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TECHNICAL INSTRUCTIONS

DESCRIPTION TELS. R. 05

EQUIPMENT RADAR I.F.F. MK. III

(FOR A.A. No. 1 Mk. II)

DISTRIBUTED AND ACCOUNTED FOR BY C.G.S., G.S.I. (x) (iv-A), G.H.Q. (I), NEW DELHI

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EQUIPMENT RADAR I.F.F. Mk. III (FOR A.A. No. 1, Mk. II)

Description and Function

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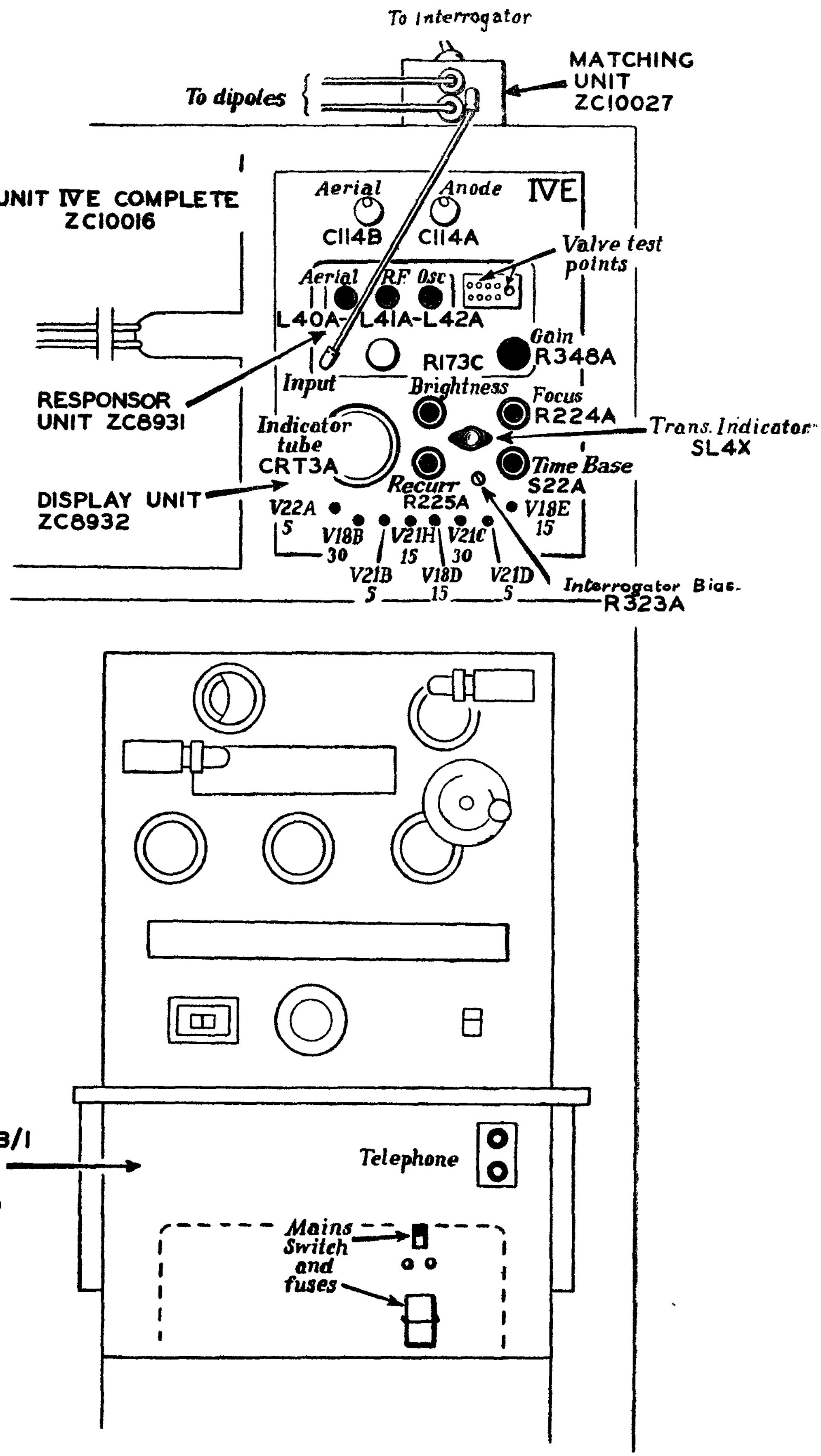

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FIG. 1 FRONT VIEW OF AA. No. 1 Mk. II RECEIVER SHOWING LOCATION OF I.F.F. Mk. III.

GENERAL DESCRIPTION OF APPARATUS AND ITS FUNCTION

1. The equipment consists of the following units :—

(*a*) A special directional aerial system for transmission and reception.

(*b*) An ultra-short wave transmitter covering a range of 157 to 187 Mc/s (1·911 to 1·604 metres). This is named the Interrogator Unit.

(*c*) An ultra-short wave receiver covering a similar range to the transmitter. This is named the Responsor Unit.

(*d*) A cathode ray tube for the observation of received signals, a transmitter indicator incorporated with interlocked modulating equipment for the transmitter, and a time-base generator for the cathode ray tube. All these are incorporated in the Display Unit.

(*e*) A Coupling Unit for taking a selector or strobe voltage from the A.A. No. 1, Mk. II receiver for synchronising purposes.

(*f*) The necessary Power Unit, switching and subsidiary arrangements (Fuse Panel Assembly) for the above.

2. The function of the equipment (for which a separate operation instruction book exists) is briefly as follows :—

The object of the I.F.F. equipment is to "interrogate" targets located by the A.A. No. 1, Mk. II equipment for the purpose of establishing their identity.

Accordingly, an entirely separate signal is radiated towards the location of the target aircraft by directive aerials mounted on the A.A. No. 1, Mk. II receiver. These signals, on reaching an aircraft fitted with the complementary responder apparatus, return an answering signal which is received on the same directional aerial as that used for transmission, and interpreted by the receiving equipment Display Unit.

3. To ensure that signals received and read on the Display Unit are only those from the location of the A.A. No. 1, Mk. II. target, a very directional aerial system is employed, mounted on the A.A. No. 1, Mk. II receiver so that it rotates with it, and thus always points in the right direction. To ensure that the signals received are from the same range as the A.A. No. 1, Mk. II target, the transmitted interrogator pulses are timed by the "locking" pulse from the A.A. No. 1, Mk. II transmitter to occur at the same time as (or just a little after) the pulses sent from the A.A. No. 1, Mk. II transmitter. Actually, the recurrence frequency of the pulses is less than that of the A.A. No. 1, Mk. II transmitter, but the timing of them is always approximately coincidental.

Further, the strobe pulse from the A.A. No. 1, Mk. II receiver is used to start the horizontal time base of the indicator tube in the receiving equipment (Display Unit). It therefore follows that, of the signals received and fed continuously to the vertical deflection plates of the C. R. tube, only those will be seen which come from aircraft in the same line of sight as, and at ranges equal to or greater than, the aircraft on which the A.A. No. 1, Mk. II receiver, is strobed. Moreover, if the target is kept continuously on the cross wire on the range tube of the A.A. No. 1, Mk. II receiver, this target will remain stationary on the Display Unit C. R. tube in the I.F.F. equipment.

Power Requirements

4. The complete equipment is operated from the 220V 50 cycle supply which operates the A.A. No. 1, Mk. II receiver. The consumption is of the order of 1·0 amp. The safety device, in the form of gate switches which cut off the supply to H. T. units in the main Receiver, has been adapted so that the section IV gate switch also protects the equipment in the upper rack.

Arrangement of Units

5. The equipment has been allocated unit numbers which follow the scheme already in use for the main

A.A. No. 1, Mk. II receiver equipment. The various units are as follows :—

UNIT NO.	CIRCUIT FIG. NO.	DESCRIPTION	REMARKS
IB/47 (ZC 10018)	7	Coupling Unit. RADAR No. 1	Picks up and converts to low impedance a Signal Selector voltage from Unit IB in main equipment.
IVB/1 (ZC 10017) IVB/2 (ZC 10019)	10 10	Power Unit Fuse Panel Assembly }	Contains four separate power supplies for Interrogator, Responsor, C. R. tube (high voltage), and Display Unit.
IVE (ZC 10016) Consisting of :— IVE/3 (ZC 8930) IVE/1 (ZC 8931) IVE/2 (ZC 8932)	 5 12 9	 Interrogator Responsor Display Unit }	These three units together form IVE. The Display Unit incorporates the indicator tube.
ZC 10027	5	Matching Unit RADAR No. 1	Aerial matching transformer.
ZC 10026	5	Aerial Units, RADAR No. 1	Two complete aerial arrays with support frames etc.

Circuits and Coding

6. The circuit diagrams and coding of components and terminal numbers follow the same practice as that adopted in D. M. E. (I) T. I. Description Tels. R. 08. All terminals for inter-connexions are numbered in the circuit diagrams, all corresponding numbers on different units being connected together. A diagram (fig. 14) s provided showing the actual wiring of the cable-form which connects the various units together. This is provided for the purpose of checking up the continuity of the various wires.

7. Components are coded by numbers which refer to a particular value and different suffix letter each time the particular component occurs. For example R201 is always a 1,000 ohms $\frac{1}{4}$ watt resistor, but it may occur several times in the circuit, and we find R201A, R201B, R201C etc. *Both terminal numbers and component numbers follow on in sequence those used in D. M. E. (I) T.I. Description Tels. R. 08.*

8. Resistances are coded in the standard colour code as follows :—

BODY AND END COLOURS OR FIRST AND SECOND HAND (1st. AND 2nd. FIGURES)	SPOT COLOURS OR THIRD BAND (ADDITIONAL o'S)	FOURTH BAND (LIMITS)
0 Black	·0 Black	± 1 per cent. Brown.
1 Brown	0· Brown	± 2 per cent. Red.
2 Red	00· Red	± 5 per cent. Gold or Green.
3 Orange	000· Orange	± 10 per cent. None.
4 Yellow	0,000· Yellow . . .	± 20 per cent. Silver.
5 Green	00,000· Green.	
6 Blue	000,000· Blue	
7 Violet		
8 Grey		
9 White		

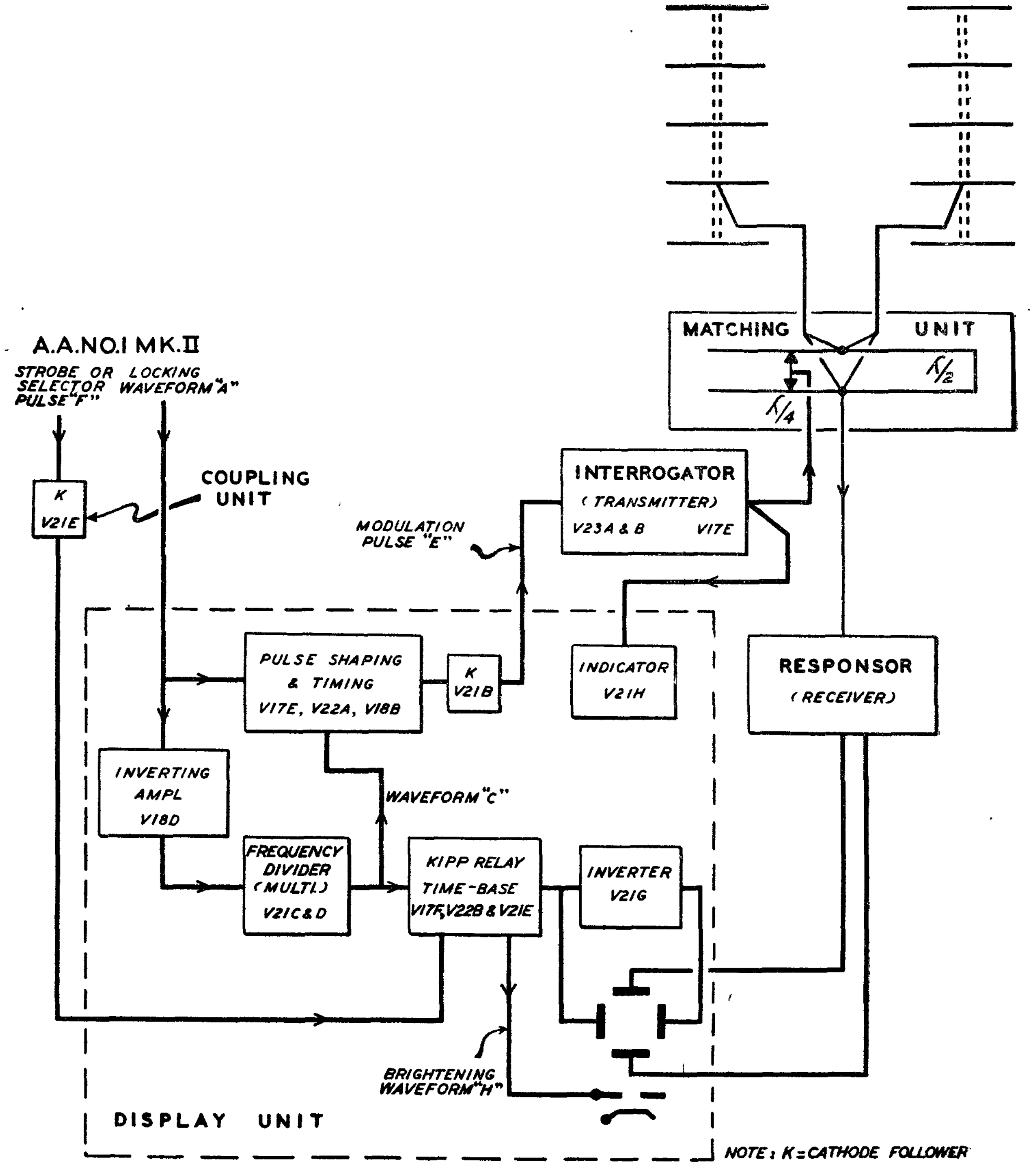

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FIG. 2 BLOCK DIAGRAM OF I.F.F. Mk.III EQUIPMENT

