Duncan's Amp Pages

Avo CT-160 in use - last updated 26/08/06 21:34:52

Home
Up

This page contains instructions on how to use the Avo CT-160 portable tube tester. It's a rough guide, no more, but will get you up an running. It will also show you how to test the tubes with no manual.

WARNING

Warning - the CT-160 generates high voltages which are present within the test area and accessible to the operator. Do not insert or remove tubes with the power switched on.

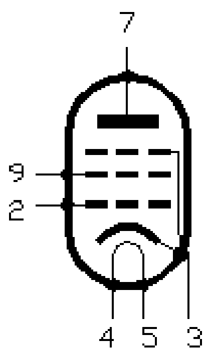
In addition, the mains voltage selector presents mains voltage to the operator if the flap is lifted - there are **no** safety interlocks. Again, do not adjust the mains voltage taps with the unit switched on.

An Example

For this example, we will test a 6BQ5/EL84 tube using nothing other than information available in a standard tube manual. In the USA, Essential Characteristics [General Electric] is an excellent book. For UK/European tubes, Radio Valve and Transistor Data [Ball, A.M.] will provide you with plenty of information.

If you don't have any tube manuals, you can visit the **Tube Data Sheet Locator** online which provides sufficient information to test many vacuum tubes.

For our example, we will do just that. On the right is the pinout diagram for the 6BQ5.



From the TDSL we can obtain some characteristic data on this tube. First the ratings and filament voltages:

Vh V	Ih A	Va max V	Vg2 max V	Vh-k max V	Pa max W	Pg2 max W	Ik max mA	Notes
6.3	0.76	300	300	100	12	2	65	Max Pg2 = 4W for music/speech short term

The useful information here, is that Vh (heater or filament voltage is 6.3). Now we need to gather some static test data:

Mode	Va V	Vg2 V	Vg1 V	Ia mA	Ig2 mA	Ra Ohms	S ma/V	Rk Ohms	Zout Ohms	Pout W	THD %
A S/E	250	250	-7.3	48	5.5	38,000	11	135	5,200	5.7	10

A S/E (triode)	250			34-36				270	3,500	1.95	9
A P/P (triode)	300			48-52				270	10,000	5.2	2.5
AB1 P/P	250	250	-11.6	20-75	2.2-15				8,000	11	8
AB1 P/P	250	250		62-75	7-15			130 shared	8,000	11	8
AB1 P/P	300	300		72-92	8-22			130 shared	8,000	17	10
AB1 P/P	300	300	-14.7	15-92	1.6-22				8,000	17	10
AB1 P/P (triode)	250			40-43.4				270	10,000	3.4	2.5

Only the first three lines are of interest, the remainder are for push-pull applications. The first line provides some class A static conditions which will be ideal for our test purposes.

Testing preamp and power tubes

1. **Setting up**. With the power switched off, plug the tube to be tested into an appropriate socket, and set all of the following switches.

2a. **Circuit switch**. Ensure this is on "Set~".

2b. **Pinout thumbwheel switches**. These must be set to match the pinout of the tube. There are nine thumbwheel switches which correspond to up to 9 pins on a tube. Please ignore the numbers on the thumbwheel switches - they are **not** the tube pin numbers!

Running through the nine switches, we get the following mapping onto the 6BQ5 pinout:

Switch	Setting
1	[O] (open circuit)
2	[4G] G = grid
3	[1C] C = cathode
4	[2H-] H- = heater -
5	[3H+] H+ = heater +
6	[O]
7	[6A] A = anode (plate)
8	[O]
9	[5S] S = screen

Again, ignoring the numbers on the wheels (they are for correlation with the handbook), the markings around each thumbwheel are **[O]** = Open circuit, **[1C]** = Cathode, **[2H-]** = Heater-, **[3H+]** = Heater+, **[4G]** = Grid, **[5S]** = Screen, **[6A]** = Anode (plate), **[7A2]** = Anode2, **[8D1]** = Diode anode 1, **[9D2]** = Diode anode 2.

You will notice A1 and A2 links within the test area. These are for putting resistors in while testing magic eye tubes. Careful, the links are "hot".

2c. Voltages. Set the neg grid volts, heater volts, anode volts and screen volts to appropriate values. From the table above, these would be -7.3, 6.3, 250 and 250. Take care with the toggle switch above the heater voltage selector - this flips in a whole different set of heater voltages.

2d. Current. The CT-160 (and other Avo tube testers) measure current by using a bridge method. The two current switches are set to where you think the current will be, then adjusted to balance the bridge - more on this later. In the meantime, we are looking for 48mA or thereabouts, so set the units dial to 8 and the tens dial to 40.

3 Power up. Switch on the mains supply, and wait for the unit to stabilise for a couple of minutes. At the top of the meter is a red **~** at the end of the scale. This is the calibration point. Should it read a little low after warming up, switch off and knock the mains tap down to the next lower voltage. Equally, if it is reading high, then knock it up a little.

Note that if the meter is reading really low, and you feel that the mains voltage is about right, then your CT-160 may be in need of repair or service. Don't tap down any further than what you believe is a reasonable value for your local mains supply.

4a. Heater continuity. Rotate the circuit selector to H/CONT. This will test the heater continuity. If the meter drops down to zero, then you have an open circuit heater. Bye bye tube...

4b. Electrode insulation. Ensure the electrode selector is at A1 (for anode 1), and rotate the circuit selector to A/R. this measures the insulation between the Anode/Rest of the electrodes. You can read the number of megohms of insulation of the dial. Treat any movement with total suspicion. Flip between A1 and A2 for twin triodes etc.

Rotate the circuit selector to S/R (Screen/Rest) and C.H/R (Cathode+Heater/Rest). Again, there should be no noticeable movement of the meter.

4c. Cathode / Heater insulation. Rotate the circuit selector to C/H (Cathode/Heater) - the tube heater will be energised at this point. Keep an eye on the meter as the tube warms up.

You will have to use your own judgement on what is acceptable as leakage between cathode and heater. 0.25meg might be acceptable for a power tube in a fixed-bias configuration, but no good for a cascode amplifier.

4d. Anode current. When the tube has warmed up for a couple of minutes, rotate the circuit selector to TEST. At this point, the high voltages will be applied to the tube. If the buzzer sounds and the dial lights up red, then there is likely a fault with the tube (like grid shorted to cathode) - check this with a multimeter.

If the tube lights up like a firework or UV lamp, then it's full of gas - throw it away...

