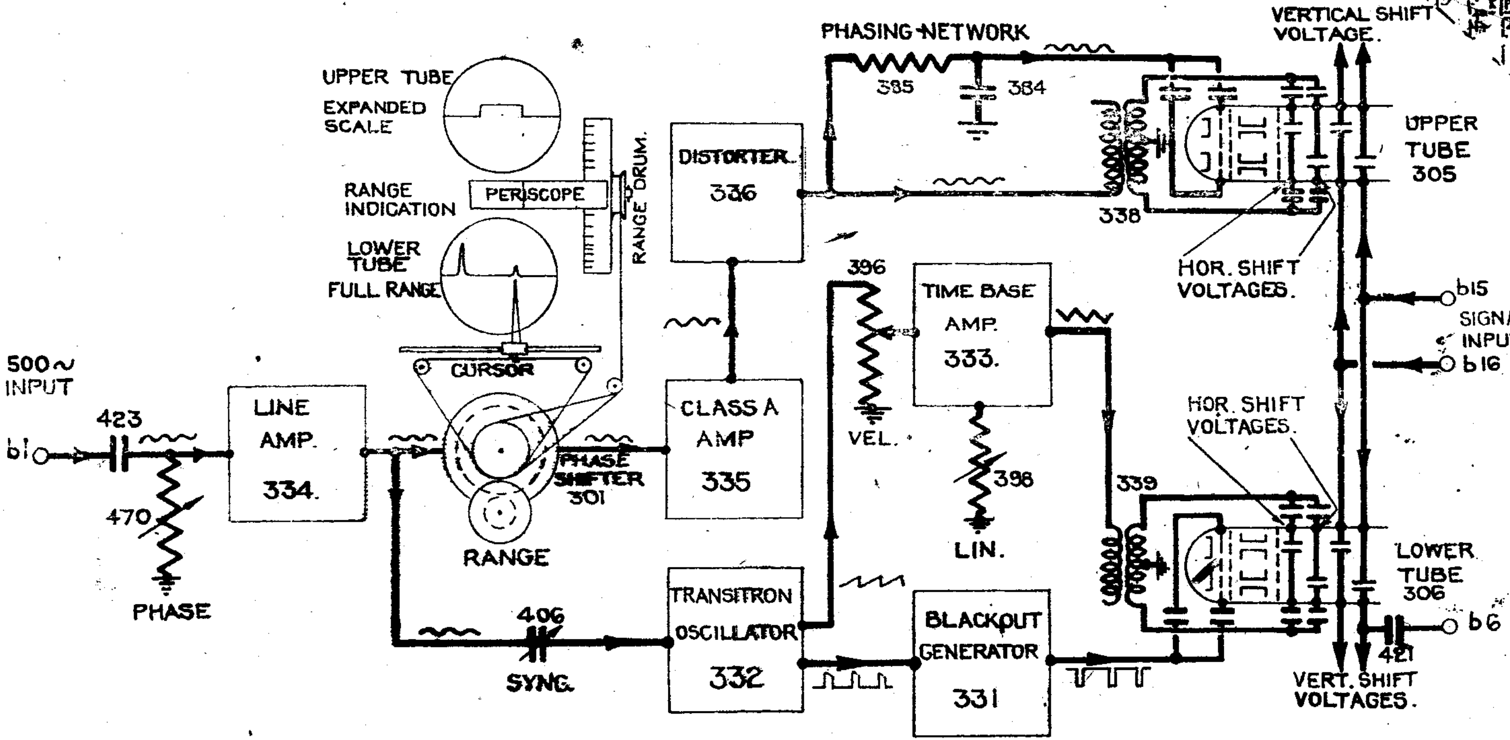
GERM

FU.


DIAG. Nº 9961/8
DR
TR
CH
APP
464
465
466
467
452 453 454 455
349
353
343
396
373
363
A
B
TUBE 305
C
D
TUBE 306
400
331
332
333

LEFT HAND V

ISSUE Nº I



GERMAN GROUND RADAR EQUIPMENT,
FU. M.G. (FLUM.) 40 G. (f B) (FREYA)
MAIN PRESENTATION UNIT N.B 110
BLOCK SCHEMATIC.

DIAG. Nº 10186/B