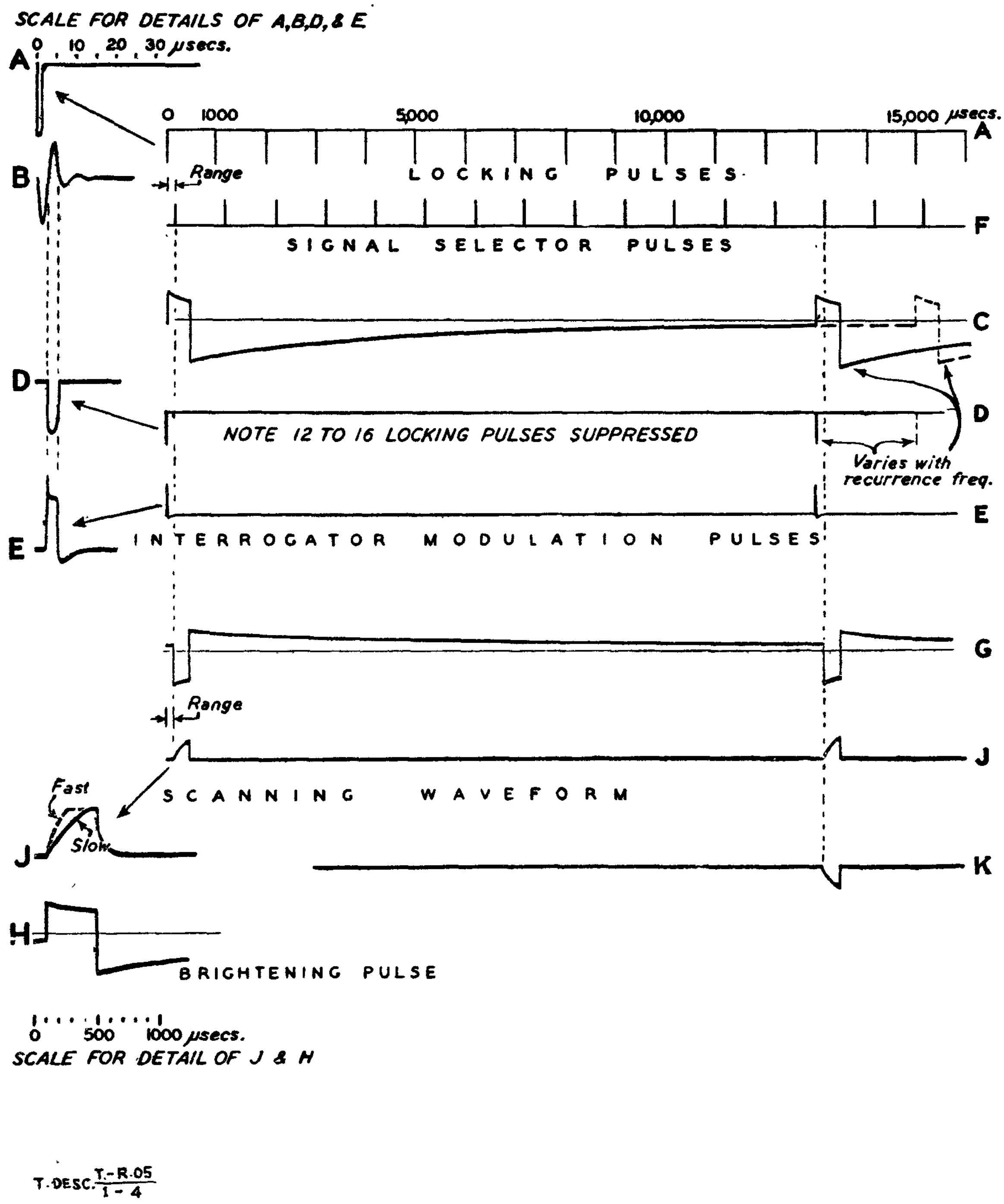

FIG. 4. WAVEFORMS AT VARIOUS POINTS

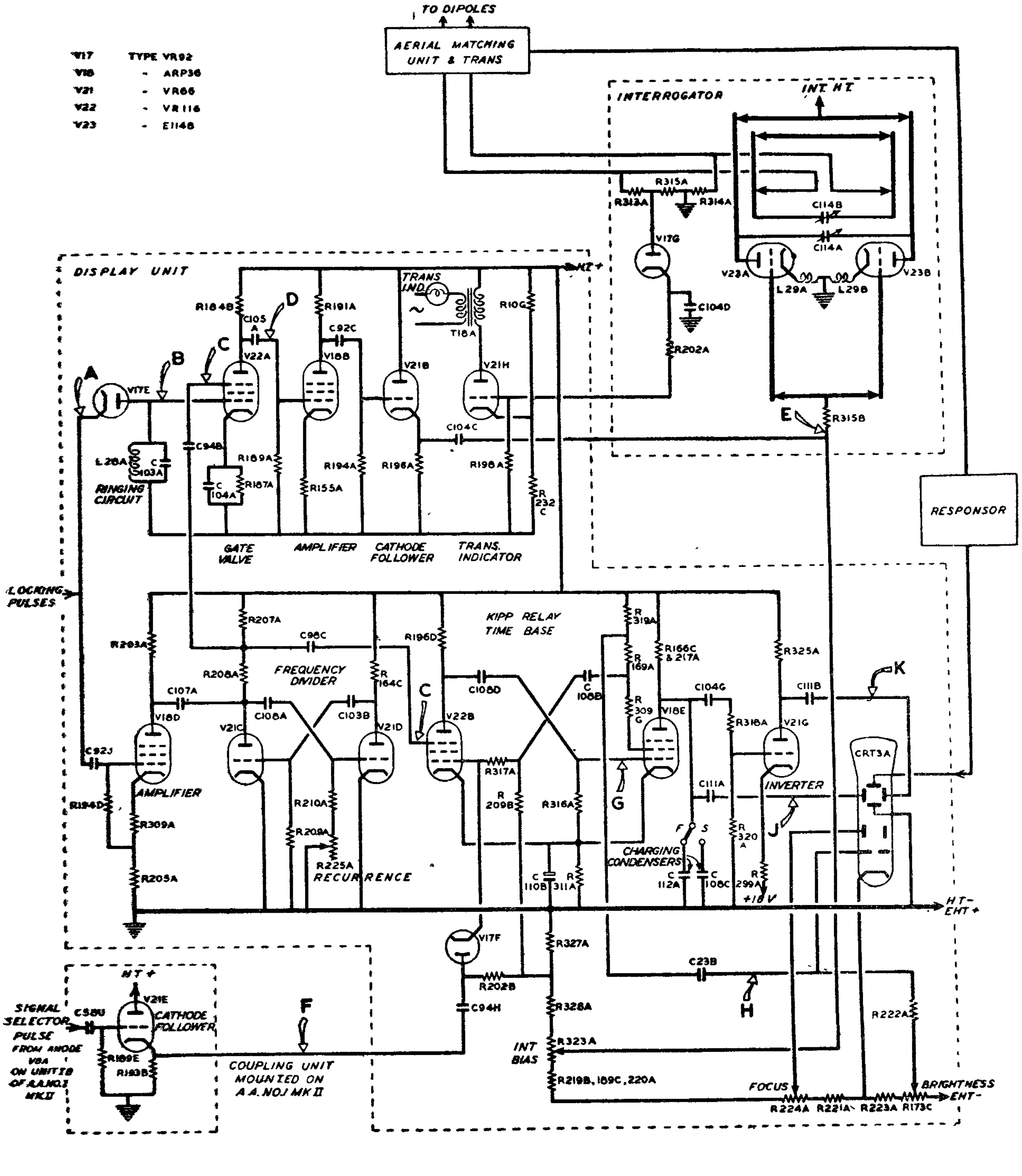

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FIG. 3. SIMPLIFIED CIRCUIT DIAGRAM, SHOWING POINTS WHERE WAVEFORMS IN FIG. 4 ARE TAKEN

CIRCUIT DESCRIPTION

(See figs. 3 and 4.)

Frequency of Interrogator Pulses

9. To ensure that pulses are sent at the same moment as the A.A. No. 1, Mk. II pulse, an input is taken from the A.A. No. 1, Mk. II transmitter locking cable. The locking pulses are of a frequency of approximately 1000/sec., (or pulse pitch of 1000 microseconds), but it is desired to send pulses less frequently from the Interrogator. This is accomplished by using a multivibrator or frequency divider circuit giving a long and short period waveform. The valves employed are two triodes V21C and V21D, and they are connected so that the time constants of the two circuits C108A, R210A, R225A, and C103B, R209A give respectively long and short periods. It will be noted that R225A is variable so that the long period may be adjusted over certain values.

10. Each positive peak of the voltage produced on the anode of V21C (C in the fig. 4) allows one out of a certain number of locking pulses to be passed, and thus brings about the slower recurrence frequency required.

Modulation Circuit

11. The locking pulses are fed in through a diode V17E which isolates the tuned ringing circuit L28A, C103A from the line. This tuned circuit gives a damped wave train (B) owing to the diode being connected in the conductive direction in series with the low impedance locking line across the tuned circuit. The first positive half cycle of the wave train is large enough to release the high bias on the pentode gate valve V22A, giving an anode voltage wave form as at D. It will be noted that the squared and lengthened pulse in the anode circuit occurs very slightly after the locking pulse, owing to its derivation from the *second* half cycle produced in the tuned circuit. The anode current in gate valve V22A is controlled in addition by its suppressor voltage, and this is taken from the frequency divider described above, with the result that after one pulse has passed, the valve is cut off for between 12 and 16 pulses, which are thus suppressed.

12. The frequency divider is also synchronised by taking a voltage from the locking pulse line and applying it directly to the grid of the inverter valve V18D. The anode of this valve produces positive pulses in its anode circuit which are used to keep the multivibrator in step by injection into the anode of V21C via C107A. It will be noted that since these positive pulses are not affected by the tuned ringing circuit L28A, C103A, they are not delayed 3 μ seconds as the positive half cycle on the grid is, and consequently the valve V22A is "opened" well in time.

13. After inversion in the pentode amplifier V18B the modulation pulse is fed to the transmitter through the cathode follower V21B. The final modulation waveform is given at E.

Interrogator

14. The carrier wave, which is modulated to give short pulses, is originated by a small transmitter with two valves (V23A and B) operating in a balanced circuit. This circuit has coupled adjustable grid and anode lechers, the latter tuned by a variable capacity C114A and feeding an inductively coupled aerial circuit consisting of a further pair of adjustable lechers and a variable capacity C114B. The output to the aerial feeder is taken from adjustable tappings on the aerial lechers.

Interrogator Indicator

15. To ensure that the transmitter is exciting the aerial, a tapping from a potentiometer R314A, R315A, and R313A across the output, provides voltage to the anode of a diode V17G which rectifies and gives a positive voltage at the grid of an indicating valve V21H located in the Display Unit. This triode valve is normally biased to cut-off by the potentiometer R10G, R232C. In the anode circuit is a double wound, iron-cored component T18A, which has its second winding fed from the 6·3 volt A. C. valve heater supply and includes a series indicating lamp. When no anode current flows (due to the valve being cut-off), the impedance of the winding is high and little A.C. flows. On receipt of the positive voltage derived from the diode in the transmitter, the bias on the grid of V21H is reduced and current flows in its anode circuit. This causes a drop in the impedance of the winding, due to the magnetic saturation of the core, and sufficient A.C. flows to light the lamp, the brightness of which gives an indication of the power in the transmitter aerial circuit.

Interrogator Modulation

16. The transmitter valve grids are connected to a high negative voltage developed across a portion of the E.H.T. potentiometer, (resistances R328A, 219B), and this is sufficient to keep the valves cut-off. Receipt of the positive pulses already described, (shown at E), momentarily cancels the standing bias, and allows the transmitter to operate for the duration of the pulses (about 5 μ seconds).

Production of Scanning Voltages

17. The waveform produced by V21C and D has already been described and is illustrated at C. In addition to operating the modulator gate valve as already described, it is passed on via C98C to a Kipp relay circuit consisting of V22B and V18E. The second of these pentodes has a dual function. Its screen is utilized as an anode for the Kipp relay circuit, whilst the anode provides the discharging device for the time-base circuit R166C, R217A, and C112A or C108C.

18. The operation of the Kipp relay is as follows :— Owing to the bias produced across the cathode resistance R311A and the potentiometer resistance R327A the relay will normally stand with V18E conducting and V22B cut-off. This also means that since V18E is conducting, the time-base charging condenser C108C or C112A cannot charge above the low anode voltage of V18E. To set the relay to the other condition, *i.e.* V22B conducting and V18E cut-off, two control voltages are required, a positive pulse on the grid and a positive voltage on the suppressor of V22B. The latter is provided by the frequency divider as stated above, (waveform C), whilst the former is derived from the Signal Selector pulse from the A.A. No. 1, Mk. II Receiver.

This pulse has a form as shown at F and arrives after the locking pulse, by an amount dependent on the range of the target. After passing through the cathode follower V21E, (which is mounted on a small separate unit), the voltage is applied to the anode of a diode V17F, which isolates the low impedance of the cathode follower output from the grid circuit, and so to the grid of V18E.

19. Since the suppressor voltage on V22B arrives earlier than the grid pulse, the valve is held in readiness to receive the grid triggering voltage. The Kipp relay changes over to the condition of V22B conducting, (the resultant waveform on the grid of V18E, the time base valve, is shown at G), and V18E cut-off, with the result that the time-base condenser charges through the anode resistances R116C and R217A.

20. This charging voltage (illustrated at J) is applied to one of the 'X' plates of the cathode ray tube via C111A and also through C104G to the grid of an inverter triode V21G, which in turn drives the other 'X' plate, (waveform K).

Modulation of C.R.T. and Pulse Indication

21. The cathode ray tube is normally blacked out by the bias produced across R223A, R173C, but by applying a positive voltage (waveform H) to the grid via C23B from the Kipp relay, the spot is brightened up for the periods of sweep. The 'Y' plates of the tube are supplied with a voltage from the Responsor which operates continuously. (See paragraph 49.)

Ref. No.	Value			Vocab. No.
C92	0·001 μ F			ZC11916
C104	0·1 μ F			ZC11922
C114	Assembled on lechers			
L29	R. F. Choke			ZC11980
L30	R.F. Choke			ZC11981
L31	R.F. Choke			ZC11982
R202	·22 M	± 20%	¼ W	ZC11936
R313	100	± 10%	¼ W	ZC11146
R314	400	± 10%	¼ W	ZC8520
R315	500	± 10%	¼ W	ZC8519
V17	VR92.			ZC2981
V23	VR135			ZC/CV/6

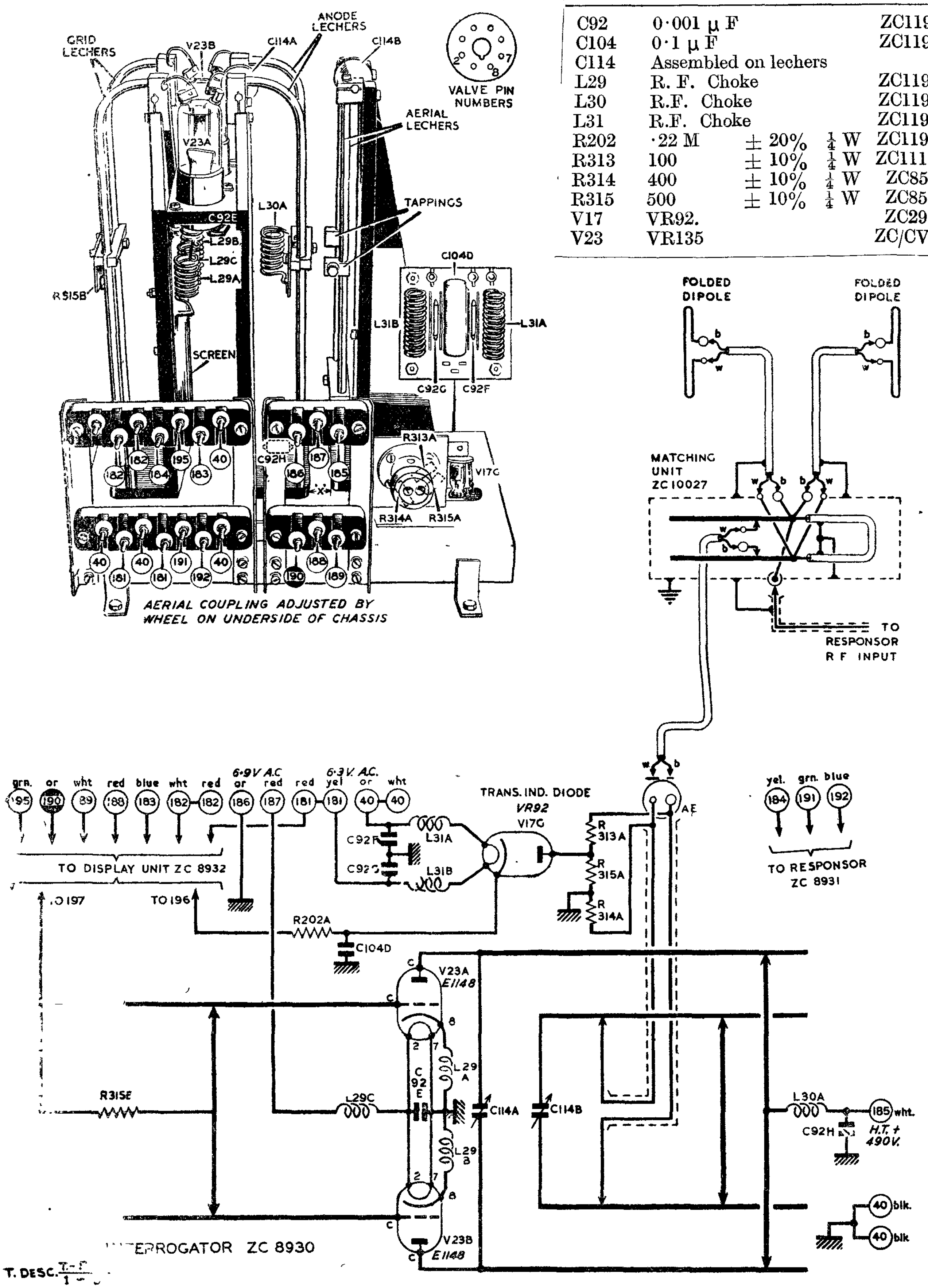


FIG. 5 THE INTERROGATOR AND CIRCUIT OF THE AERIALS

THE INTERROGATOR

(See fig. 5)

22. A pair of oscillating triode valves (type VR135) are mounted in holders secured in a moulded supporting platform. This platform also supports two pairs of silver plated lechers, constituting the anode and grid circuits, having adjustable shorting clamps which can be moved up or down the pairs of lechers for pre-tuning. The anode and grid connexions of the valves are brought out to the top of the glass bulbs, and are connected by short pieces of flexible braiding to the tops of the lechers.

23. Mounted on another moulding is a third pair of lechers constituting the aerial coupling circuit. In addition to the pre-adjustable shorting strip, on this pair, adjustable clamps are arranged for the purpose of tapping off the output to feed to the aerial. The whole of the support for the aerial lechers can be adjusted to vary the coupling with the anode lechers by sliding them nearer to or further from them. A capstan wheel clamp is provided under the chassis to secure this adjustment.

24. At the top of the anode and aerial lechers are adjustable condensers (C114A and B) consisting of parallel, circular, silver plated discs, the spacing of which can be varied by screw adjustments which are brought out to the front panel, and constitute the aerial and anode tuning controls. On the back of the aerial output socket are mounted the three resistances which form the potentiometer for the indicator diode feed. The diode itself (a VR92) is located close by. The heater and cathode chokes for the transmitting valves are mounted under the valve holder platform, and the earth connexions are taken to a copper screen which extends up from the chassis, and is intended to reduce the coupling between the anode and grid lechers. The chokes and condensers associated with the diode (which is fed from the Display Unit heater supply) are mounted on a small panel under the chassis.

25. A number of terminal panels take connexions from the separate 500 V. H. T. power supply and 6·9 V. heater supply, and provide for connexions between this unit and the Display Unit. Many of the terminals (188, 189, 190, 191 etc.) are not connected electrically to the Interrogator but merely form a convenient junction point for supplies to the Display Unit.

Setting up

26. For optimum output voltage the various adjustable elements of the tuned circuits must be set to certain dimensions. These are as follows :—

From the *top* of the moulded base to the *top* of :

Grid shorting bar . .	18 cm.
Anode shorting bar . .	18 cm.
Aerial shorting bar . .	8 cm.
Aerial tapping . . .	13 cm.
Distance between moulded bases	3 cm. (Equivalent to 4·5 cm. between centres of lecher bars).