Balancing the bridge - at this point, our desire is to have the meter reading zero. That's right, zero! If the meter goes off the right hand side of the scale, increase the current units/tens switches to compensate. If the meter goes off the left hand side of the scale, reduce the current switches.

Hover around zero, and let the tube stabilise for a little longer. This is especially important if a power tube is being tested, as the internal structure will move around a little due to the increase heat from having B+ applied. Make minor adjustments to the current as necessary, and finally read the current off the two current controls, not the meter!

4e. Mutual conductance. Or gm, or transconductance - an important measure of the effectiveness of a tube to amplify a signal. Assuming that the current from step 4d is in the right ball park, rotate the Set ma/V dial slightly so that the pointer is in the set zero range. This intensifies the sensitivity of the bridge, and while holding in this position, make further fine adjustments to the current controls to bring back our zero balance.

In our 6BQ5 example, we are looking for around 11 mA/V on a good tube. Continue to rotate the Set mA/V dial round to correspond to 11 on the dial - this is somewhere between the markings of 10.0 and 12.5 on the dial.

The meter needle will rise, and you can use the **Replace** and **Good** indicators on the meter to give an indication of the effectiveness of the tube. If you want to measure gm more accurately, alter the Set mA/V dial to a point where the meter needle lines up with 1mA/V above the **Good** section. Simply read the actual gm off the Set mA/V dial.

4f. Gas test. Release the Set mA/V dial and rotate the circuit selector to Gas. The lowest scale on the meter shows the amount of grid current. Note that it is not unusual for preamp tubes to go slightly negative at this point.

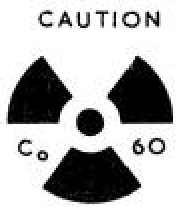
5. Finishing off. If the tube contained two devices (e.g. 12AX7), repeat steps 4d to 4f with the electrode selector set to A2.

Finally, rotate the circuit selector back round to Set~ and switch off. The tube will be hot, especially if a power tube, so take care when removing it.

Testing Rectifiers

This is a little different, and is a more basic go/no go test. Ignore the anode screen and grid voltages, and make absolutely sure that the pinouts correspond to D1 and D2 **not** A1 and A2. Set the silver portion of the current dial to a test current for the rectifier, and hit test.

NOTES FOR THE USE OF AVO CT160 VALVE TEST METER FROM THE UK MILITARY MANUAL AP117L-0101-1(Pt.2), ALSO KNOWN AS BR1171(13)B.



RADIO ACTIVE VALVES of British make are marked with a symbol similar to that shown above. Radio active valves manufactured in the U.S.A. are marked with a symbol of the same shape but with the colour image reversed on a magenta background. These symbols supersede an earlier warning mark of a ¼ inch orange band. ALL SUCH VALVES ARE POTENTIALLY DANGEROUS AND MUST BE TREATED WITH CARE. Detailed instructions for the handling and disposal of radio active valves are published in current Defence Council Instructions.

GUIDANCE NOTES ON THE CORRECT INTERPRETATION OF VALVE RESULTS

1. The Valve Tester CT160 is a useful instrument provided that its indications are correctly interpreted. Without regard to the function of a valve in its circuit however, it is not possible to devise a simple method of "go - no go" indication that is completely reliable. In general, if this tester shows a valve to be good by the routine go - no go tests the valve will function properly in circuit; if the tester indicates a poor performance then the valve is the most likely cause of a circuit fault. The limitations of such valve tests are considered in the following paragraphs.

2. The green-white-red sectors of the meter scale may be used for reading "percentage goodness" although no direct calibration marks for this are shown. Because the full scale deflection is about 130% of nominal slope, the 100% slope indication is in the centre of the word GOOD where there is a black line across the green sector whilst the 70% slope is just above the lower end of the green scale. Above the coloured scale there are gradations, 0.1, 0.5, 1 mA/V, provided for measuring a slope less than 1 mA/V. These can be used as a "percentage goodness" scale by relating the 0.1 position with 10%, 0.5 with 50% and 1 mA/V with 100%. Percentages above 100 can be estimated from the knowledge that f.s.d. is approximately 130%. After balancing the anode current to zero, the SET mA/V control should be turned until the nominal slope (obtained from data tables) is set adjacent to the pointer. Percentage goodness can then be read off as stated previously.

3. It must be noted that variation in the mutual conductance of a new valve may cause the pointer to lie anywhere within the green sector. For a valve with mutual conductance of a nominal value given in the data tables the pointer should rest at the 100% position on the green scale. A valve should be rejected only when the pointer is clearly within, or below, the red sector. Should the pointer lie in the white sector the indication represents possible failure but, because of the relative inaccuracy of the CT160 compared with laboratory test facilities, the valve should not be thrown away immediately. In a certain circuit the valve may be satisfactory and its use for this specific purpose should be considered.

4. Users of the valve tester should study the following points.

(a) The instrument is intended to give a go - no go indication measured to a particular limit. Sometimes this limit may be very close to that at which the valve just functions properly in a certain circuit.

(b) Some circuits will still function, though perhaps not well, even when a valve is almost useless as indicated on the CT160. Thus,

(i) a multi stage amplifier with one valve giving negligible amplification may still pass some signal;

(ii) an oscillator in which loop gain is normally very high may still oscillate;

(iii) a stabilising or limiting valve will not seem faulty when the prevailing circuit conditions do not call for the correction normally afforded.

(c) A few circuits will not function properly even though the tester shows the valves to be good. The tester may be faulty but it is more likely that the circuit is faulty elsewhere, or has design peculiarities, and requires a valve of above average performance to work properly. Examples are:

(i) an oscillator in which the loop gain is just unity when using an above-average valve;

(ii) a pulse circuit in which the electrode potentiometer or bias levels are such that the circuit operation is critical.

Thus the valve tester readings may mislead and if the fault symptoms are such that the valve is suspect then, even though the CT160 indicates a good valve, it is worth trying a better valve. Note the relative goodness to the average figures of the valve in question before removing it from the group of components under suspicion. A wrong elimination can entail considerable delay in finding a fault.

(d) Pulse circuits often use valve parameters such as grid-to-screen mutual conductance, or the suppressor grid cut-off potential (e.g. Miller stage). These parameters are not usually defined by the valve data and are not readily tested by the CT160.

(e) Class A push-pull circuits require pairs of valves that are balanced for mutual conductance and anode current. Usually a tolerance of ± 10% is permitted, any unbalance being countered by pre-set adjustments of the circuit. Reference should be made to the handbook for the equipment to determine how exacting are the requirements.