NOTE.—Early advance copies of the maintenance handbook quoted *two* sets of figures one for each working frequency. It has since been found possible to set the Interrogator shorting bars and tappings at positions common to both frequencies. Tuning is then carried out as per para. 27 under (Set up thus, the interrogator is more stable).

27. When these adjustments are completed, replace the screening cover, and assuming that the aerials and matching unit are set up to the correct frequency as outlined on page 15, the Interrogator bias (the control of which is mounted on the Display Unit) is set, and the Interrogator tuned as follows :—

(*a*) Couple the Wavemeter I.F.F. No. 1 (W 1310) to the equipment by inserting probe into aerial matching unit. Tune wavemeter to the desired frequency.

(*b*) Tune anode condenser (C 114A, right-hand on front panel) for maximum deflection of wavemeter indicator.

(*c*) Adjust aerial condenser (C 114B, left-hand on front panel) for maximum light in transmitter indicator of Display Unit, or preferably for maximum current on milliammeter plugged in V21H Jack.

(*d*) Turn bias control (screwdriver-operated control just below indicator lamp) fully anti-clockwise.

(*e*) Tune the anode condenser (C 114A top right-hand screwdriver-operated control) until the frequency is correct, (clockwise to *decrease* frequency).

(*f*) Insert meter-jack in " V21H ", and tune aerial circuit (C 114B top left-hand screwdriver-operated control) to resonance, as indicated by maximum meter reading. It will probably be necessary to repeat (*e*) and (*f*) in succession until resonance is attained at the correct frequency.

(*g*) Rotate the bias control clockwise until there is a decrease in the meter reading. Then rotate control about 30° anti-clockwise. This is assumed then to be the correct setting.

If any doubt is felt about the adjustment, the modulation pulse may be examined on the range tube of the A.A. No. 1, Mk. II receiver as outlined on page 34 where the correct shape is given.

Voltages and Currents

28. H.T.+(terminal 185 to earth) 49) V. (Avo 1,200 or 1,000 V. scale).

Average H.T. current (at terminal 185) 0·25 mA.

NOTE.—The peak current which indicates transmitted power is much higher, and of the order of 200 to 300 mA.

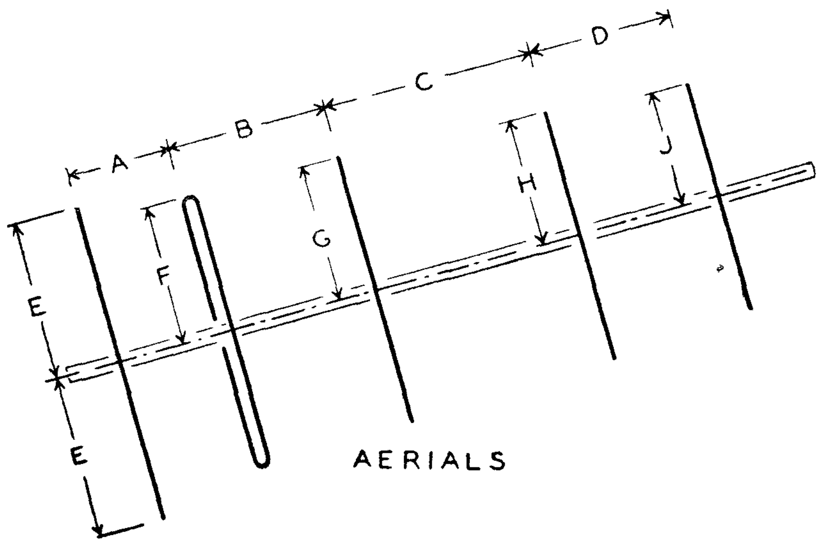
L.T. for V17G (terminals 181 and 40) 6·3 V. A.C.

L.T. for V23 A and B (terminals 186 & 187) 6·9 V. A.C.

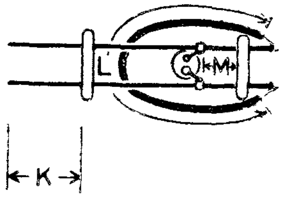
For voltages at terminals 182, 188, 189, and 190 (see Display Unit, page 21).

TABLE I
SPACING OF AERIALS AND Q BARS

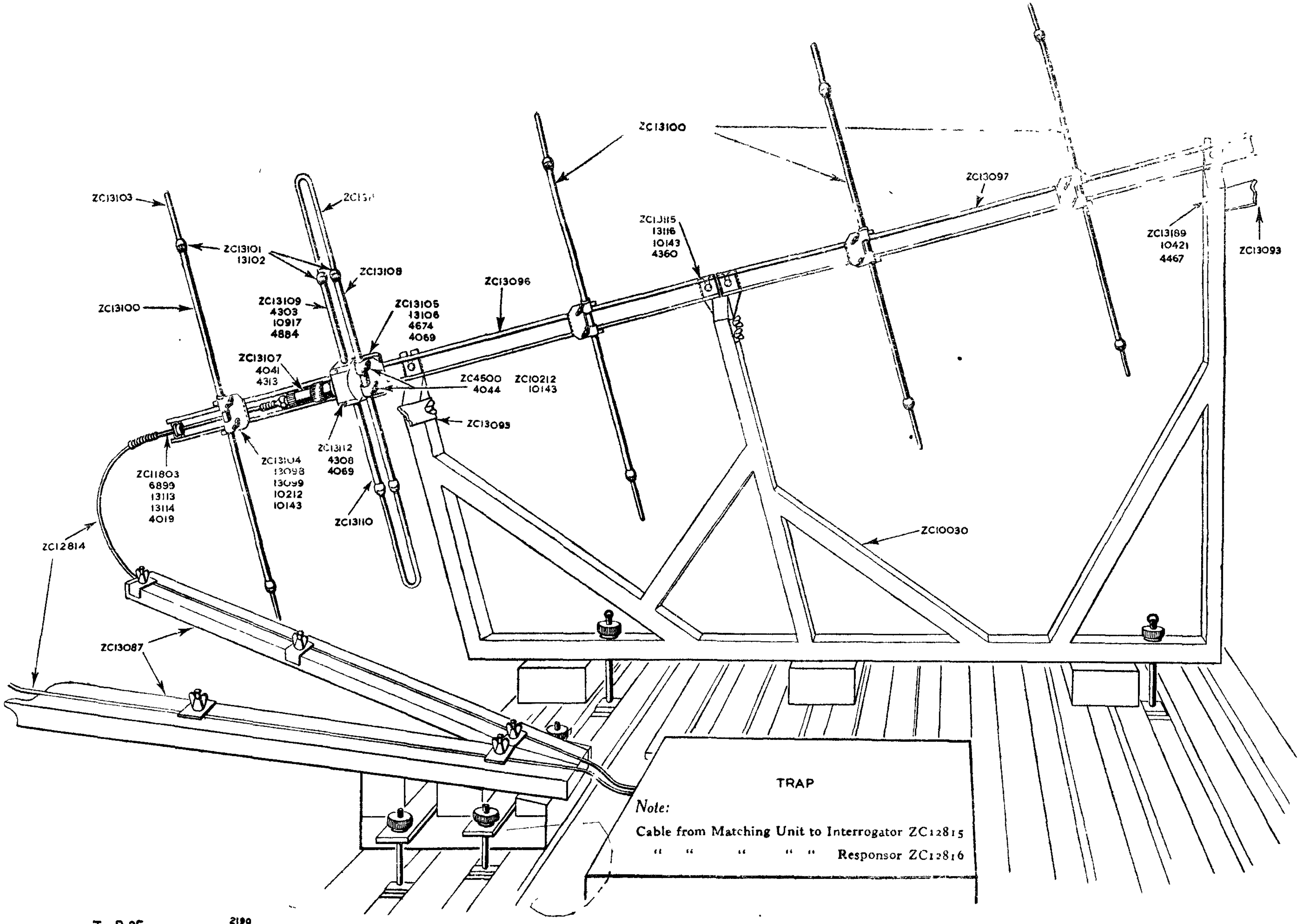
Frequency (Mc/s)	165	171
Distance between centres of support frames.	91·5 cm (36″)	87·8 cm (34½″).
Dimension A	26·4 cm (10 3/8″)	25·5 cm (10 1/32″).
Dimension B	46·75 cm (18 13/32″)	45·15 cm (17 25/32″).
Dimension C	53·35 cm (21″)	51·5 cm (20 9/32″).
Dimension D	40·9 cm (16 1/8″)	39·5 cm (15 9/16″).
Dimension E	46·45 cm (18 5/16″)	44·8 cm (17 5/8″)
Dimension F	42·7 cm (16 13/16″)	40·5 cm (15 15/16″).
Dimension G	39·6 cm (15 19/32″)	38·15 cm (15 1/32″).
Dimension H	41·3 cm (16¼″)	39·85 cm (15 11/16″).
Dimension J	38·05 cm (15″)	36·65 cm (14 7/16″).
Dimension K	16 cm (6 5/16″)	16 cm (6 5/16″).
Dimension L	50 cm (19 11/16″)	50 cm (19 11/16″).
Dimension M	5 cm (1 31/32″)	5 cm (1 31/32″).



AERIALS



MATCHING UNIT



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2190

FIG. 6 ONE OF THE AERIAL ARRAYS AND THE CABLE SUPPORT ASSEMBLY

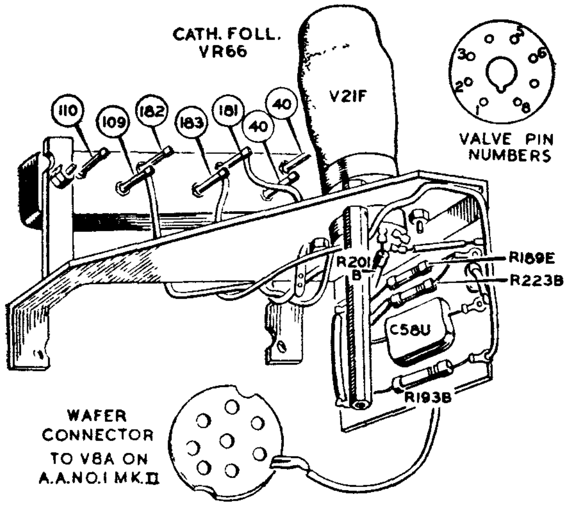
AERIALS AND AERIAL MATCHING UNIT

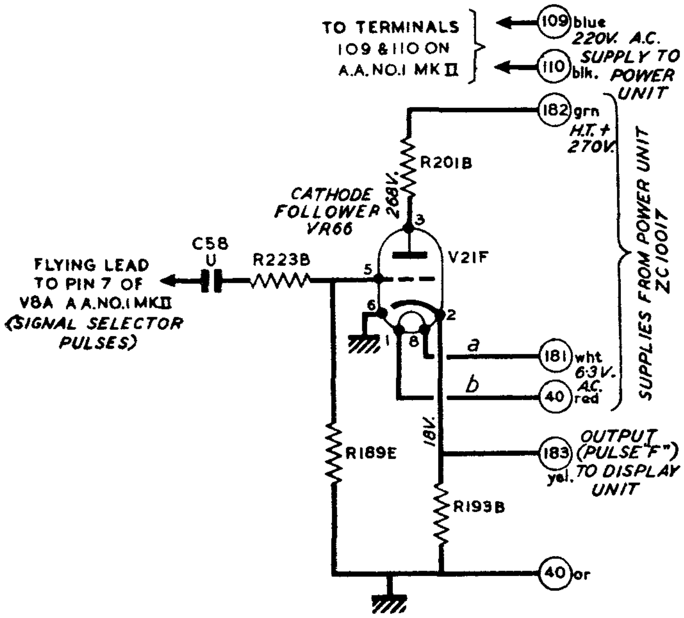
(See figs. 5 and 6)

29. The output of the interrogator is fed along a balanced feeder to a tuned transformer consisting of $\frac{1}{4}$ wavelength bars with a $\frac{1}{2}$ wavelength closed line. The input to the transformer is tapped into the Q bars to give correct impedance matching to the aerials which are connected at the junction of the bars and the closed line. Balanced feeders go from this point to the folded dipoles which are arranged half a wavelength apart in two arrays, each consisting of a reflector, the folded dipole, and three directors. This gives the desired polar diagram, a single lobe pointing in the direction of the directors.

30. The feed for the responsor is taken off the junction point of one of the bars and the half wavelength line. This is because the input of the responsor is through an unbalanced feeder, whereas the transmitter connexions are by balanced feeders.

31. A table showing the dimensions for setting up the aerial and matching unit is given on page 13.





Ref. No.	Value			Vocab. No.
C58	.002 μF			ZC2694
R189	47 k	± 20%	¼ W	ZC11252
R193	10 k	± 20%	½ W	ZC11253
R201	1 k	± 20%	¼ W	ZC11245
R223	22 k	± 20%	¼ W	ZC11251
V21	VR66			ZC3086

T.DESC. $\frac{\text{T.–R.05}}{\text{1 – 7}}$

FIG. 7 THE COUPLING UNIT

COUPLING UNIT

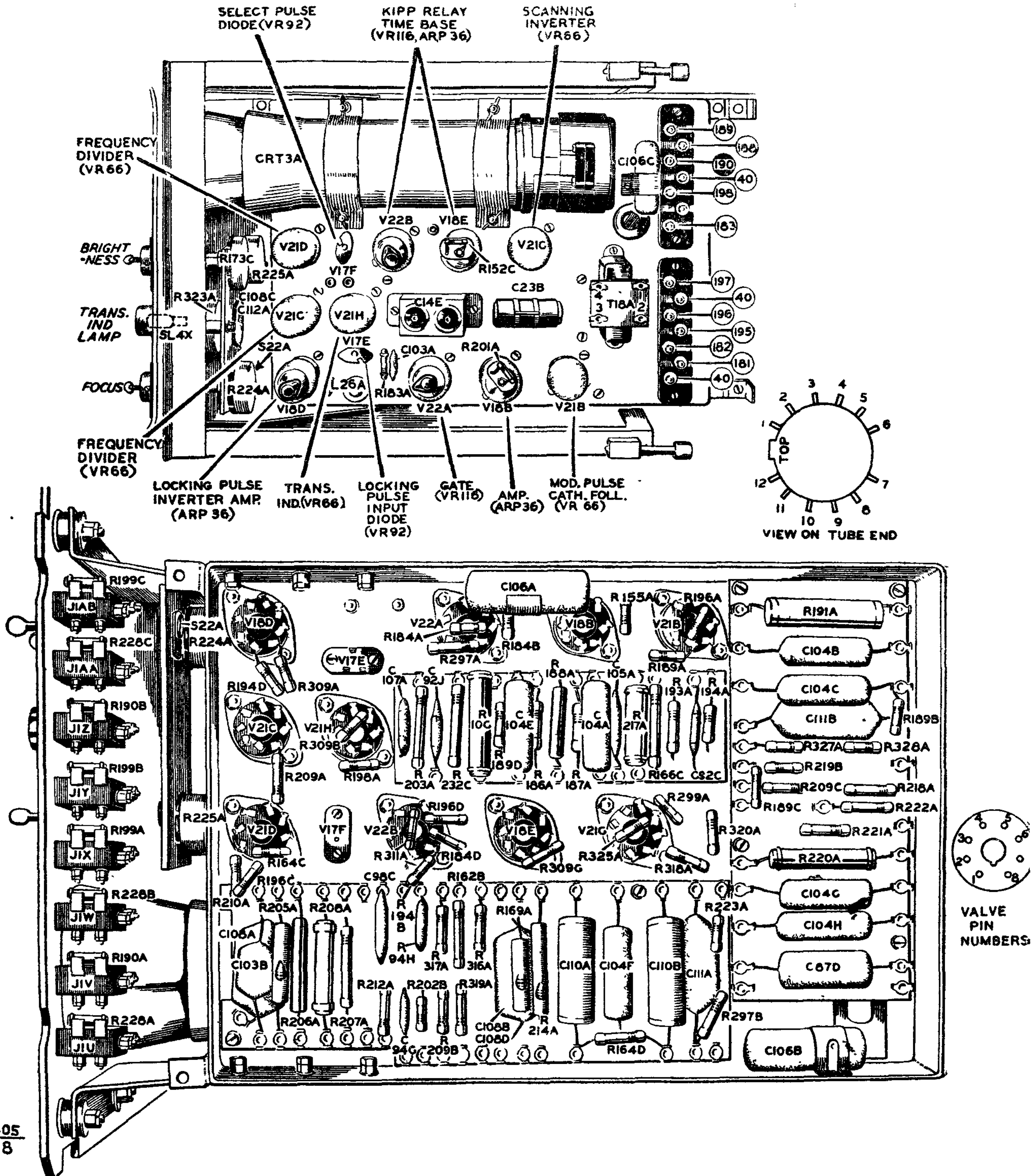
(See fig. 7)

32. The Coupling Unit contains one valve (VR66) used in a cathode follower circuit and is mounted on a small specially shaped chassis for attachment to existing Unit IB/3 in the A.A. No. 1, Mk. II receiver. Connexion is made to the anode of V8A (signal selector output valve) in this Unit by means of a thin connecting wafer, which is interposed between the valve and its holder.