(f) When measuring mutual conductance it must be remembered that this reading varies with cathode current and the measured value may not be the same as that existing under circuit conditions. The equipment designer is responsible for ensuring that a circuit will work correctly using valves with parameters (such as mutual conductance) lying within wide limits. These limits are of the order of ± 35% of the nominal value given in the valve data tables. A "used" valve is still serviceable if a mutual conductance of 50% of nominal value is indicated on test, i.e. if the reading is in the white or green sectors.

(g) There are two methods of testing heater cathode insulation. With the heater hot and isolated from cathode, an ohmmeter can be connected between the elements to measure the insulation. If the cathode is made negative with respect to the heater, then thermal emission from any part of the heater that is affected by the cathode is suppressed by the effective negative bias. (Consider the cathode as the "anode" of a directly-heated diode). This connection is the preferred test for heater-cathode insulation.

If the ohmmeter is connected such that the cathode is positive with respect to the heater (as in CT160 heater-cathode tests), then thermal emission can also contribute to a "low" heater-cathode insulation.

The readings of insulation taken on CT160 must be carefully interpreted with a knowledge of the circuit that the valve is to work in. If it has a few volts bias due to a small cathode resistor, e.g. r.f. or i.f. amplifier, a heater-cathode insulation of even 50k or 100k can be discounted.

In a.f. amplifiers such as low-level microphone amplifiers etc., hum troubles may occur. With pulse circuits where the cathode may be an active element (cathode follower, cathode coupled amplifier, grounded grid amplifier etc.,) a low heater-cathode insulation (due to either ohmic resistance, emission, or a culmination of both,) may cause trouble. Therefore, considering the valve circuit, it may be that a valve with poor heater cathode insulation can be exchanged for one in another part of an equipment where the cathode potential is near earth.

5. In fault finding one should not rely solely on valve tester measurement but should make a proper check of voltage levels, signal amplitudes and waveforms throughout the faulty unit.

6. The CT160 is based on a patented system whereby half-wave a.c. pulses are used in place of stabilised d.c. supplies. This enables the supply to be a simple tapped transformer circuit with the virtue of very low source impedance of the supply. Theoretically zero source impedance is needed in order to achieve a true static measurement of mutual conductance etc.

7. In practice the transformer, cut-out coil and metering resistances add up to some few hundred ohms resistance. This order of source resistance is negligible for most valves but a few types are coming into service that have very low a.c. impedances (Ra). Examples are:-

CV2984 = CV5008 = civilian Type 6080
CV4079 = civilian Type A2293
CV2975 = civilian Type EL84
CV5077 = civilian Type PL81

These low Ra valves are not tested to static test conditions but under dynamic conditions because the source impedance of the power supply is no longer negligible. As a result the mutual conductance figures may be low by a factor of one half to one quarter of the nominal value. This effect is a design limitation of the CT160 that cannot be eliminated by modification of the instrument. It applies to any valve that has an a.c. impedance lower than about 400 ohms.

ABBREVIATIONS USED IN THIS BOOK

D, DD, DDD - Diodes.
DT, DDT, DP, DDP - Valve with another electrode assembly in addition to the diode.
H - Heptode or Hexode.
N - Nonode.
O - Octode.
P - Pentode or Tetrode, PP - Double Pentode or Double Tetrode.
T - Triode, TT - Double Triode, TH - Triode Heptode, or Triode Hexode.
TP - Triode Pentode.
R - Rectifier, RR - Full-wave Rectifier.
TI - Tuning Indicator (magic eye).
CCR - Cold Cathode Rectifier.
† - Appearing among ROLLER SELECTOR switch numbers, refers to third diodes in triple diodes. Refer to Volume 1, Part 1, Chapter 3, Section headed "Instructions for Testing Specific Valve Types" for full test procedure.
() - Where brackets appear around stated heater voltage thus (5) it indicates that heater voltage given in Data columns has been uprated to allow for voltage drop at valve base, due to high heater current taken by the particular valve.

NOTES REFERRED TO IN VALVE DATA REMARKS COLUMN

A The heater/cathode lead identified with red marking should be connected to Pin No. 1.

B The grid top cap is situated over Pins No. 7 and 8.

C This valve does not fit special valveholders supplied, and roller selector Data will depend on connections made to valve electrodes.

D Pin No. 1 on the flat pinch type of base is the lead adjacent to the coloured blob which identifies the anode connections, the remaining pins being directly numbered across the base from Pin No. 1.

E Alternative test figures are given for use when valve shows signs of back emission from anode to G_3. This phenomenom can be recognised by the anode current apparently decreasing as the valve heats.

G Valves on the B8D base when leads are cut, should be tested either by insertion in a B8D Adaptor, or leads lengthened and tested in the same way as those with flexible leads, by using the special 9 clip valveholder.

H Tests on tuning indicators should not be made until the resistor value (Ra), indicated in the remarks column, has been inserted across the link(s) on valve panel.

J Use special 9 clip valveholder.

K The grid top cap is situated over Pins 4 and 5.

L Anode 1 is situated over Pins 2 and 3, anode 2 is situated over Pins 7 and 8.

M To test valves with B7A bases, use adaptor, electron tube 5935-99-972-9810.

P Minimum slope figure.

Q Class B valve check for balance of both halves.

R Insulation tests only.

S Same remarks as note H, but add both sections to be tested.

T Check both sections of valve for balance.

U Red line indicates top cap anode.

V The CV number has been allocated to a pair of valves which must be checked for matching.

W Insulation checks only can be supplied to this valve.

X Low Ra Valve. Refer to paragraph 7 of Guidance Notes on the correct interpretation of valve results.

A B B R E V I A T E D   O P E R A T I N G   I N S T R U C T I O N S

F O R   T E S T   S E T ,   E L E C T R O N I C   V A L V E   C T 1 6 0

The brief notes which follow are intended as a guide to the operator who has already studied, and is familiar with, the full operating instructions given in Volume 1, Part 1, Chapter 3 of B.R.1771(13)A.

SETTING OF INSTRUMENT

1.(1) Check coarse mains voltage setting of MAINS VOLTAGE SELECTOR panel and, if necessary, re-set for supply voltage.

(2) Set CIRCUIT SELECTOR to SET ∼.

(3) Set ELECTRODE SELECTOR to A_1.

(4) Set heater volts and associated toggle switch to value indicated in Valve Data.

(5) Set ANODE VOLTS, SCREEN VOLTS, NEG GRID VOLTS, and ANODE CURRENT switches to value indicated in Valve Data.

(6) Set ROLLER SELECTOR switch to Code Number given in the Valve Data and check that the links on the top panel are firmly connected.

(7) Connect mains lead to instrument and supply.

(8) Switch on, allow a few moments for instrument to warm up, and adjust rotary MAINS VOLTAGE SELECTOR until the meter needle lies in the black zone marked "∼".

ALL VALVES

2.(1) Insert valve and if necessary, connect "Top Cap Lead" between valve and appropriate socket in TOP CAP CONNECTOR PANEL.

(2) Set CIRCUIT SELECTOR to H/CONT to check heater continuity.

(3) Set CIRCUIT SELECTOR to A/R and using successive settings of ELECTRODE SELECTOR at A_1, A_2, D_1, D_2, check electrode insulation, with the valve cold, between anodes and the remaining electrodes strapped together.

(4) Set CIRCUIT SELECTOR to S/R and set ELECTRODE SELECTOR switch to A_1 to check insulation, with the valve cold, between screen and all other electrodes (except diodes) strapped together.

(5) Set CIRCUIT SELECTOR to CH/R and ELECTRODE SELECTOR to A_1 or D_1 and D_2 to check, with valve hot, insulation between heater/cathode and all other electrodes strapped together.

(6) Set CIRCUIT SELECTOR and ELECTRODE SELECTOR to C/H to check, with valve hot, insulation between heater and cathode (for indirectly heated valves).

TRIODES, DOUBLE TRIODES, DIODE TRIODES, PENTODES, DOUBLE PENTODES, DIODE PENTODES AND TETRODES, IN SIMILAR COMBINATION

3. Set ELECTRODE SELECTOR to A_1 and CIRCUIT SELECTOR to TEST.

Should the protective relay operate, switch off and check for incorrect setting of ROLLER SWITCH or electrode voltages. If these are correct and the relay continues to buzz when the instrument is switched on, the valve is probably "soft" and the test should proceed no further.

To check relative goodness of valve in conjunction with coloured comparison scale

4.(a) Using recommended anode current

(1) Do not alter ANODE CURRENT controls, but adjust NEG GRID VOLTS control until meter reads zero.

(2) Slowly rotate SET mA/V control to SET ZERO position and make any final adjustment to zero, using fine ANODE CURRENT control.

(3) Continue rotation of SET mA/V control to expected value of mA/V (meter needle should rise).

(4) Comparative "goodness" of valve will now be shown by position of needle on coloured scale.

(b) Using recommended negative grid voltage

(1) Do not alter NEG GRID VOLTS control, but adjust ANODE CURRENT controls until meter reads zero.

(2) Slowly rotate SET mA/V control to SET ZERO position and make any final adjustment to zero, using fine ANODE CURRENT control.

(3) Continue rotation of SET mA/V control to expected value of mA/V (meter needle should rise).

(4) Comparative "goodness" of valve will now be shown by position of needle on coloured scale.

To check valve by direct reading of mutual conductance

5.(a) Using recommended anode current

(1) Do not alter ANODE CURRENT controls, but adjust NEG GRID VOLTS control until meter reads zero.

(2) Slowly rotate SET mA/V control to SET ZERO position and make any final adjustment to zero, using fine ANODE CURRENT control.

(3) Continue rotation of SET mA/V control until meter needle reaches calibration line in centre of "good" zone.

(4) Read actual value of mutual conductance from SET mA/V dial. This figure can be compared with that given in Valve Data.

(b) Using recommended negative grid volts

(1) Do not alter NEG GRID VOLTS control, but adjust ANODE CURRENT controls until meter reads zero.

(2) Slowly rotate SET mA/V control to SET ZERO position and make any final adjustment to zero, using fine ANODE CURRENT control.

(3) Continue rotation of SET mA/V control until meter needle reaches calibration line in centre of "good" zone.

(4) Read actual value of mutual conductance from SET mA/V dial. This figure can be compared with that given in the Valve Data.

To check valves having a mutual conductance less than 1 mA/V

6. Since the SET mA/V dial is not calibrated below 1 mA/V, it is not possible to check on the coloured comparison scale, valves having an expected mutual conductance less than 1 mA/V. Such valves are checked by direct measurement of mutual conductance using the procedure as in Paragraph 5 with the exception that the mA/V dial is rotated to the 1 mA/V position and the actual value for mutual conductance (being less than 1 mA/V) is read on the meter scale calibrated 0.1 - 1 mA/V.

For valves with more than one electrode assembly, having set up for any difference in electrode voltages, repeat appropriate test with ELECTRODE SELECTOR at A_2.

Gas Test

7. Set CIRCUIT SELECTOR to GAS, and ELECTRODE SELECTOR to A_1. Gas current will now be directly indicated in µA.

DIODES AND RECTIFIERS

8. Proceed as in Sections 1 and 2, then with the CIRCUIT SELECTOR at position TEST, ELECTRODE SELECTOR at D_1 and using inner ring of figures, set the right-hand ANODE CURRENT control to the load figure specified in Valve Data. The comparative "goodness" of a valve is shown by the position of the needle on coloured scale.

Load reading is per anode. Check full-wave rectifiers and double diodes with ELECTRODE SELECTOR at D_1 and D_2 respectively.

Check signal diodes at 1 mA loading unless otherwise specified in data.

B7A VALVES

9. Valves with B7A bases are tested by means of Adaptor, 5935-99-972-9810 Electron Tube Socket plugged into the A08 standard valveholder of the CT160. Connect top cap pin (if any), using normal lead, and proceed with the appropriate test.

USE OF SUBSTITUTE VALVES

1. When stocks of certain electronic valves are approaching exhaustion and cannot be replaced from new production consideration is given to the use of substitute valves which are more readily available.

2. Details of alternative valves, and any modifications to radio equipment that their use may entail, are promulgated in B.R.1917(1)(A) and B.R.1917(S) in the section entitled "Valve Replacements".

3. A demand for a valve will be met as long as stocks exist. When stocks are exhausted the substitute will be issued in lieu. Reference should then be made to B.R.1917 to determine the use of the substitute and subsequent demands should be raised only for the substitute valve.