33. The H.T. and heater supplies for the Coupling Unit are taken from the Display Unit power pack to a terminal panel mounted on the Coupling Unit chassis. The same panel also provides a junction point for a mains supply for the equipment taken from appropriate terminals (109 & 110) on the A.A. No. 1, Mk. II Unit 1B/3.

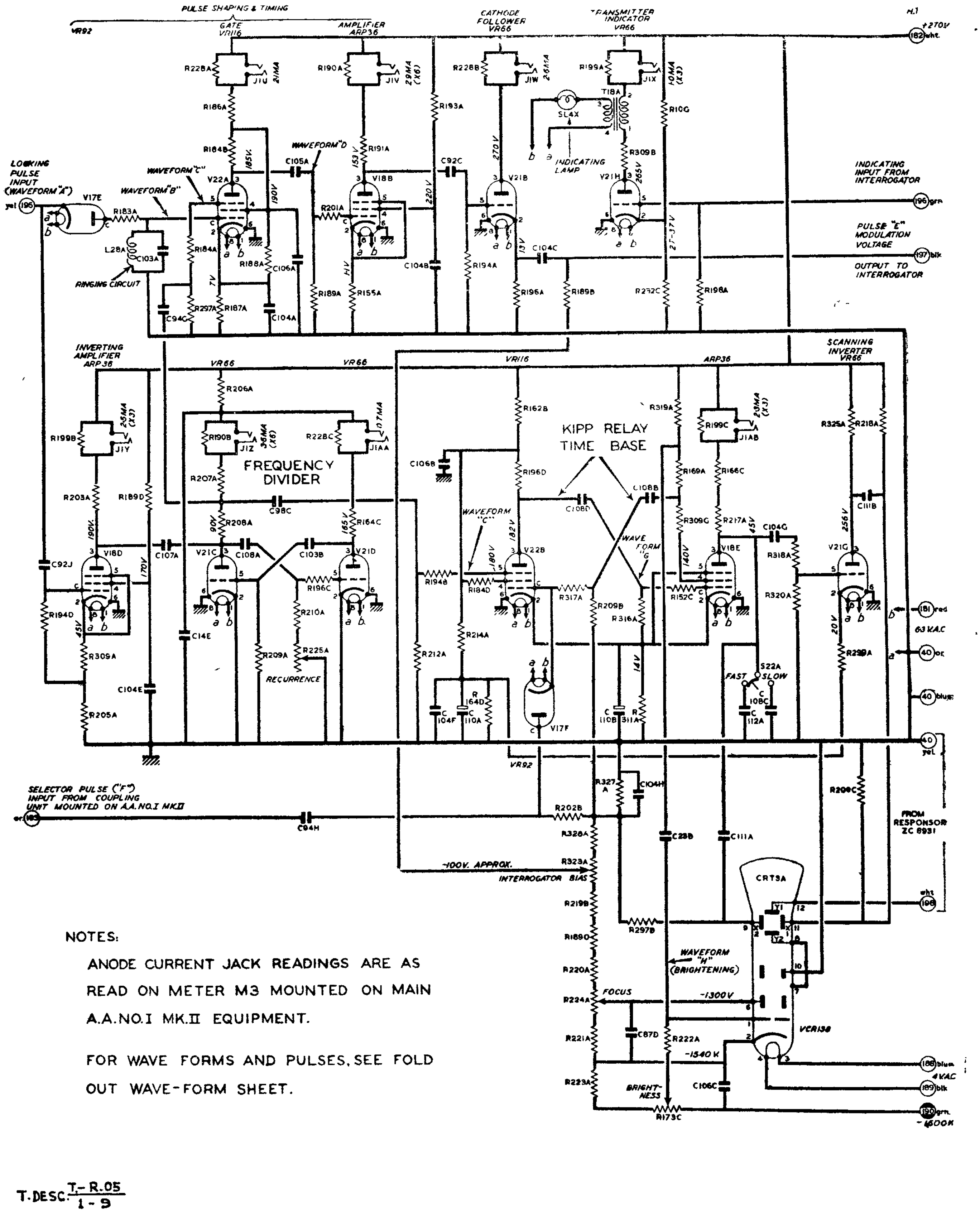
34. **Voltages and Currents**

TERMINALS	DESCRIPTION	READING.	SCALE.	
			AVO MODEL 7	AVO MODEL 40
182 to chassis	H. T. Supply	270 V.	1000	1200
183 ,, ,,	Cathode Voltage	18 V.	400	120
Anode pin (3) to chassis	Anode Voltage	268 V.	1000	12000
40 and 181	A.C. Heater Voltage	6·3 V.		
109 and 110	A.C. Mains ,,	220 V.		
At 182	Anode current	1·8 mA.		
At 109	Total A.C. supply current	1·0 A.		



T. DESC. $\frac{T-R-05}{I-8}$

FIG. 8. THE DISPLAY UNIT, VIEWS OF THE CHASSIS.



NOTES:

ANODE CURRENT JACK READINGS ARE AS READ ON METER M3 MOUNTED ON MAIN A.A.NO.I MK.II EQUIPMENT.

FOR WAVE FORMS AND PULSES, SEE FOLD OUT WAVE-FORM SHEET.

T.DESC. T.-R.05 / 1-9

FIG. 9 THE DISPLAY UNIT, CIRCUIT DIAGRAM

Ref. No.	Value	Vocab. No.	Ref. No.	Value	Vocab. No.	Ref. No.	Value	Vocab. No.	Ref. No.	Value	Vocab. No.
C14	2 μF	ZC2654	L28	2mH	ZC11929	R201	1 k ± 20 % ¼ W	ZC11245	R232	5 k ± 5 % 1 W	ZC10933
C23	0·001 μF 4,000 V.	ZC2667	R10	50 k ± 5 % 2 W	ZC2777	R202	·22 M ± 20 % ¼ W	ZC11936	R297	1 M ± 20 % ¼ W	ZC11209
C87	0·1 μF	ZC11923	R152	1·5 k ± 5 % ¼ W	ZC71340	R203	10 k ± 20 % 1 W	ZC11255	R299	1·5 k ± 10 % ¼ W	ZC7302
C92	0·001 μF	ZC11916	R162	20 k ± 5 % ½ W	ZC10930	R205	4·7 k ± 20 % ½ W	ZC11254	R155A	50 W	ZC14776
C94	500 μμF	ZC11915	R164	5 k ± 5 % ½ W	ZC11341	R206	4·7 k ± 20 % 5 W	ZC11948	R309	100 ± 20 % ¼ W	ZC11228
C98	0 005 μF	ZC11919	R166	10 k ± 5 % 1 W	ZC13351	R207	1·5 k ± 5 % 1 W	ZC11944	R311	1 k ± 10 % ¼ W	ZC1387
C103	500 μμF ± 2 %	ZC11305	R169	15 k ± 5 % 1 W	ZC10979	R208	2·2 k ± 5 % 2 W	ZC11945	R316	20 k ± 5 % ½ W	ZC11257
C104	0·1 μF	ZC11922	R173	25 k Variable	ZC11931	R209	1 M ± 5 % ½ W	ZC10932	R317	50 k ± 20 % ¼ W	ZC11258
C105	0·0023 μF	ZC11917	R183	2 2 k ± 20 % ¼ W	ZC11246	R210	0·75 M ± 5 % ½ W	ZC11942	R318	0·3 M ± 5 % ¼ W	ZC11937
C106	0 5 μF	ZC11924	R184	10 k ± 20 % ¼ W	ZC11248	R212	0·47 M ± 20 % ¼ W	ZC11259	R319	6·8 k ± 5 % ½ W	ZC10929
C107	400 μμF ± 2 %	ZC11914	R186	33 k ± 10 % ½ W	ZC11180	R214	50 k ± 5 % 1 W	ZC11317	R320	0·15 M ± 5 % ¼ W	ZC11935
C108	0·01 μF ± 2 %	ZC11921	R187	3 3 k ± 10 % ¼ W	ZC3652	R217	22 k ± 5 % 2 W	ZC11946	R323	25 k Pre-set	ZC11930
C110	25 μF 25 V.	ZC11925	R188	68 k ± 10 % 1 W	ZC3670	R218	3 5 M ± 5 % ½ W	ZC11347	R325	15 k ± % ¼ W	ZC3655
C111	0·0075 μF ± 2 %	ZC11920	R189	47 k ± 20 % ¼ W	ZC11252	R219	33 k ± 20 % ¼ W	ZC11934	R327	30 k ± 2 % ½ W	ZC14289
C112	0·003 μF ± 2 %	ZC11918	R190	3 ± 5 % ½ W	ZC11168	R220	0·47 M ± 20 % 2 W	ZC11947	R328	12 k ± 2 % ½ W	ZC14288
CRT3	VCR138	ZC3679	R191	6·8 k ± 20 % 5 W	ZC11949	R221	0 1 M ± 5 % ½ W	ZC10931	S22	Time Base Switch	ZC11953
J1	Jack Socket	ZC2623	R193	10 k ± 20 % ½ W	ZC11253	R222	2·2 M ± 20 % ¼ W	ZC11938	SL4	Pilot Lamp	ZC1814
			R194	0·1 M ± 20 % ¼ W	ZC11249	R223	22 k ± 20 % ¼ W	ZC11251	T18		ZC11958
			R196	4·7 k ± 20 % ¼ W	ZC11247	R224	1 M Variable	ZC11932	V17	VR92	ZC2981
			R198	10 M ± 20 % ¼ W	ZC11250	R225	·5 M Variable	ZC11933	V18	ARP36	ZC3085
			R199	7·5 ± 5 % ½ W	ZC11940	R228	50 ± 5 % ½ W	ZC11260	V21	VR66	ZC3086
									V22	VR116	ZC8843

DISPLAY UNIT

(See figs. 8 and 9)

35. The Display Unit contains modulation equipment for the interrogator, and the cathode ray tube together with its time-base generator all mounted on one chassis. The tube is mounted in a screen secured by two clamps on top to the left of the chassis, whilst at the front is a panel for housing the Recurrence, Interrogator bias, Brightness and Focus controls, and the Fast-Slow trace speed switch. Jacks are provided on the front panel for measuring the anode current of eight of the valves. The front panel also houses the transmitter indicating lamp SL_4 X. The valves all stand above the chassis in the conventional manner, and the majority of the small components are housed below on insulated tag panels. Two seven way terminal panels take the supply and other connecting leads.

Setting up the Display Unit

36. The setting up of the Interrogator bias control, which is mounted on the Display Unit, has been given in paragraph 27.

Test Jack Readings

37. The following current readings are taken on the 5 mA., A.A. No. 1, Mk. II equipment meter, and are the anode currents of the valves indicated.

VALVE	METER READING	ACTUAL CURRENT
V22A	2·1 mA.	2·1 mA.
V18B	2·9 mA.	17·4 mA.
V21B	2·6 mA.	2·6 mA.
V21H	1·0 mA. (approx.) . . .	3·0 mA. (transmitter operating)
	0·25 mA.	0·75 mA. (transmitter not operati g)
V18D . . .	2·5 mA.	7·5 mA.
V21C	3·6 mA.*	21·6 mA.*
V21D	0·7 mA. *	0·7 mA.*
V18E	2·3 mA.	6·9 mA.

* Varies with recurrence frequency.

Valve Voltages

38. The following voltages were taken on the meters indicated, with the Unit operating normally. The value given may be assumed to be approximately the actual voltage at the point, and in some cases a slightly lower value may be obtained, particularly on Avo Model 40.

The H. T. supply voltage (at terminal 182) was 270 volts, and the C. R. tube voltage, (terminal 190), 1,600 volts, (negative in respect of earth). Measured with Avo model 7 and multiplier, the C.R.T. voltage was 1,500 volts. With Avo model 40 and multiplier, it was 1,300 volts.

	Valve	V22A	V18B	V21B	V21H	V18	V21C	V21D	V22B	V18E	V21G
Anode Voltage.		185	153	270	265	190	90	165	182	45	256
	Scale: Avo Model 7 .	1000	1000	1000	1000	1000	1000	1000	1000	400	1000
	Scale: ,, ,, 40 .	1200	1200	1200	1200	1200	1200	1200	1200	120	1200
Screen Voltage.		190	220	..	..	170	..	..	180	140	..
	Scale: Avo Model 7 .	1000	1000	..	..	1000	..	..	1000	1000	..
	Scale: ,, ,, 40 .	1200	1200	..	..	1200	..	..	1200	1200	..
Cathode voltage.		7	1·1	13	* 27-37	45	..	..	14	14	20
	Scale: Avo Model 7 .	100	10	100	100	400	..	..	100	100	100
	Scale: ,, ,, 40 .	120	12	120	120	120	..	..	120	120	120

* Lower value when transmitter is *not* operating.

C.R.T. Voltages

39. Specimen voltages are as follows :—

ELECTRODE	MEASURED BETWEEN CHASSIS AND PIN No.	-VE VOLTAGE READINGS: ELECTROSTATIC VOLTMETER	-VE VOLTAGE READINGS: AVO MODEL 7 AND MULTIPLIER	AVO MODEL 40 AND MULTIPLIER
Cathode . .	2 . . .	1470 volts	1425	1200
Grid . . .	1 (Brightness Max.)	1540	1000	565
,, . . .	1 (,, Min.) .	1490	1000	555
Focusing Anode .	6 (Max.) . .	1300	1075	1000
,, . .	6 (Min.) . .	1130	950	860

D.C. Resistance of Windings

40. L28A — 6·2 ohms.
T18A terminals 1 & 2, — 2,900 ,,
,, 3 & 4, — 3·2 ,,

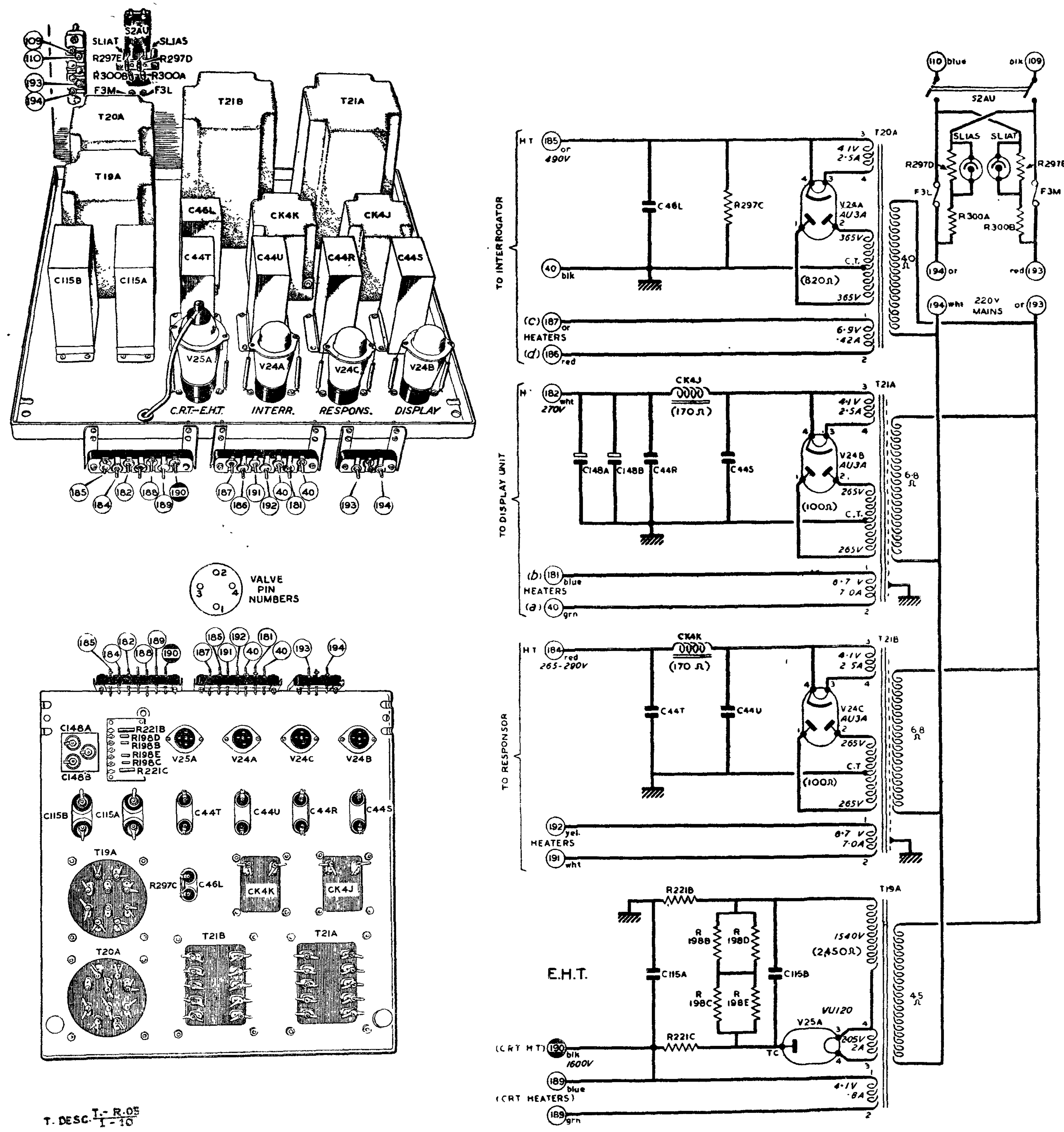


FIG. 10. THE POWER UNIT AND FUSE PANEL.