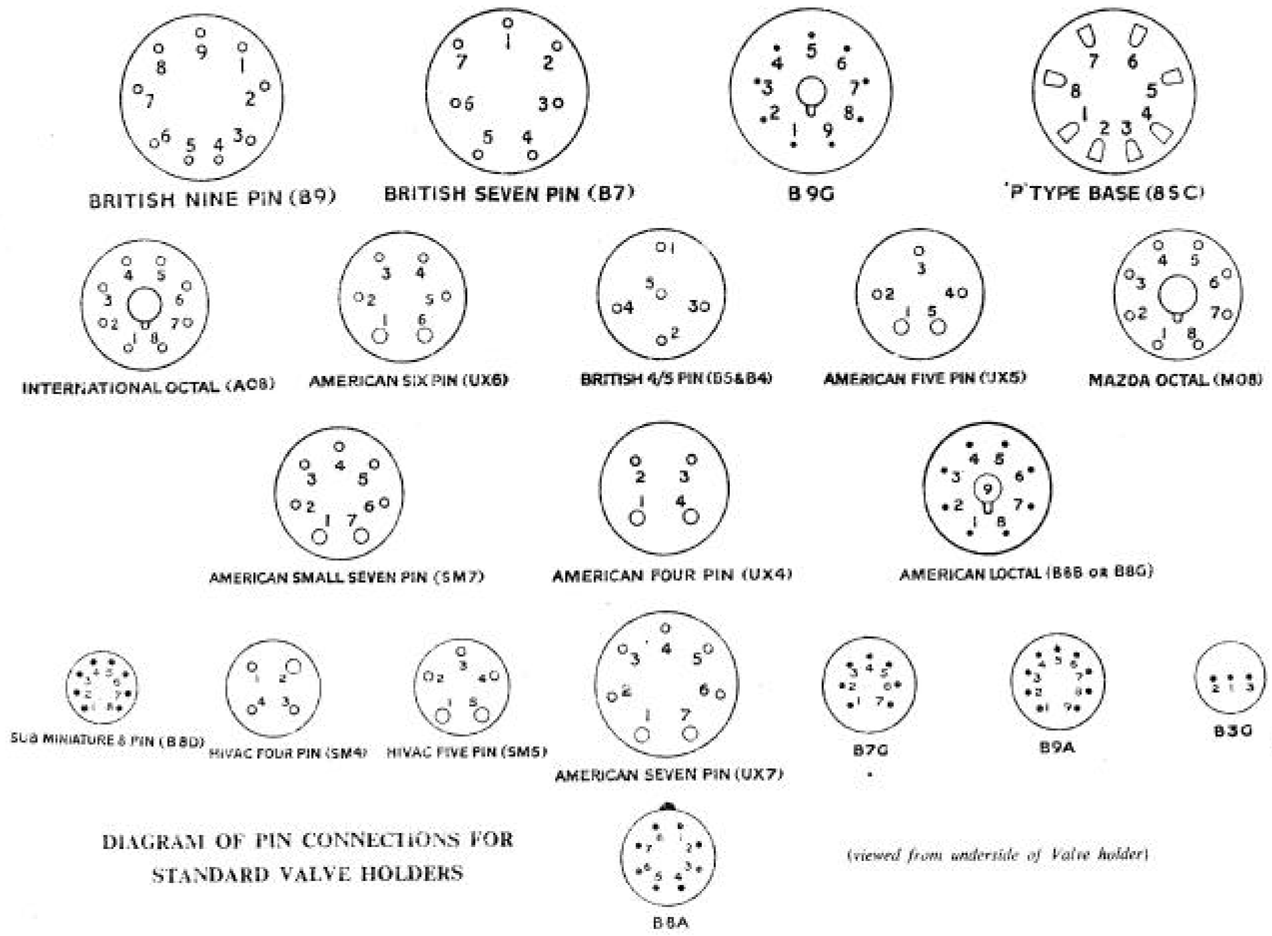


DIAGRAM OF PIN CONNECTIONS FOR
STANDARD VALVE HOLDERS

(viewed from underside of Valve holder)

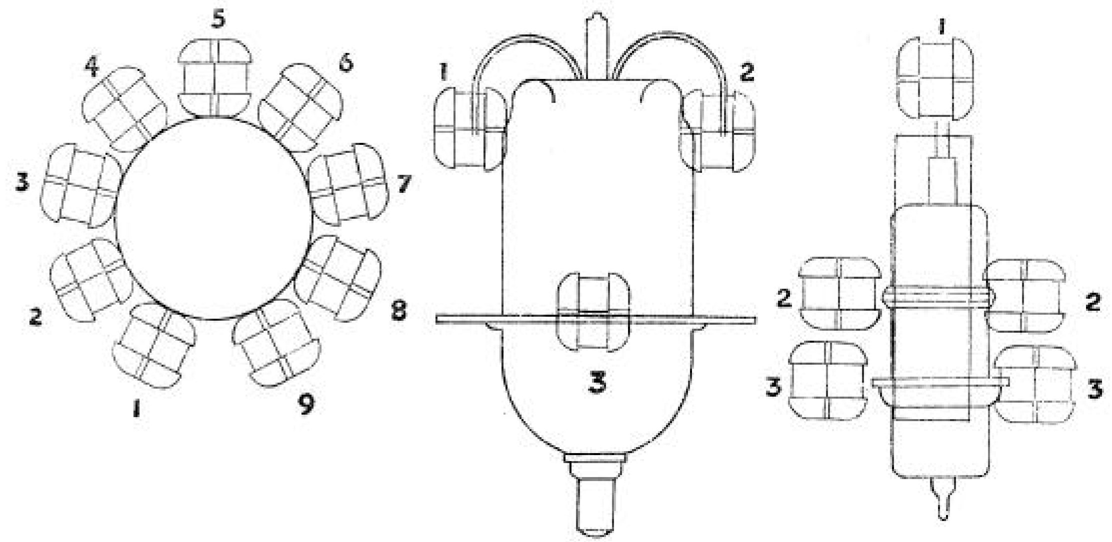


DIAGRAM OF SPECIAL VALVE HOLDERS
(showing pin connections viewed from above).

What follows in the manual is 106 pages of valve set up data for the CT160 which I have not scanned!

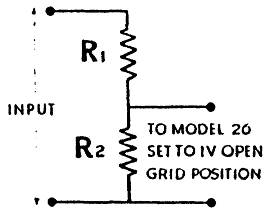
PART 2

CHAPTER 1

CALIBRATION AND MAINTENANCE OF THE INSTRUMENT

Instruments to be employed.

1. All measurements and tolerances stated do not include those of the testing instrument, and where necessary, these should be ascertained before commencement of the calibration procedure. Where possible, the recommended instruments should be employed. Where the Valve Voltmeter is not available in Dockyard Calibration Centres, the Electronic Instruments Model 26 Valve Voltmeter should be used on its 1V open grid position, in conjunction with a suitable potential divider as shown in Fig. 11.



Input Range	R_1	R_2
1 Volt	0	10M Ω
2·5 Volts	6M Ω	4M Ω
10 Volts	9M Ω	1M Ω
25 Volts	9·6M Ω	400K Ω
50 Volts	9·8M Ω	200K Ω

FIG. 11
R1 AND R2 MUST BE SELECTED TO WITHIN ±1% USING GRADE ONE HIGH STABILITY RESISTORS.

500 c/s A.C. Supply Operation and its Relation to Servicing

2. Whilst the instrument is suitable for use on 50—500 ∼ A.C. supplies, service and calibration should normally be carried out using a 220/230V 50 ∼ supply.

3. The following features play a vital part in the correct operation of the instrument on a 500 ∼ supply.

(*a*) The two electrostatic screens (S1 and S2) on the H.T. transformer prevent spurious mA/V readings, and care must be taken when replacing a transformer to ensure that these screens are connected as shown in the Circuit Diagram (Fig. 3).

(*b*) The separate cable forms lying side-by-side across the instrument ensure that the grid circuit and its associated wiring is kept well apart from H.T. wiring to prevent the transference of energy from one circuit to the other at high mains frequencies. If at any time, it is necessary to displace wiring within the instrument, great care must be taken to ensure that it is replaced in its original position.

(*c*) The 0·02μF (C1) and 0·02μF (C2) capacitors prevent spurious readings on insulation ranges when the instrument is used at high mains frequencies.

To Check Accuracy of Instrument

4. Before commencing servicing work and on completion, the instrument should be checked to the following schedule:—

(i) Connect the instrument to an A.C. voltage supply of 200—250V, 50 ~ of known magnitude, and set the instrument voltage adjustment to its appropriate position.

(ii) Switch on, noting that panel indicator lights, and set MAINS VOLTAGE SELECTOR FINE CONTROL, such that the meter needle lies as near as possible to the centre of the " ~ " zone.

(iii) Using a CV455 strapped as a single triode which has been standardised for mutual conductance at 16mA anode current with 200V D.C. applied to anode (see para 5 for standardisation procedure), check that for 16mA anode current, the negative grid volts indication is within ± 5% of the nominal voltage, and slope (mA/V) is within ± 5% of standardised value, using an external AvoMeter in series with the A_1 link to read anode current. A reading of 8mA on the external instrument will be equivalent to a D.C. current of 16mA through the valve (this is the value normally indicated by the anode current controls when the meter is at its null position).

(iv) Remove valve and external meter. With NEG GRID VOLTS Control set at 40, connect a resistance of 680k Ω ± 5% between grid and cathode sockets on the top cap connector panel. With the CIRCUIT SELECTOR switch set to position " GAS ", panel meter should indicate full scale deflection ± 20%.

To obtain Standard Figures for a Valve using D.C. Supplies

5. The valve should be connected as shown in Fig. 12.

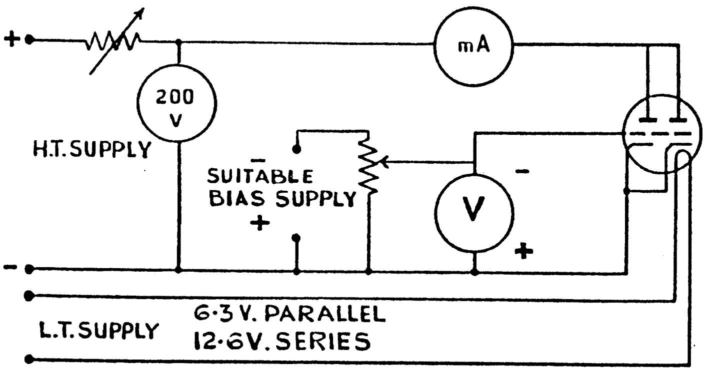


FIG. 12.

6. The meters used should be of sub-standard accuracy (E.I. Model 44) the current meter (having a maximum voltage drop of 100mV) preferably being scaled 0—25mA, the voltmeters having a sensitivity of 1,000 Ω/V. If rectified A.C. is used for the H.T. supply then it is essential that steps are taken to ensure that the supply circuit is adequately smoothed. The Solartron Varipack is a suitable source. The bias supply should be obtained from a suitable battery (note polarity of connection). The heater supply for the valve may be A.C. or D.C., but must be within ±5% of the rated voltage.

7. Set the grid bias voltmeter to read 9V, adjust H.T. supply to 200V, then by means of successive adjustments of the bias and H.T. voltage controls, set the anode current at 16mA (the anode voltmeter must read 200V). Note the bias voltage reading. Re-adjust the bias control, and if necessary, the anode voltage control until the anode current is 17mA (the anode voltmeter must read 200V). Note the new grid bias voltage reading. The standardised slope for the valve can now be obtained from:—

The difference between the two anode current readings (i.e. 1mA) over the difference between the two grid voltage readings $\frac{Ia_2 - Ia_1}{V_{g1} - V_{g2}}$

The result will generally be between 4 and 5mA/V.

For greater accuracy it is suggested that readings of grid voltage be plotted against values of anode current between 10 and 20mA and the slope taken from the curve at 16mA.

8. The valve should now be labelled as follows:—

Va	=200V D.C.
Ia	=16mA D.C.
Vg	= . . . .
Slope	= . . . . . mA/V
Date	. . . .
CV455	

The valve should now be re-standardised daily when in use.

Mechanical Features

9. The instrument comprises two units in a hinged transit case, the lid of which is not detachable. Electrical connection between the two units is affected by means of two 5-way side-by-side cables.

Removal of the Instrument from its case

10. To facilitate servicing or calibration of the instrument, it is necessary to remove both sections from the casing, this being accomplished by the removal of four hexagonal headed bolts, which form the feet of the control unit, from the underside of the case. The control panel will then be released. The Valve Panel can be withdrawn from its section of the case by the removal of eight fixing screws around its periphery.

Simple Faults

11.