Ref. No.	Value		Vocab. No.
C44	8 µF		ZC2663
C46	4 µF		ZC2656
C115	·5 µF 2,500 V		ZC11959
C148A	16 µF		ZC11965
C148B	16 µF		
CK4	Choke 9·5 H		ZC2562
F3	Fuse 2A		ZC0038
R198	10 M	± 20 per cent. ¼ W	ZC11250
R221	·1 M	± 5 per cent. ½ W	ZC10931
R297	1 M	± 20 per cent. ¼ W	ZC11209
R300	·5 M	± 20 per cent. ¼ W	ZC11212
SL1	Signal Lamp		ZC0042
S2	Mains Switch		ZC2589
T19	Mains Transformer		ZC11971
T20	” ”		ZC11970
T21	” ”		ZC11969
V24	AU3A		ZC0098
V25	VU120		ZC0047

POWER UNIT AND FUSE PANEL

(See fig. 10)

41. Four separate power packs are housed in the Power Unit for the Interrogator, Display Unit, (valves), Responsor, and the high voltage supply for the Cathode. Ray tube.

42. The 500 V. Interrogator supply consists of a VU39 type full wave rectifier fed from its own power transformer T20A with a reservoir condenser C46L and a voltage stabilizing resistance R297C. No H. T. smoothing is provided. The transformer also supplies 6·9 V. A.C. for the heaters of the Interrogator valves.

43. A 275 volt, smoothed H. T. supply is produced for the Display Unit by a type VU39 full wave rectifier fed from T21A. Following the single stage of choke smoothing (CK4J) are two 16 mfd. capacity electrolytic condensers, which are included to prevent slow period fluctuation of the H. T. supply voltage. The mains transformer of this supply has an L.T. winding which supplies the heaters of the Display Unit at 6·3 V. after allowing for voltage drop along the connecting cable.

44. A similar smoothed H. T. supply is provided by V24C and T21B for the Responsor. Electrolytic condensers are not included; an L.T. winding for Responsor valve heaters is provided.

45. The type VU120 half-wave high voltage rectifier V25A is fed from T19A. The 1,600 V. H.T. supply is earthed on its positive side, and is smoothed by resistances R221B and R221C in conjunction with condensers. The cathode ray tube heater supply (a 4 volt winding) also comes from T19A, and this is held at 1,600 V. to earth by a connexion with the H.T. −supply. The four mains transformer primaries are in parallel.

46. All the components of the power packs are mounted on a stout tray chassis with three terminal panels for connexion at the back. This Unit is associated with the Fuse Panel Assembly, to which it is wired, and which forms in effect a front panel to the power Unit, although the two are not mechanically joined together. The Fuse Panel incorporates a double pole mains switch S2AU, a pair of fuses, and neon indicating lamps connected (together with their voltage adjusting resistances) to show when the power is on and that the fuses are intact.

47. **Supply Voltages and Currents**

SUPPLY	H.T. VOLTAGE	MEASURED BETWEEN CHASSIS & TERMINAL No.	CURRENT (mA)
Interrogator . .	490	185	0·25
Display . .	270	182	86
Responsor . .	265 (Gain control at maximum).	184	90
C.R.T. . . .	−1,600	189	1·7

The first three voltages taken on Model 40 Avo. 1200 V. scale or Model 7 Avo. 1000 V. scale. The last voltage taken on electrostatic voltmeter.

Transformer and Choke Data

COMPONENT	WINDING	D.C. RESISTANCE	CURRENT ON LOAD	CURRENT OFF LOAD
T19A	Primary (220 V.)	45 ohms.	0·12 A.	Not more than 90 mA.
	1,540 V.	2,450 ,,		..
	2·05 V.	negligible.	2·0 A.	..
	4·1 V.	,,	0·8 A.	..
T20A	Primary (220 V.)	40 ohms.	0·095 A.	Not more than 75 mA.
	365-0-365 V.	820 ,, *	..	..
	4·1 V.	negligible	2·5 A.	..
	6·9 V.	,,	0·42 A.	..
T21A	Primary (220 V.)	6·8 ohms.	0·42 A.	Not more than 0·17 A.
	265-0-265 V.	100 ,, *	..	..
	4·1 V.	negligible	2·5 A.	..
	6·7 V.	,,	7·0 A.	..
T21B	Primary (220 V.)	6·8 ohms.	0·35 A.	Not more than 0·17 A.
	265-0-265 V.	100 ,, *	..	..
	4·1 V.	negligible.	2·5 A.	..
	6·7 V.	,,	7·0 A.	..
CK4		Approx. 170 ohms.		

* Whole winding.

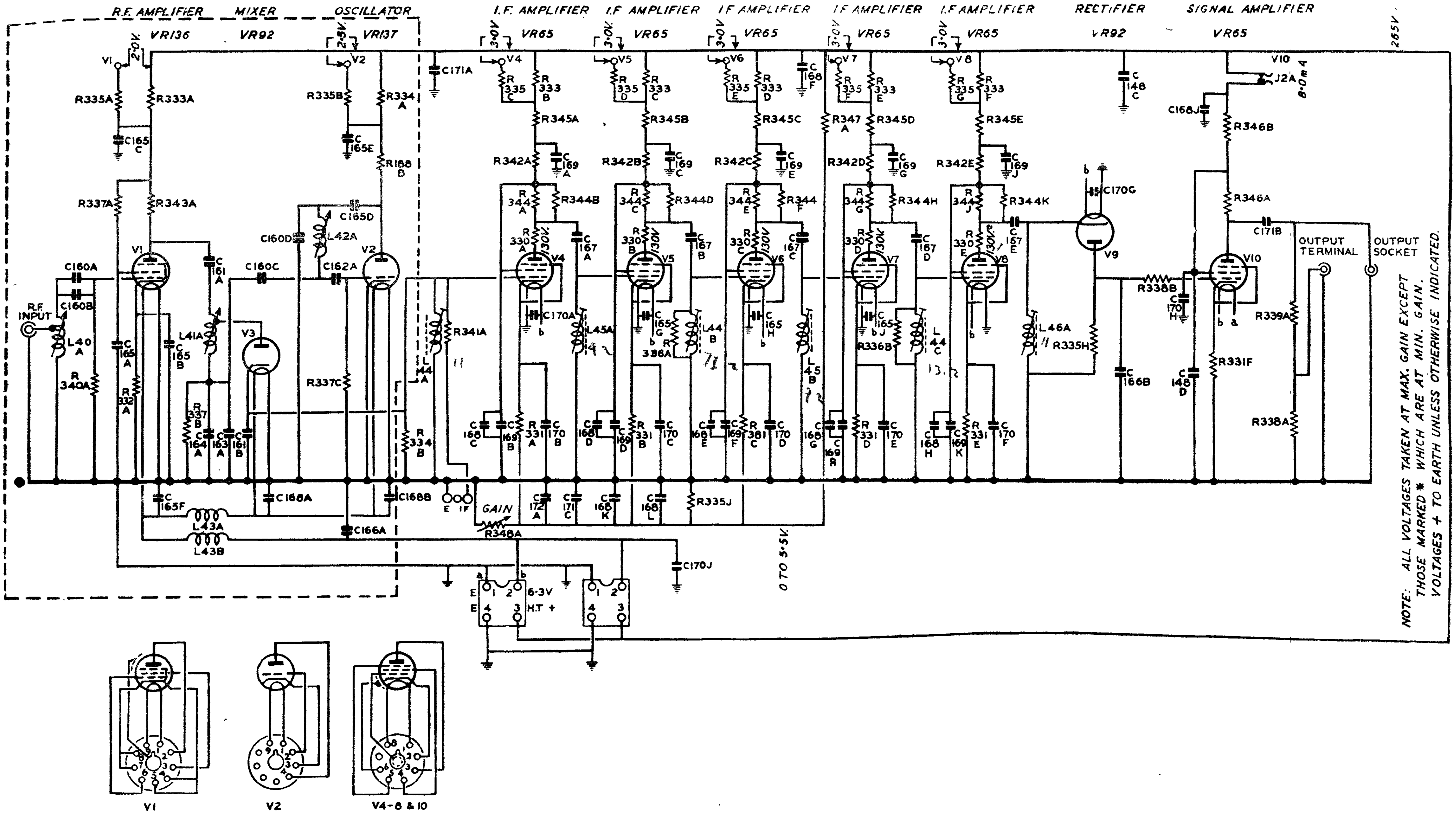


FIG. 11(a). THE RESPONSOR, CIRCUIT DIAGRAM.

Ref. No.	Value		Vocab. No.
C148	16 + 16 μF		ZC11965
C160	3 μμF	500 V	ZC3260
C161	5 μμF	500 V	ZC12005
C162	10 μμF	500 V	ZC12006
C163	15 μμF	500 V	ZC12007
C164	25 μμF	500 V	ZC12008
C165	50 μμF	500 V	ZC12009
C166	100 μμF	500 V	ZC3527
C167	200 μμF	350 V	ZC12010
C168	500 μμF	350 V	ZC0136
C169	·002 μF	400 V	ZC12011
C170	·01 μF	400 V	ZC12012
C171	·1 μF	400 V	ZC12013
C172	50 μF	12 V	ZC3278
L40	R.F. Tuning Coil		ZC12030
L41	" " "		ZC12029
L42	" " "		ZC12028
L43	R.F. Choke		ZC12003
L44	I.F. Tuning Coil		ZC11343
L45	" " "		ZC11344
L46	" " "		ZC11345

Ref. No.	Value		Vocab No.
R188	68 k	1 W	ZC3670
R330	27	¼ W	ZC11370
R331	100	¼ W	ZC11146
R332	180	¼ W	ZC3647
R333	470	¼ W	ZC13022
R334	2·2 k	¼ W	ZC3651
R335	4·7 k	¼ W	ZC0305
R336	10 k	¼ W	ZC3823
R337	22 k	¼ W	ZC11176
R338	47 k	¼ W	ZC0297
R339	68 k	¼ W	ZC11173
R340	·1 M	¼ W	ZC11249
R341	1·8 M	¼ W	ZC12041
R342	1 k	½ W	ZC9926
R343	6·8 k	½ W	ZC3659
R344	10 k	½ W	ZC11177
R345	4·7 k	1 W	ZC11371
R346	15 k	1 W	ZC8557
R347	·1 M	1 W	ZC0618
R348	3 k	Variable	ZC11346

T. DESC. T.-R.05 / 1-11B

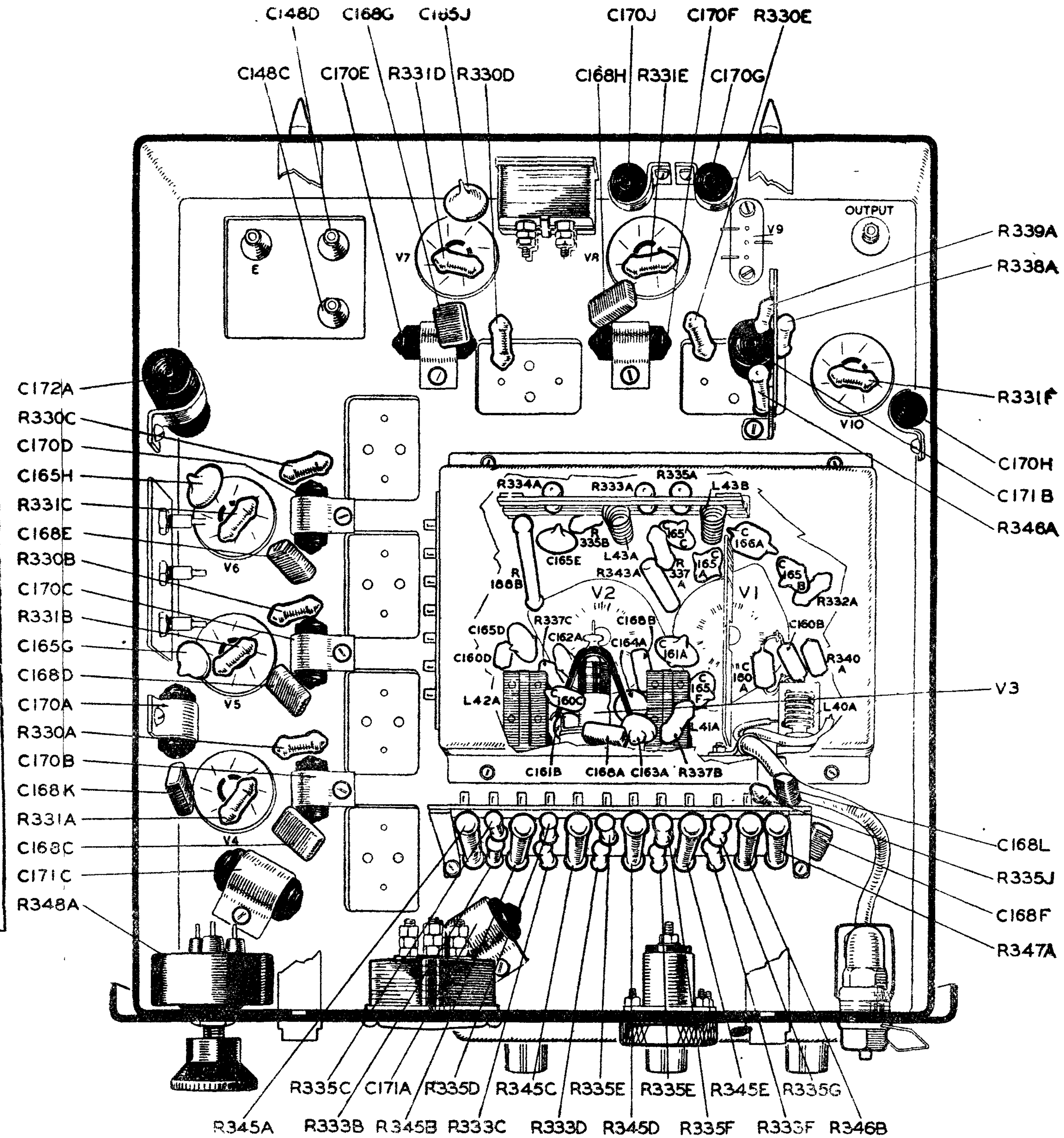
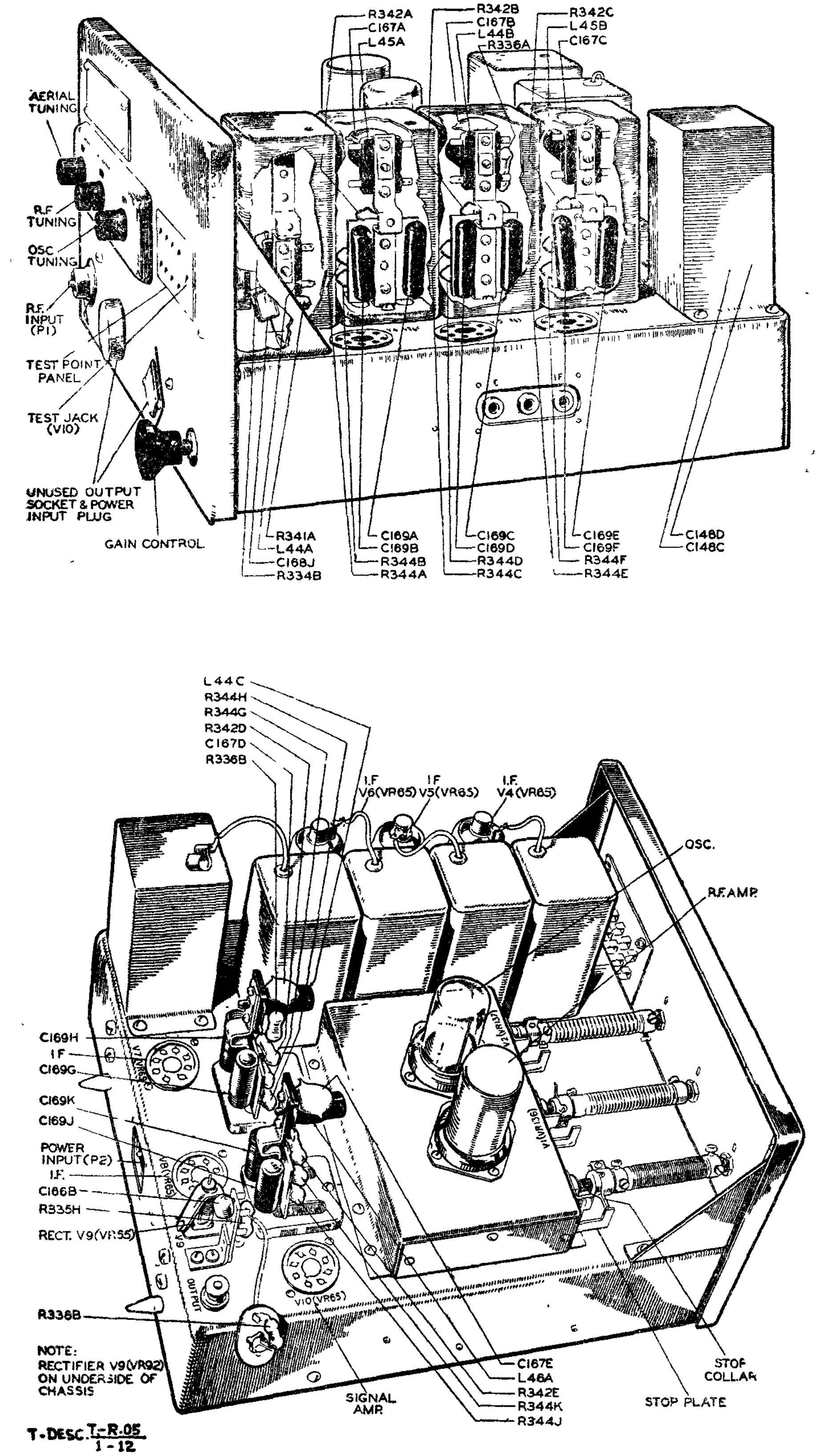