Symptoms	Possible Fault	Action
(*a*) No dial light indication.	No mains input.	Check mains connector.
	Dial light bulb burnt out.	Replace LP1.
No dial light indication or meter deflection on SET ~ setting of CIRCUIT SELECTOR.	Fuse blown.	Check MAINS VOLTAGE SELECTOR setting and replace F1 and/or F2.
(*b*) No indication of meter current.	No anode volts at valve pin.	Check that links A_1 and A_2 are tight and making firm contact.
No indication of meter current and protective relay operates when testing tetrodes or pentodes.	No anode volts at valve pin, but screen volts present.	Check that links A_1 and A_2 are tight and making firm contact.

Relay operates and fails to clear

12. Should relay operate due to suspected faulty valve, and fail to clear after switching off and on again with no valve in panel, set ROLLER SELECTOR Switch to read 000 000 000 and remove top cap connecting lead. Switch instrument off and on.

13. If fault clears, the most likely cause of the trouble is a short on the Valve Panel, certain pin(s) being shorted out to earth by stray wire or solder, or a breakdown in insulation.

14. If the fault still persists however, check H.T. line for breakdown to earth between ROLLER SELECTOR switch on Valve Panel and H.T. transformer on control unit.

Voltage checks with no valve under test

15. Connect instrument to *known* 220—230V 50 ~ supply, and adjust coarse and fine settings of the mains voltage selector panel, to match the supply voltage as accurately as possible. Set the CIRCUIT SELECTOR to TEST and ELECTRODE SELECTOR to A_1 and proceed to check the relevant electrode voltages as follows:—

Heater Voltages

16. Use a Model '7', '8', '40', '47', '47A' or '48A' AvoMeter on its A.C. voltage ranges. Connect meter between H+ and H— sockets on top cap connector panel. Rotate the HEATER VOLTAGE Switch through the full range of values, the external meter being set to the appropriate voltage range, as required. The heater voltage reading on the meter should conform to the voltage limits shown in table 4. Due allowance must be made for the limits of accuracy of the measuring instrument for each particular reading.

TABLE 4

Heater Switch setting with Toggle Switch set to its 0·625—117 Position.	Voltmeter must read between these limits.
0·625	0·5— 0·8
1·25	1·2— 1·45
2·0	2·2— 2·45
2·5	2·6— 3·0
4·0	4·2— 4·7
5·0	5·1— 5·5
6·3	6·6— 7·0
10·0	10·3— 10·9
11·0	11·3— 11·9
13·0	13·5— 14·1
16·0	16·3— 17·3
20·0	20·7— 21·7
25·0	26·0— 27·0
30·0	31·0— 32·2
48·0	50·3— 52·3
70·0	73·0— 76·0
117·0	123·0—130·0
Heater Switch setting with Toggle Switch set to its 1·4—80 position.	
7·5	7·6— 8·0

Anode Voltages

17. Use a Model '7', '8', '40', '47', '47A' or '48A' AvoMeter on its A.C. voltage ranges. Connect meter between A_1 and C sockets on top cap selector panel, rotate the ANODE VOLTAGE Switch through successive positions, the actual meter being set to the appropriate range as required. The meter readings obtained should be 1·1 × the voltage indicated by the ANODE VOLTAGE Switch ±5%. Due allowance must be made for the limits of accuracy of the measuring instrument for each particular reading e.g., with the ANODE VOLTAGE Switch set to 100, actual *voltage* reading should be 110 ± 5% volts, i.e., between 104·5 and 115·5V.

Screen Voltages

18. Use a Model '7', '8', '40', '47', '47A' or '48A' AvoMeter on its A.C. voltage ranges. Short the anode of V_1(a) to cathode (pins 2 and 5. See Fig. 13). Connect meter between S and C on the top cap selector panel, rotate the SCREEN VOLTAGE switch through successive positions, the external meter being set to the appropriate range as required. The meter readings obtained should be 1·1 × the voltage indicated by the SCREEN VOLTAGE switch ± 5%. Due allowance must be made for the limits of accuracy of the measuring instrument for each particular reading, e.g. with the SCREEN VOLTAGE switch set to 200, the actual *voltage* reading should be 220 ± 5% volts, i.e. between 209 and 231V.

Calibration of the Instrument

19. Use a D.C. Valve Voltmeter with an input impedance greater than 1M Ω, e.g. the "AVO" Electronic Test Meter, or the Multimeter Electronic C.T.38. The meter should be standardised at the appropriate voltages before making any adjustment mentioned in the following sections. When using the Valve Voltmeter Model 26, a potential divider should be used as in Fig. 11.

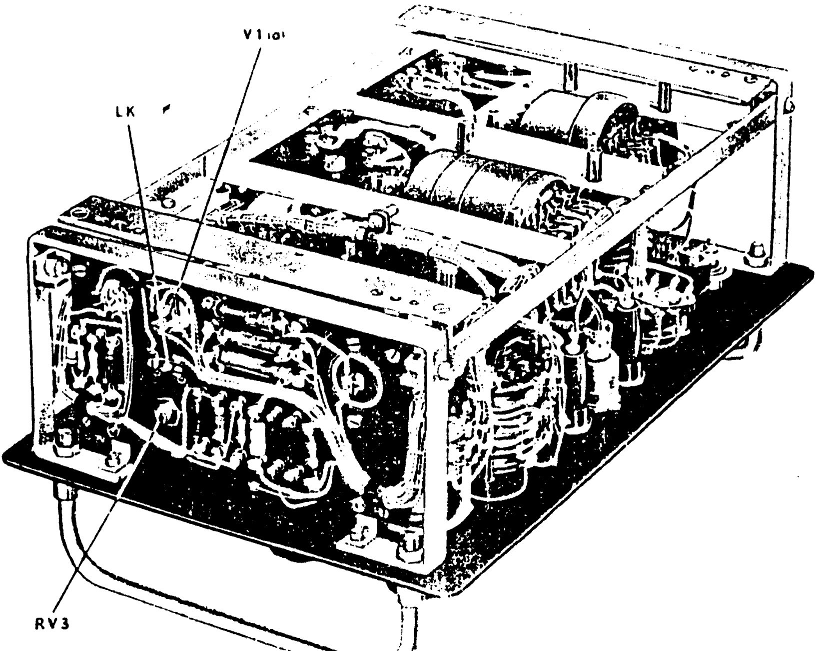


FIG. 13.

20. Open LK (Fig. 13) and set the panel controls as follows:—

CIRCUIT SELECTOR to TEST, ELECTRODE SELECTOR to A_1 and NEG GRID VOLTS to 40.