FIG. 11 (*b*). THE RESPONSOR, UNDER VIEW OF CHASSIS

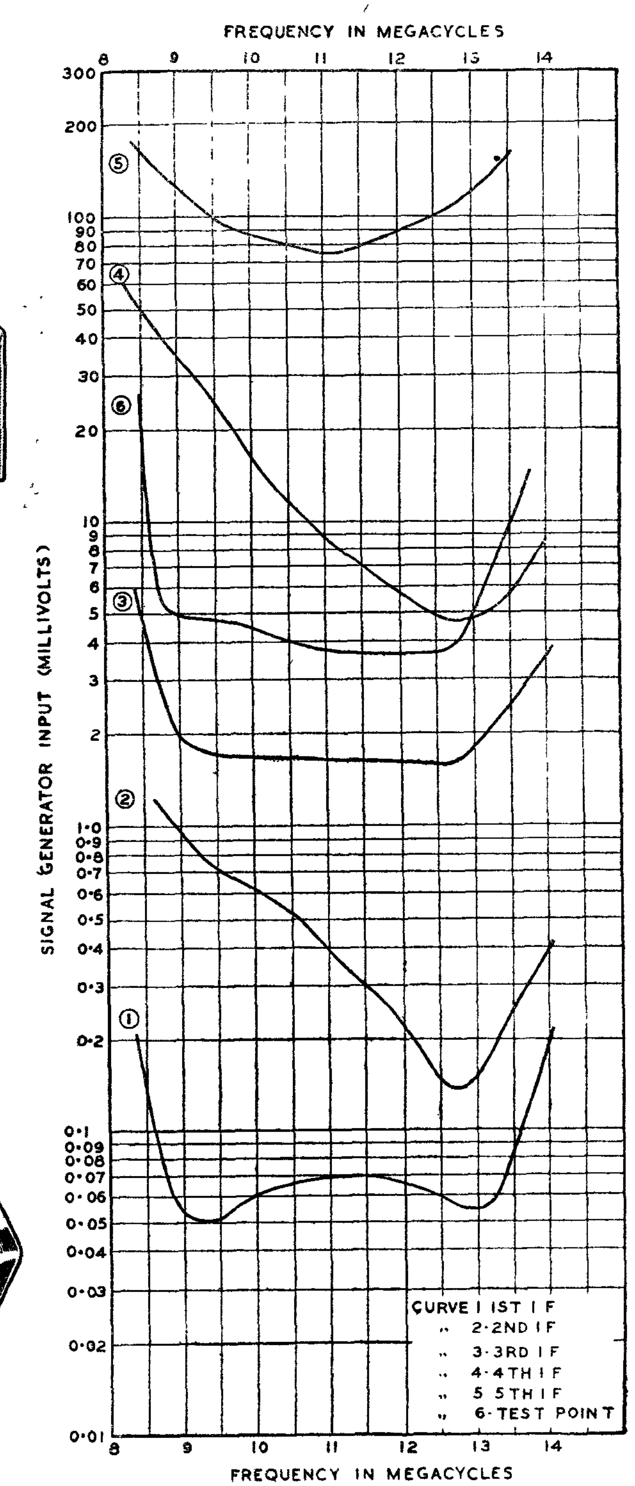
Ref. No.	Value		Vocab. No.	Ref. No.	Value		Vocab No.
C148	16 + 16 μF		ZC11965	R188	68 k	1 W	ZC3670
C160	3 μμF	500 V	ZC3260	R330	27	¼ W	ZC11370
C161	5 μμF	500 V	ZC12005	R331	100	¼ W	ZC11146
C162	10 μμF	500 V	ZC12006	R332	180	¼ W	ZC3647
C163	15 μμF	500 V	ZC12007	R333	470	¼ W	ZC13022
C164	25 μμF	500 V	ZC12008	R334	2·2 k	¼ W	ZC3651
C165	50 μμF	500 V	ZC12009	R335	4·7 k	¼ W	ZC0305
C166	100 μμF	500 V	ZC3527	R336	10 k	½ W	ZC3823
C167	200 μμF	350 V	ZC12010	R337	22 k	¼ W	ZC11176
C168	500 μμF	350 V	ZC0136	R338	47 k	¼ W	ZC0297
C169	·002 μF	400 V	ZC12011	R339	68 k	½ W	ZC11173
C170	·01 μF	400 V	ZC12012	R340	·1 M	¼ W	ZC11249
C171	·1 μF	400 V	ZC12013	R341	1·8 M	¼ W	ZC12041
C172	50 μF	12 V	ZC3278	R342	1 k	½ W	ZC9926
L40	R.F. Tuning Coil		ZC12030	R343	6·8 k	½ W	ZC3659
L41	" " "		ZC12029	R344	10 k	½ W	ZC11177
L42	" " "		ZC12028	R345	4·7 k	1 W	ZC11371
L43	R.F. Choke		ZC12003	R346	15 k	1 W	ZC8557
L44	I.F. Tuning Coil		ZC11343	R347	·1 M	1 W	ZC0618
L45	" " "		ZC11344	R348	3 k	Variable	ZC11346
L46	" " "		ZC11345				

T. DESC. T-R.05 / 1-11B



T-DESC. T-R.05 / 1-12

FIG 12 THE RESPONSOR, TOP VIEWS OF THE CHASSIS



T-DESC. T-R.05 / 1-13

FIG. 13 I.F. BAND-PASS CURVES AT VARIOUS STAGES

RESPONSOR

(see figs. 11 (a), 11 (b), 12 and 13)

Introduction

49. The I. F. F. receiver, type ZC8931, or Responsor, type II, is a superheterodyne receiver designed for the reception of pulses of R. F. at a frequency between 157 and 187 Mc/s. It does not incorporate its own power supply, which it obtains from the associated equipment.

50. It is of robust construction, and weighs approximately 16 lb. It's power consumption is approximately 90 mA. at 265 volts, and 4·5 amps. at 6·3 volts.

General Description

51. Referring to the theoretical circuit diagram, (fig. 11a), the receiver will be seen to comprise one R.F. amplifier V1, followed by the local oscillator V2, and mixer diode V3. The five I.F. amplifier valves, V4, V5, V6, V7 and V8, operate at a mean frequency of 11 Mc/s. and a bandwidth of 4 Mc/s., the bandwidth being measured at-6 db. The gain of the first three I.F. valves is controlled by a variable resistance, R348A, included in their common cathode circuit.

52. Following the last I.F. valve V8, is the second detector diode V9, whose output is amplified by the valve V10. The amplified signal is then passed to the output socket on the front panel, and via a potentiometer R339A, R338A, to a terminal at the rear of the chassis.

53. A 75 ohm feeder from the receiving aerial system, connected to the plug P1 on the front panel, is terminated at a tapping of the inductance coil L40A, selected to provide a 75 ohm termination. This coil is tuned by inductance variation, effected by a movable silver plated brass plunger, to the incoming frequency, and the output voltage applied to the grid of valve V1 via condensers C160A and C160B in parallel, and grid leak R340A. The object of the parallel condensers is to reduce the inductance of the grid lead, which tends to restrict tuning range.

54. The valve V1 is biassed by the cathode resistance R332A, which is by-passed by the condenser C165B. The H.T. supply to the anode and screen is furnished via a resistance R333A, which in conjunction with decoupling resistance R335A, provides a test point for monitoring purposes.

55. The screen of V1 is decoupled by resistance R337A and condenser C165A. The anode load consists of series resistance R343A, and a shunt circuit consisting of blocking condenser C161A, tuning coil L41A, and resistance condenser combination R337B, C164A, C163A. Signal voltages developed on the anode of V1 are fed to the tuning coil, which is similar in construction to L40A, and thence from a tap on the coil to the anode of V3, the mixer diode.

56. The oscillator valve V2 has an oscillatory circuit consisting of inductance L42A tuned by condensers C160D and the series combination of C160C, C164A, and C163A in parallel (here again C164A and C163A are used instead of a single condenser, in order to reduce unwanted inductance). V2 receives its H. T. supply via the monitoring resistance R334A, and feed resistance R188B. A portion of the heterodyne voltage appears at the junction of C160C, C164A, and C163A, and this voltage is fed via L41A to the anode of the mixer diode V3. Inductance L42A is tuned by the same method as the R.F. circuits.

57. The cathode of V3 is shunted to earth for R.F., by condenser C161B, and I.F. voltages are fed to the coil L44A, which is shunted by resistance R334B. The operating bias for V3 is provided by resistance R337B, which is in series with the diode circuit and shunted by C164A and C163A.

58. Coil L44A, which is tuned by an iron dust core, constitutes the grid circuit of the first I.F. amplifier valve V4. A high resistance R341A, connected to the grid of V4 and to a socket on the side of the chassis provides a high impedance in series with the signal generator during alignment, thus avoiding damping of L44A.

59. The anode and screen circuit of V4 consists of monitoring resistance R333B, followed by decoupling resistances and condensers, R345A, C169A, R342A, C168C and C169B. The anode load consists of two resistances, R344A, and R344B in parallel, and anode stopper R330A, the output voltage being connected to the tuning coil and grid of the succeeding valve via condenser C167A. The cathode is connected to a gain control line, via resistance R331A, and is by-passed to earth via condenser C170B. The gain control line is similarly connected to the cathodes of V5 and V6, and is connected to earth via the gain control R348A, and decoupled by C172A, C171C, C168K and C168L. The shunt resistance R335J and bleeder resistance R347A are provided to give the required range of gain control.

60. The circuits of the remaining I.F. valves, V5, V6, V7 and V8, are similar to that of V4, except that the cathodes of V7 and V8 are not connected to the gain control line, and that extra damping resistances, R336A and R336B, are provided across L44B and L44C.

61. The top of the last I.F. coil L46A is connected to the cathode of the second detector V9, whose load is in the anode circuit, and which consists of resistance R335H shunted by condenser C166B. The negative D. C. pulses developed across R335H are applied to the grid of valve V10 via the I.F. stopping resistance R338B, and appear in amplified form as positive pulses at the anode. These pulses are applied via condenser C171B to the output socket on the front panel, and a portion of them, tapped off across R339A and R338A, to the output terminal at the rear of the chassis. The anode circuit of V10 is taken to a jack on the front panel for monitoring purposes.

62. The receiver does not incorporate its own power supply, which it draws from the associated equipment. To meet different requirements, two input plugs are provided, one on the front panel, and one on the rear flange of the chassis. These are wired in parallel. The rear one is used in this equipment.

Constructional Details

63. Three views of the receiver are given, side and front, top and rear in fig. 12, and underside of chassis in fig. 11 (*b*).

64. In fig. 12 the details of the R. F. tuning mechanism are shown. The tuning knobs are connected by flexible bellows, secured by grub screws, to an insulating coupling, which in turn is secured to the tuning plunger by a further grub screw. The insulating coupling carries a stop collar which in conjunction with the stop plate limits the travel in both directions.

65. The R.F. unit is easily removable from the main chassis, being held by four 4BA screws, some of which can be seen in fig. 12. To remove the R.F. chassis, the wires to the connecting strip are unsoldered, the aerial plug unplugged, and the fixing screws removed. [See fig. 11 (*b*)]. The grub screws on one end of the bellows couplings are then loosened, and the R. F. unit lifted out.

Installation

66. The receiver is tuned in a straight forward manner using a wavemeter I.F.F. No. 1 (W1310), and the dial readings when the signal is correctly tuned agree fairly closely. It is best to start with the gain turned well up and to locate the signal on the oscillator control, first setting the other two controls to their approximate positions. This can be done roughly if it is remembered that the tuning varies in a fairly linear manner from 157 Mc/s at about 2 on the dial to 187 Mc/s at about 14.

67. The method of tuning the oscillator circuit is as follows. Plug the A.A. No. 1 Mk. II meter plug into the test jack provided on the front panel (this is the socket labelled V10 on the test point panel, see fig. 1), and with the wavemeter or other source of signal tuned to the required frequency, tune the oscillator, R. F., and aerial controls until a minimum is obtained on the meter, reducing gain as necessary to prevent blocking (with low gain setting and no signal in tune the meter reads slightly more than full scale). Adjust the gain of the receiver until a deflection of about 1 milliamp is obtained. Now turn the oscillator control until a deflection of $4\frac{1}{2}$ mA. is obtained, and note the dial number and position of the arrow round the scale. Repeat, tuning the oscillator to the other side of resonance, and finally, set the oscillator control mid-way between the two readings obtained. This procedure ensures that the oscillator frequency is very nearly correct.

68. The R.F. and aerial circuits are now retuned to give minimum deflection on the meter, after which the receiver is correctly tuned. When tuning the receiver it must be remembered that over the bottom portion of the tuning range it is possible to receive the signal at two points of the oscillator control, and the setting with the lowest dial reading must be chosen.

Maintenance and Precautions

69. Frequent measurements of the performance of the receiver should be made to ensure that no deterioration has occurred, and it is a good plan to measure the performance on installation in order to have a basis of comparison for the particular set in question. These measurements are preferably made with the aid of a signal generator covering the range of 134 to 187 Mc/sec., having an accurately calibrated output, and a generator of 11·2 Mc/sec. A milliammeter covering the range 0-10 mA. is also required. The Avometer Model 7 or Model 40 is suitable. The meter is connected to a suitable plug and plugged into the test jack on the test point panel (V10).

70. In cases where a signal generator covering the R.F. range is not available, the R.F. can be obtained by using a Signal Generator U.S.W. No. 1, working on the 2nd harmonic. Under these conditions the attenuator readings give no indication of the true output in terms of the 2nd harmonic ; but they may be used for qualitative measurements provided that the figures obtained with one Signal Generator are not compared with those obtained with another, because the 2nd harmonic content will vary considerably with different Signal Generators. Where the Signal Generator U.S.W. No. 1 is used in this way, the figures given in the following tests must be modified accordingly, but the technique will be the same.

71. The measurements to be made are as follows :—

(*a*) Sensitivity.

(*b*) Signal to noise ratio.

(*c*) Image ratio.

(*d*) Bandwidth.

(*e*) Range of Gain Control.

In making these tests the local oscillator must be accurately tuned, and the method adopted is as follows :

A C.W. signal of the required frequency is fed into the R.F. input, and a signal of 11·2 Mc/s fed into the I.F. test points on the side of the chassis. The tuning of the local oscillator is now varied until a beat is produced between the intermediate frequency and the injected 11·2 Mc/sec. This beat can be observed either by an oscilloscope across the receiver output or by a headphone in series with the test meter. The receiver oscillator is now accurately tuned to the incoming R.F. signal, and the 11·2 Mc/sec. signal may be switched off. The method of making the various tests is described in the ensuing paragraphs.

Sensitivity and Signal to Noise Ratio

72. An R.F. signal of 40 microvolts is injected into the R.F. plug via a series resistance of 80 ohms, and the receiver is accurately tuned, the oscillator by the method described in (70), and the aerial and R.F. tuners by maximum deflection of the test meter. The gain control is now adjusted so that the change in current, shown by the test meter on shorting the 4th I.F. (V7) grid to earth, is three milliamps. The R.F. input is switched off, when the change in current due to the noise should not exceed 1 mA. This test is carried out at 157 and 187 Mc/sec. The sensitivity of the receiver must be sufficient to allow the signal to noise test to be carried out.

Image Ratio

73. The receiver is tuned to the incoming 40 microvolt signal as described above, and the gain control adjusted to give a reasonable deflection on the meter. The signal generator is now tuned to the image frequency, *i.e.*, the signal frequency minus about

22·4 Mc/sec., and the signal increased about 30 db. Final tuning of the signal generator is now carried out by the beat method previously described, taking care not to disturb the setting of the receiver controls, and the attenuator setting adjusted until the meter reading is the same as before. The difference, measured in db, between the attenuator readings for the true and image frequencies, should not be less than

29 db. at 157 Mc/sec.

27 " " 172 " "

25 " " 187 " "

Bandwidth

74. Tune the receiver to the signal generator and adjust the gain until the anode current of the amplifier valve is say 5 mA. Increase the signal by 6 db., and measure the two frequencies, one each side of the tune point, at which the anode current equals 5 mA. The difference between the frequencies should be between 4 Mc/sec. and 4·75 Mc/sec. This test should be carried out at 157, 172 and 187 Mc/sec.

Gain Control

75. With the gain control at minimum, a signal of 10 mV. injected into the R.F. input, with the receiver correctly tuned, should not cause saturation to occur.

76. If as a result of these tests, the performance is found to be unsatisfactory, the first step is to check up individual valves. To assist in this operation the test point panel is provided, where the current of each valve can be checked. Voltage readings on the test-points should not depart seriously from the figures given below :—

77. In the case of certain of the valves, the test-point readings are not always a true indication of the circuit's condition, and as a further check the anode voltages of these valves, taken with a meter of ½ Megohm resistance, *e.g.* an Avometer Model 7 on the 1,000 volt range are given :

V4	130 volts	With gain at maximum
V5	130 "	
V6	130 "	
V7	130 volts	With gain at minimum
V8	130 "	

78. If the receiver performs in a satisfactory manner, but has insufficient gain, the faulty section of the receiver can be discovered if, on installation, a check of the I.F. sensitivity has been made and recorded. A measure of this can be obtained by feeding in 11·2 Mc/sec. at the I.F. test socket, and noting how many millivolts it requires to give a reading of say 5 mA. on the test meter. It is best to do this with the gain control set at a value of 1000 ohms. If on later checks the signal required to give the same reading has seriously increased, the trouble can be looked for in the I.F. amplifier, second detector or amplifier. On the other hand, a satisfactory I.F. performance will indicate that the fault is in the R.F. unit.

79. Figure 13 shows stage by stage and overall sensitivity curves taken under the following conditions using a Signal Generator U.S.W. No. 1 with 14 ohm termination and metering in the V10 jack.

(*a*) Set gain control to give an effective resistance of 200 ohms, (*i.e.* R348A and R335J in parallel).

(*b*) Disconnect 5th I.F. (V8) grid (top cap) and note the anode current of V 10 with no signal input.

(*c*) Inject at different frequencies covering the I.F. band, and vary the Signal Generator output to produce the same drop (3·0 mA.) in the anode current of V 10 at each frequency.

Test Point Voltages

Taken with gain at maximum under no signal conditions

	AVO MODEL 7 : 10 V. RANGE	AVO MODEL 40 : 12 V. RANGE
+ to V1	2·0 volts	1·3 volts
+ to V2	3·0 "	1·5 "
+ to V4	3·0 "	2·0 "
+ to V5	2·5 "	2·0 "
+ to V6	3·0 "	2·0 "
+ to V7	3·0 "	2·0 "
+ to V8	3·0 "	2·0 "

Anode current V10. 8 mA.

(*d*) Plot Signal Generator output against frequency, using a log scale for the former, and so obtain curve 5 on figure 13.

(*e*) Repeat (*c*) and (*d*) at the remaining I.F. grids and at the I.F. test point, and plot curves as in (d). The curves should be similar to those shown in figure 13, and will indicate whether the I.F. circuits require re-tuning and/or re-aligning. If this is necessary, proceed as outlined in paragraph 81.

80. When the receiver is behaving normally, the voltage across the gain control varies smoothly between 0 and about 5 5 volts.

81. If an I.F. coil has to be replaced, or for any reason the I.F. circuits have to be realigned, the procedure to be adopted is as follows :—

Connect a signal generator capable of giving a signal at 9·2, 11 and 13·2 Mc/sec. to the I.F. input sockets, and plug the meter into the test jack. Adjust the gain control, with the receiver switched off, until the resistance of R348A and R335J in parallel, is approximately 800 ohms.

Tune circuits as follows :—

L45A and L45B to 9·2 Mc/sec.

L44A and L46A to 11·0 ,, ,,

L44B and L44C to 13·2 ,, ,,

Figure 13 shows the kind of I.F. response that should be obtained.

82. In the following fault-finding table, the receiver has been divided into two sections, the R.F. unit, and the I.F. chain and amplifier, and it is assumed that the location of the trouble in one or the other has been determined as described in (78) above. Certain faults which leave the gain almost unaffected, but which affect tuning range, can obviously be located by the behaviour of the various controls and trimmers.

Fault Finding Table

Faults in the R.F. Unit

83. Remember that disc type condensers may become open circuit while appearing mechanically sound.

SYMPTOM	FAULT	PROCEDURE
No signal	V2 not oscillating . .	Occasionally a VR137 will fail to oscillate even when the current is apparently correct. If on replacing V2, it still refuses to function, suspect the disc type condensers C162A, C165D. Inspect mechanically and replace if necessary.
	Faulty output lead . .	This is the screened lead connecting the R.F. unit to the first I.F. circuit. It may become open circuit. A short circuit in this lead is treated in a subsequent section.
Signal, but sensitivity about 40 db down.	(1) Mixer diode V3 faulty .	Replace V3, at the same time checking the bias resistance R337B for open circuit.
	(2) Aerial tap disconnected from coil. Short in connecting feeders .	Continuity test between inner and outer of R.F. input plug should show short circuit. Disconnect and apply continuity test.
Signals weak, up to 20 db down	V1 faulty, or circuit fault .	Check test point volts and, if necessary , replace V1. Check bias resistance and inspect by-pass condensers.
Signals weak, associated with inability to tune to bottom end of range on R.F. tuner.	Coupling capacity C161A open circuit.	Replace C161A.
Signals practically normal, unable to tune to bottom end of range on aerial tuner.	C160A or C160B open circuit.	Inspect and replace faulty component. (Note that when examining the ceramic condensers, a gentle tug with pliers is sometimes required to show up an open circuit).
Signals practically normal, oscillator tuning range limited at bottom end.	Tuning capacities C160C or C160D open circuit.	Inspect and replace faulty condensers.

Faults in I.F. Amplifier and Output Stage

84. (*a*) To localise faults in this section of the receiver it is a good plan to feed 11·2 Mc/s. on to the grids of the I.F. valves in turn, commencing with the last one, V8. A signal of ·1 volt on the grid of V8 should cause a change in anode current of V10 of about 2 to 3 milliamps.

(*b*) A progressively smaller signal on the grids of the earlier I.F. valves will give the same output until the faulty stage is reached. The gain of individual I.F. stages at 11·2 Mc/sec. is about 10.

SYMPTOM	FAULT	PROCEDURE
No signals. No output when feeding on to grid of V8.	(1) Short circuit in screened lead to output.	Galvo.
	(2) V10 faulty . . . (3) Open circuit test jack or leads to test panel.	If output meter registers zero current, and replacing V10 does not cure fault, test leads to test jack for continuity, and examine jack contacts.
	(4) V9 faulty . . . (5) V8 faulty . . . (6) Associated circuit fault .	Replace if necessary. If test point figure for V8 is correct, check anode volts as described in paragraph 77, and check resistances and coil L46A for continuity.
Output from grid of V8, but no output when feeding on to preceding grid.	(1) Faulty valve . . . (2) Associated circuit fault .	Check as above for circuit faults. (This procedure is applied to each valve in turn).
Output from grid of V7, but no output from grids of V6, V5 and V4. No reading on test points of V4, V5 and V6.	Gain control R339A open circuit.	Test for continuity control and leads. Replace where necessary.
Output from grid of V4, but no signal from I.F. test sockets.	Short circuit on connecting lead to R.F. unit.	Disconnect and test for continuity.
Low gain . . .	(1) Faulty valve . . . (2) Open circuit I.F. coil L44A, L45A, L44B, L45B, L44C or L46A.	Check test point voltages. If no serious discrepancies, replace valves one at a time. This in general causes a serious loss in gain, but does not cause the receiver to cease functioning. A simple continuity check between grids and ground will disclose any open circuit.

SYMPTOM	FAULT	PROCEDURE
	(3) Open circuit coupling condenser C167A, C167B, C167C, C167D, C167E.	In this case the loss in gain is more serious. After locating the faulty stage by methods previously described, remove suspected condenser and replace.
Range of gain control excessive	R335J open circuit . .	Test between gain control line and earth. Resistance should be just under 2,000 ohms when the gain control is fully anti-clockwise.
Receiver functions normally with test meter plugged in, but stops on unplugging meter.	Jack contacts faulty . .	Inspect jack, and if necessary bend contacts to ensure completeness of circuit on removing plug.

85. Many of the small condensers in the receiver can be open circuit without causing any change in gain or change in valve currents. The main effect of any such open circuit is to modify the shape of the I.F. response due to the introduction of feed-back at signal frequency, and where any such fault is suspected, not much more than a thorough mechanical inspection can be attempted. The I.F. alignment can be checked as outlined in paragraph 81.

86. If the receiver remains paralysed for more than about 50 microseconds after the interrogator pulse, suspect the 50 µF. by-pass condenser C172A.

FAULT TABLE

87. If the equipment becomes inoperative the first steps are to decide if the fault is in the equipment itself, and if so in which part, or external to the equipment.

88. If it is assumed that the main A.A. No. 1, Mk. II equipment is functioning normally, this automatically clears the possibility of a failure in the locking and signal selector voltages, but note should be made of the faults outlined below.

89. Operation of the Interrogator is automatically checked by the indicating lamp.

90. If transmission is normal but no breaks appear on the trace, the fault is probably in the Responsor, in which case see separate Faults Table on page 31.

91. If trace is absent from tube, or if above checks do not show up the fault, the Display Unit must be checked.

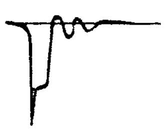
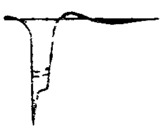
92. **Interrogator Faults**

SYMPTOM	FAULT AND PROCEDURE
No output visible on indicating lamp .	Insufficient locking voltage from A.A. No. 1, Mk. II transmitter. The voltage may be enough to operate the main A.A. No. 1, Mk. II equipment, but not enough for the Interrogator. To check locking voltage, connect a lead between the locking cable input terminal (75) on front of II B and the right hand spring contact (f), visible when the I.F. door is opened. The voltage will then be visible on the 'R' tube, if the Setting Switch is set to position 2 and range time base to low speed. The tube sensitivity is approx. 60 V/cm., and the voltage should be at least 60 V. If lower voltage is obtained, check electrical connexions between A.A. No. 1, Mk. II transmitter and receiver, and locking line. Interrogator bias too high, see page 12.
Output visible on indicating lamp	Incorrect polarity of aerial feeders. This can only occur if feeder plugs have been replaced and wrongly connected. For correct connexion see fig. 5. If lamp is bright, and trace on tube is disturbed and raised above its normal position, it is possible that the interrogator has gone into C.W. oscillation due to incorrect setting of bias control. see page 12.

Display Unit Faults.

93. To check one of the functions of the Display Unit (the production of a modulator pulse) the Range tube of the main A.A. No. 1 Mk. II equipment may be used in a similar manner to that described for examining the locking pulse voltage. In this case a lead is taken from cathode V21B to the spring contact inside the I.F. door which is connected to the 'Y' plate of the range tube. The correct shape for the modulation pulse is given below; it will be noted that when the transmitter operates, the grid current flowing back down R189B, etc. reduces the modulation voltage, and thus produces the "stepped" shape of the pulse.

The presence of this step can be taken as an indication that the interrogator is functioning. The following faults are based on incorrect pulse shapes obtained on the 'R' tube.

PULSE SHAPE	FAULT AND PROCEDURE
	Correct pulse shape. Note: Pulses are "upside down" owing to sense of connexion of the Range tube vertical plates.
	Modulation pulses repeated owing to ringing circuit (L28A, C103A) damping not being sufficient. This damping is mainly due to the low impedance of the locking line, so check the 100 ohm resistance in the locking line switch box on front of A.A. No. 1, Mk. II equipment (Section IIB). Check diode V17E. Check V22A for loss of emission.
	Presence of suppressed pulses is shown at bottom of modulator pulse. If these are more than 50 per cent. of the amplitude of the modulation pulse proper, the grid base of V22A is incorrect, and the valve must be replaced. Alternatively, check V21 C and D.

94. **Faults visible on Display Unit C. R. T. Screen**

SYMPTOM	FAULT AND PROCEDURE
Trace does not travel full width of tube	Fault in V21G circuit. Check voltages or replace valve.
Trace starts too near centre of tube or too far to the left.	Check R218A, R209C, and R297B.

SYMPTOM	FAULT AND PROCEDURE
No trace on tube	Check voltages on tube, and try replacement tube. If fault is not cured. the Kipp relay valves V22B and V18E are probably not working. Test valve voltages and currents (see page 23).
	The current in valves V22A, V21C & D, and V18E is affected by the presence of locking and signal selector voltages. In the case of V22A, the current will be slightly lower than that quoted on page 20, say 2·0 mA if no locking pulse is arriving.
	V21C and D currents depend quite a lot on the setting of the recurrence frequency, but if no locking pulse is arriving, the multivibrator will run at a slightly slower frequency, with the result that V21C current will be higher, (say 24·0 mA), while V21D may be lower (say 0·65 mA) than normal. If the frequency dividing multivibrator is not operating owing to a fault in the circuit the anode currents of the two valves will be affected, being much higher in the case of the V21D, and lower in V21C than normal. V18E current is affected by strobe or selector voltage as well as locking voltage. It will be of the order of 8·0 mA if no selector voltage is arriving.
Unexplainable breaks on trace. The range of these breaks is often varied by altering the Responsor oscillator tuning.	These may be caused by parasitic oscillations emanating from the main A.A. No. 1 Mk. II equipment. A possible source is the signal selector valve V8A, which can be cured by inserting a 50 ohm ¼ W. resistance in the screen circuit of the valve.

FIELD SETTING UP PROCEDURE

95. (*a*) When installation is complete check all connexions with fig. 14.

(*b*) Check all dipole lengths and spacings, including matching unit bars and line with the table on page 13.

(*c*) Set up Interrogator to correct frequency in accordance with details given on page 12.

(*d*) Switch on equipment. The main A.A. No. 1, Mk. II switch must be closed and the supply voltage checked on M2A.

(*e*) Switch on main A.A. No. 1, Mk. II equipment and ensure that a locking pulse is arriving from the transmitter.

(*f*) A trace should now be obtained on the Display Unit tube.

(*g*) The Responsor may now be adjusted by tuning, first oscillator and then R.F. and aerial, (see page 29) for maximum signal. A wavemeter may be required for initial adjustments.

(*h*) If the cabin is now rotated, any prominent local echoes should be noted on the Display Unit tube. If the whole trace jumps slightly to and fro, the Recurrence frequency should be varied until a stationary picture is obtained.

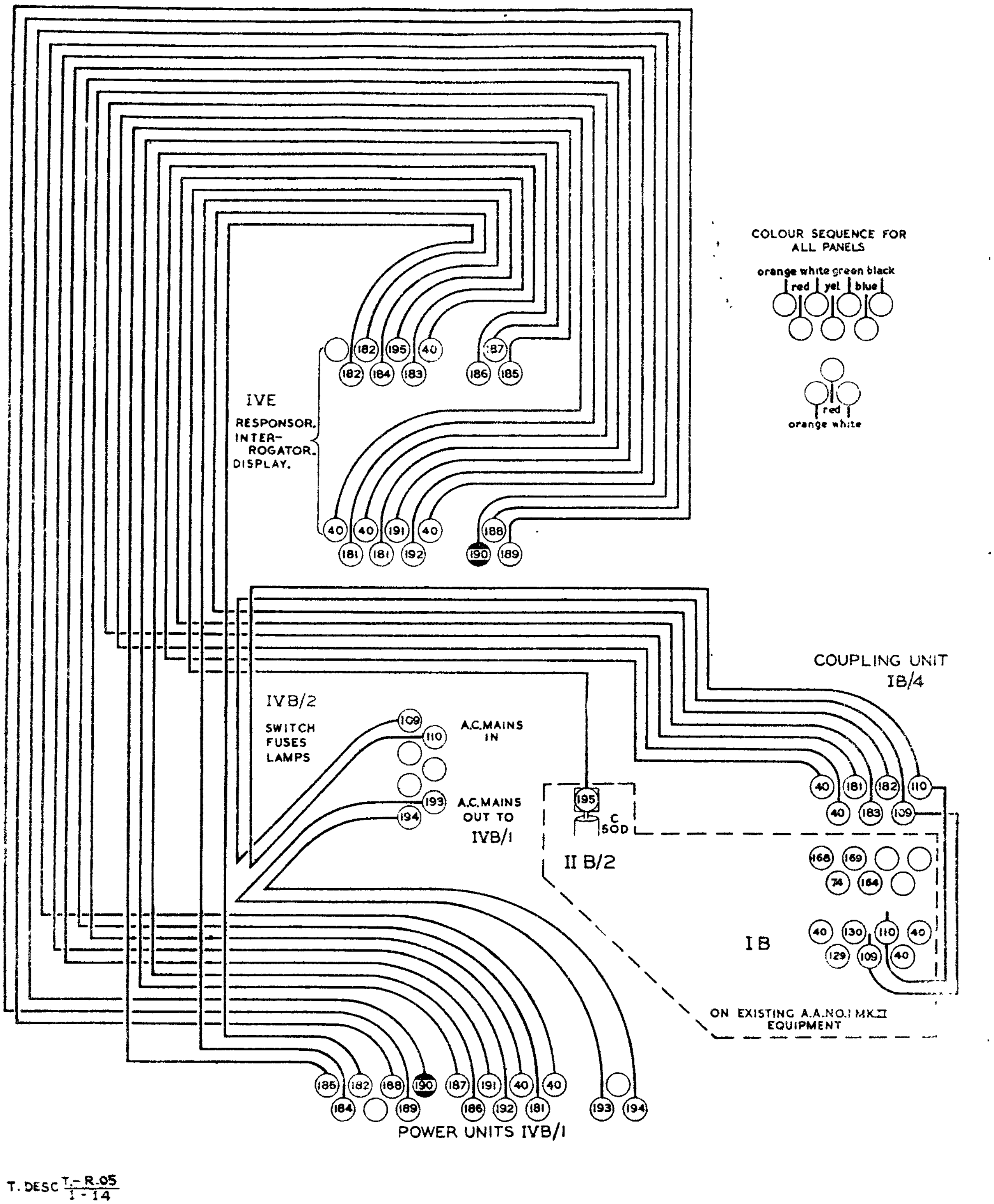


FIG. 14 DIAGRAM OF THE CABLE FORM

PARTS LIST

The complete equipment consists of the following :—

Cat. No.	Designation		No. Off
*ZC 10025	Aerial Equipment complete comprising :—		1
*ZC 10026	Aerial Units Radar No. 1 (a)	2 off	
ZC 13093	Tie-bar, graduated	2 ,,	
ZC 10027	Matching Unit Radar No. 1	1 ,,	
ZC 12814	Connector, Radar, twin No. 12	2 ,,	
ZC 12815	Connector, Radar, twin No. 13	1 ,,	
ZC 12816	Connector, Radar, coaxial No. 5	1 ,,	
ZC 13087	Cable support assembly (a)	1 ,,	
*ZC 10016	Unit IVE consisting of :—		1
ZC 8932	Unit IVE/2 (Display)	1 off	
ZC 8930	Unit IVE/3 (Interrogator)	1 ,,	
ZC 8931	Unit IVE/1 (Responsor No. 2)	1 ,,	
*ZC 10020	Frame Supporting Unit IVE		1
ZC 10017	Unit IVB/1 (Power Unit)		1
*ZC 10021	Support, unit IVB/1 (a)		2
ZC 10018	Coupling unit, Radar No. 1		1
*ZC 10019	Unit IVB/2 (fuse panel assembly)		1
*ZC 10022	Cable form No. 3 (a)		1
*ZC 10023	Case minor spares, No. 4		1
*ZC 10024	Frame, supporting cases (a)		1
*ZC 13187	Strip, safety device		1
*ZC 13188	Clamp assembly, spare C.R.T.		1
*ZC 13189	Bolts, cup head, square, 3/8″ × 3½″ special		4

Note. (a) Complete with all necessary fixing screws, bolts, etc.

Various items on the above list are further sub-divided and held as stores as follows :—
Electrical components for all units are given at the end, together.

Cat. No.	Designation	No. Off
*ZC 10025	Aerial equipment, complete includes the following :—	1
ZC 13091	Screw, 2 BA, special for securing Matching Unit	2
ZC 13092	Plate, securing, for above	2
ZC 13182	Bolt, securing tie bars	4
ZC 13095	Label, aerial connexions	1
ZC 13088	Bolts securing aerial support frames	4
ZC 13089	Clamp plate for above	4
ZC 13090	Hand nut for above	4
*ZC 10026	Aerial Units Radar No. 1 comprising :—	2
*ZC 10028	Bar, dipole support, complete	2
ZC 13096	Bar, dipole support, less aerials	2
*ZC 10029	Bar, director support, complete	2
ZC 13097	Bar director support, less directors	2
ZC 13098	Plate, securing directors and reflectors	8
ZC 13099	Clamp, ,, ,, ,, ,, ,,	8
ZC 13100	Aerial tube, directors and reflector, outer	8
ZC 13101	Clamp nut, for aerial tubes	8
ZC 13102	Ferrule, for aerial tubes	8
ZC 13103	Aerial tube, directors and reflector, inner	16
ZC 13104	Clamp, for aerial tubes	10
ZC 13105	Clamp assembly for folded dipole	2

* Shows parts not normally kept in Ordnance Stores as spares.

Cat. No.	Designation	No. Off
ZC 13106	Insulator for folded dipole	2
ZC 13107	Socket assembly for folded dipole	2
ZC 13108	Aerial tube, folded dipole, outer	2
ZC 13109	Aerial tube, folded dipole, top outer	2
ZC 13110	Aerial tube, folded dipole, lower outer	2
ZC 13111	Aerial tube, inner, " U " shape	4
ZC 13112	Cover, moulded, folded, dipole	2
	Block, cable support	2
ZC 13113	Clamp, cable support	2
ZC 13114	Nut, cable support	2
ZC 13115	Plate, securing for aerial support bars	8
ZC 13116	Bolt, $\frac{1}{4}''$ Whit, for above	8
ZC 10027	Matching Unit Radar No. 1 includes the following :—	1
ZC 2585	Socket assembly	3
ZC 13117	Support, moulded, for Q bars	2
ZC 13118	Clamp, moulded, for Q bars	2
ZC 13119	Tube, Q bar (outer)	2
ZC 13120	Connector plate for Q bars	2
ZC 13121	Tube, Q bars (inner)	2
ZC 13122	Clamp assembly, tapping for Q bars	2
ZC 13123	Screw securing clamp	2
ZC 13124	Insulator, moulded for above	1
ZC 13125	Cover	1
ZC 13126	Matching loop assembly	1
ZC 13127	Matching loop, spare	1
ZC 13128	Clamp, cable, No. 1	2
ZC 8932	Unit IVE/2 (Display) includes the following :—	1
ZC 4007	Blocks, terminal, 7 way No. 2	2
ZC 2603	Bushes, S.P.	4
ZC 2584	Caps, valve, No. 4	3
ZC 11913	Caps, valve, No. 10	2
ZC 11926	Grommets, rubber No. 12	3
ZC 11927	Grommets, rubber No. 13	7
ZC 4736	Grommets	3
ZC 4812	Handle, No. 15A	4
ZC 10754	Holders, valve, 3-pin, No. 3	2
ZC 0597	Holders, valve, British octal, No. 1	10
ZC 4038	Keys	4
ZC 4781	Packings, for socket assembly jack	8
ZC 11950	Saddles, C.R.T. No. 1	4
ZC 11951	Screens, C.R.T. No. 1	2
ZC 4174	Screws, thumb, No. 5	4
ZC 11952	Sockets, C.R.T. No. 2	1
ZC 4178	Spindles, extension, No. 2	4
ZC 11954	Tag assembly, No. 1	1
ZC 11955	Tag assembly, No. 2	1
ZC 11956	Tag assembly, No. 3	1
ZC 11957	Tag assembly, No. 4	1
ZC 8930	Unit IVE/3 (Interrogator) includes the following :—	1
ZC 11974	Bar, lecher, shorting	3
ZC 11975	Bars, lecher, shorting, tapped	3
ZC 4080	Blocks, terminal, 3 way, No. 2	2
ZC 4007	Blocks, terminal, 7 way, No. 2	2
ZC 11976	Bolts, special, No. 2	1
ZC 11977	Brackets, moulded, double	1
ZC 11978	Brackets, moulded, single	1
ZC 11979	Cable form, No. 2	1
ZC 11983	Clip, assembly, aerial	2

Cat. No.	Designation	No. Off
ZC 11261	Connectors, valve, No. 4	4
ZC 4736	Grommets, rubber	1
ZC 11097	Holders, valve, 3-pin, No. 4	1
ZC 2641	Holders, valve, octal, No. 2	2
ZC 11985	Leads, aerial	1
ZC 11986	Lecher assembly, curved	4
ZC 11987	Lecher assembly, straight	2
ZC 11988	Nuts, special, No. 2	1
ZC 11989	Panels, No. 1	1
ZC 11991	Panel assembly No. 2	1
ZC 11992	Panel supporting lecher shorting bars	2
ZC 11993	Panel, valve retaining	1
ZC 11994	Plates, condenser, fixed (C114)	2
ZC 11960	Plates, condenser, moving (C114)	2
ZC 11961	Screw, fixing, for 3-pin valve holder	2
ZC 11962	Spring, retaining for 3-pin valve holder	2
ZC 2585	Sockets, coupling, aerial	1
ZC 11414	Tags, insulated, No. 2	1
ZC 10017	Unit IVB/1 (Power Unit) includes the following :—	1
ZC 4080	Blocks, terminal, 3-way No. 2	2
ZC 4007	Blocks, terminal, 7-way No. 2	2
ZC 4736	Grommets	1
ZC 11966	Holders, valve, 5-pin, No. 11	4
ZC 11968	Tag assembly, No. 5	1
ZC 13352	Valve retainer No. 22	1
ZC 11967	Valve retainer No. 14	3
ZC 10018	Coupling Unit Radar No. 1, includes the following :—	1
ZC 11972	Adaptors No. 1	1
ZC 4007	Blocks, terminal 7-way, No. 2	1
ZC 0597	Holders, valve, British octal No. 1	1
ZC 11973	Tag assembly No. 6	1
*ZC 10019	Unit IVB/2 (fuse panel assembly) includes the following :—	1
ZC 2604	Holders, lamp, assembly, 2-point	2
ZC 2598	Holders, fuse No. 4	2

*Shows parts not normally kept in Ordnance Stores as spares.

ELECTRICAL COMPONENTS (All Units).

Vocab. No.		Value		Circuit Ref. No.	No. Off.
ZC 3260	3 μμF		500 V.	C160	4
ZC 12005	5 μμF		500 V.	C161	2
ZC 12006	10 μμF		500 V.	C162	1
ZC 12007	15 μμF		500 V.	C163	1
ZC 12008	25 μμF		500 V.	C164	1
ZC 12009	50 μμF		500 V.	C165	9
ZC 3527	100 μμF		500 V.	C166	2
ZC 12010	200 μμF		350 V.	C167	5
ZC 11914	400 μμF	± 2 per cent.		C107	1
ZC 11305	500 μμF	± 2 per cent.		C103	2
ZC 0136	500 μμF		350 V.	C168	11
ZC 11915	500 μμF			C94	2
ZC 2667	·001 μF		4,000 V.	C23	1
ZC 11916	·001 μF			C92	6
ZC 2694	·002 μF			C58	1
ZC 12011	·002 μF		400 V.	C169	10
ZC 11917	·0023 μF			C105	1
ZC 11918	·003 μF	± 2 per cent.		C112	1
ZC 11919	·005 μF			C98	1
ZC 11920	·0075 μF	± 2 per cent.		C111	2
ZC 11921	·01 μF	± 2 per cent.		C108	4

Vocab. No.	Value			Circuit Ref. No.	No. Off.
ZC 12012	·01 μF		400 V.	C170	9
ZC 11923	·1 μF			C87	1
ZC 11922	·1 μF			C104	8
ZC 12013	·1 μF		400 V.	C171	3
ZC 11924	·5 μF			C106	3
ZC 11959	·5 μF		2,500 V.	C115	2
ZC 2654	2 μF			C14	1
ZC 2656	4 μF			C46	1
ZC 2663	8 μF			C44	4
ZC 11965	16+16 μF Electro.			C148	2
ZC 11925	25 μF 25 V. Electro.			C110	2
ZC 3278	50 μF 12 V. Electro.			C172	1
ZC 2562	Choke 9·5 H			CK4	2
ZC 0038	Fuse 2A			F3	2
ZC 2623	Jack socket			J1	8
ZC 11929	2 mH			L28	1
ZC 11980	R.F. Choke			L29	3
ZC 11981	,, ,,			L30	1
ZC 11982	,, ,,			L31	2
ZC 12030	,, Tuning Coil			L40	1
ZC 12029	,, ,, ,,			L41	1
ZC 12028	,, ,, ,,			L42	1
ZC 12003	,, Choke			L43	2
ZC 11343	I.F. Tuning Coil			L44	3
ZC 11344	,, ,, ,,			L45	2
ZC 11345	,, ,, ,,			L46	1
ZC 11168	3 ohms	± 5 %	½ W.	R190	2
ZC 11940	7·5 ,,	± 5 %	½ W.	R199	3
ZC 11370	27 ,,		¼ W.	R330	5
ZC 11260	50 ,,	± 5 %	½ W.	R228	3
ZC 14776	50 ,,	± 5 %	¼ W.	R155	1
ZC 11228	100 ,,	± 20 %	¼ W.	R309	2
ZC 11146	100 ,,	± 10 %	¼ W.	R313	1
ZC 11146	100 ,,	± 10 %	¼ W.	R331	6
ZC 3647	180 ,,		¼ W.	R332	1
ZC 8520	400 ,,	± 10 %	¼ W.	R314	1
ZC 13022	470 ,,		¼ W.	R333	6
ZC 8519	500 ,,	± 10 %	¼ W.	R315	2
ZC 11245	1,000 ,,	± 20 %	¼ W.	R201	2
ZC 1387	1,000 ,,	± 10 %	¼ W.	R311	1
ZC 9926	1,000 ,,		½ W.	R342	5
ZC 11340	1,500 ,,	± 5 %	¼ W.	R152	1
ZC 11944	1,500 ,,	± 5 %	1 W.	R207	1
ZC 7302	1,500 ,,	± 10 %	¼ W.	R299	1
ZC 11246	2,200 ,,	± 20 %	¼ W.	R183	1
ZC 11945	2,200 ,,	± 5 %	2 W.	R208	1
ZC 3651	2,200 ,,		¼ W.	R334	2
ZC 11346	3,000 ,,	Variable		R348	1
ZC 3652	3,300 ,,	± 10 %	¼ W.	R187	1
ZC 11247	4,700 ,,	± 20 %	¼ W.	R196	3
ZC 11254	4,700 ,,	± 20 %	½ W.	R205	1
ZC 11948	4,700 ,,	± 20 %	5 W.	R206	1
ZC 0305	4,700 ,,		¼ W.	R335	9
ZC 11371	4,700 ,,		1 W.	R345	5
ZC 11341	5,000 ,,	± 5 %	½ W.	R164	2
ZC 10933	5,000 ,,	± 5 %	1 W.	R232	1
ZC 11949	6,800 ,,	± 20 %	5 W.	R191	1
ZC 10929	6,800 ,,	± 5 %	½ W.	R319	1
ZC 3659	6,800 ,,		½ W.	R343	1

Vocab. No.	Value			Circuit Ref. No.	No. Off
ZC 13351	10,000 ohms	± 5 %	1 W.	R166	1
ZC 11248	10,000 „	± 20 %	½ W.	R184	3
ZC 11253	10,000 „	± 20 %	½ W.	R193	2
ZC 11255	10,000 „	± 20 %	1 W.	R203	1
ZC 3823	10,000 „		¼ W.	R336	2
ZC 8535	10,000 „		½ W.	R344	10
ZC 14288	12,000 „	± 2 %	½ W.	R328	1
ZC 10979	15,000 „	± 5 %	1 W.	R169	1
ZC 3655	15,000 „	± 10 %	¼ W.	R325	1
ZC 8557	15,000 „		1 W.	R346	2
ZC 10930	20,000 „	± 5 %	½ W.	R162	1
ZC 11257	20,000 „	± 5 %	¼ W.	R316	1
ZC 11946	22,000 „	± 5 %	2 W.	R217	1
ZC 11251	22,000 „	± 20 %	¼ W.	R223	1
ZC 11176	22,000 „		¼ W.	R337	3
ZC 11931	25,000 „	Variable		R173	1
ZC 11930	25,000 „	Preset		R323	1
ZC 14289	30,000 „	± 2 %	½ W.	R327	1
ZC 11180	33,000 „	± 10 %	½ W.	R186	1
ZC 11934	33,000 „	± 20 %	¼ W.	R219	1
ZC 11252	47,000 „	± 20 %	¼ W.	R189	3
ZC 0297	47,000 „		¼ W.	R338	2
ZC 2777	50,000 „	± 5 %	2 W.	R10	1
ZC 11317	50,000 „	± 5 %	1 W.	R214	1
ZC 11258	50,000 „	± 20 %	¼ W.	R317	1
ZC 3670	68,000 „	± 10 %	1 W.	R188	2
ZC 11173	68,000 „		¼ W.	R339	1
ZC 11249	·1 megohm		¼ W.	R340	1
ZC 0618	·1 „		1 W.	R347	1
ZC 11249	·1 „	± 20 %	¼ W.	R194	3
ZC 10931	·1 „	± 5 %	½ W.	R221	3
ZC 11932	·1 „	Variable		R224	1
ZC 11935	·15 „	± 5 %	¼ W.	R320	1
ZC 11936	·22 „	± 20 %	¼ W.	R202	2
ZC 11937	·3 „	± 5 %	¼ W.	R318	1
ZC 11259	·47 „	± 20%	¼ W.	R212	1
ZC 11947	·47 „	± 20 %	2 W.	R220	1
ZC 11933	·5 „	Variable		R225	1
ZC 11212	·5 „	± 20 %	¼ W.	R300	2
ZC 11942	·75 „	± 5 %	½ W.	R210	1
ZC 10932	1 „	± 5 %	½ W.	R209	3
ZC 11209	1 „	± 20 %	¼ W.	R297	5
ZC 12041	1·8 megohms		¼ W.	R341	1
ZC 11938	2·2 „	± 20 %	¼ W.	R222	1
ZC 11347	3·5 „	± 5 %	½ W.	R218	1
ZC 11250	10 „	± 20 %	¼ W.	R198	5
ZC 2589	Mains Switch			S2	1
ZC 11953	Time Base Switch			S22	1
ZC 0042	Signal lamp			SL1	2
ZC 1814	Pilot „			SL4	1
ZC 11958	Indicator transformer			T18	1
ZC 11971	Mains Transformer			T19	1
ZC 11970	„ „			T20	1
ZC 11969	„ „			T21	2
ZC 3679	VCR 138			CRT3	1

END.

(51553/120/2/MG-ME-12.)