21. Connect measuring leads of Valve Voltmeter across RV2 (Fig. 6) and adjust RV3 (Fig. 13) until a voltage reading of 20·8V is obtained. Transfer measuring leads to G_1 and C sockets on the top cap connection panel, or if panel has been dis-connected for servicing, to the G_1 and C positions on the tag board at back of unit. (See Fig. 6.) Check that at the 13 and 4 marks of the dial readings of 6·75V and 2·1V ± 5% are obtained. If either or both readings are out of tolerance, the dial should be adjusted mechanically to split the error. If it is necessary to make an adjustment, slacken the three counter-sunk headed screws on the top of the dial, which will then be free to move within the latitude of kidney shaped slots. After adjustment, re-tighten screws and check readings. The areas marked 0, 5, 15 and 40 should correspond within the indicated area to 0V, 2·6V, 7·8V and 20·8V ± 5% respectively.

Checking the set mA/V Control

22. Using the Valve Voltmeter set to a suitable D.C. range with the link still open, and measuring leads connected across R5, check that when the dial is advanced to its 10, 5 and 2mA/V positions, readings of 52·5mV, 105mV and 260mV ± 3% are obtained. If for any reason the relationship between the dial and the potentiometer has been upset, the procedure headed "SETTING THE mA/V DIAL" should be adopted. (See para 34.)

Checking the set ~ indication

23. Standardise the Valve Voltmeter at 47V D.C. Close the link LK (Fig. 13) and set the panel controls as follows:—

CIRCUIT SELECTOR to SET ~ and ELECTRODE SELECTOR to A_1.

24. With the Valve Voltmeter connected across RV_2, a reading of 47 volts should now be obtained, whilst the meter on the instrument panel should indicate within the "~" zone. If voltage reading is correct, but panel meter indication is outside "~" zone, check resistors R_3 and R_4.

Ia Calibration check

25. Open the A_1 link on the valve base panel, and insert a suitable D.C. Moving Coil Ammeter, e.g. a Model '7', Model '40' or similar AvoMeter into the circuit. Set up the instrument, and place under test any power valve capable of passing 100mA anode current, e.g. KT33C (CV1503), KT66 (CV1075), or 807 (CV124). Set the ANODE CURRENT controls to 100mA (90mA + 10mA), and with the instrument set to its TEST position, allow the valve to warm up, and return the panel meter needle to zero by means of the NEG GRID VOLTS control. The external meter should then indicate between 47·5mA and 52·5mA (0·5 × indicated value on ANODE CURRENT controls ± 5%), the panel instrument indicating zero. If required, repeat this test at any other settings of ANODE CURRENT controls.

The Indicating Meter

26. This is a self-contained unit which may be withdrawn from the control panel by the removal of two 2BA screws (see Fig. 6).

27. When used in the instrument as an anode current null indicator, the meter has a full scale deflection for approximately 10mA (not critical). When removed from the instrument, the meter has a full scale deflection of 30μA and an internal resistance of 3,250 Ω. When shunted by R9 only (see circuit diagram), the meter has a full scale deflection of 39·8μA.

Adjustment of Protective Relay

28. The protective relay should seldom require attention, but if, for any reason, parts are replaced, the adjustment is simple, it only being necessary to position two 4BA screws (insulated tools must be used for this adjustment). (See Fig. 6.) It should be noted that the bobbins, if replaced, should be positioned such that the flux which they produce is additive.

29. Operational limits are as follows:—

(i) Anode overload—Relay should operate on 100V short circuit.

(ii) Screen overload—Relay should operate on 60V short circuit.

(iii) The relay should not arc excessively on a 200V short circuit on anode or screen.

(iv) The Relay should not operate when checking a 120mA rectifier.

30. Before making any adjustments, check that the lamp LP1 is operative. When the instrument is used solely on a 110V supply, it may be preferable to replace LP1 with a 100V, 15W Pigmy lamp.

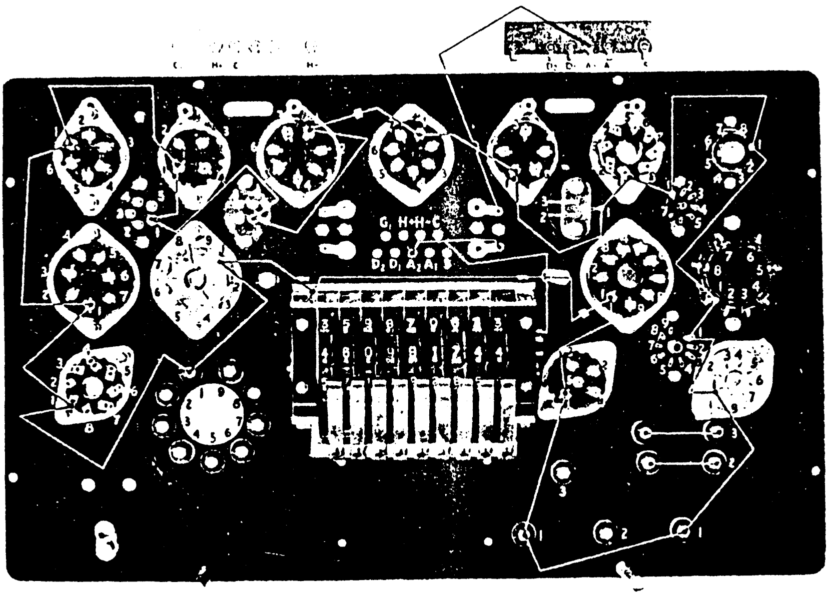


FIG. 14.

Servicing the Valve Holder Panel

31. The Valve Holder Panel is connected electrically to the control panel by means of two 5-way side-by-side cables. One of these cables embodies two thicker sections (16/·012") for H+ and H— leads. Connections to tag boards on either unit are shown in Fig. 14.

32. The wiring of the valve holders on the panel is in the form of nine separate loops, all pins 1 comprising a loop and linking in roller 1 of the ROLLER SELECTOR switch. This form of loop connection is used likewise for pins 2—9, all nine circuits approximating in length and following a similar route around the panel. These loops are further loaded with beads of ferroxcube which sufficiently damp the loop to prevent the valve under test breaking into parasitic oscillation. A diagramatic layout is shown in Fig. 14. Ferroxcube is also used on leads feeding the SELECTOR SWITCH, as a precaution against L.F. oscillation. Where it is necessary to replace valve holders, these, with the exception of the B8B, are fitted to the panel with nuts and bolts, and are, thus, easily removable. Care should be taken to replace all wiring in its original position.

Removal and Replacement of Knobs and Setting of Knob Skirts

33. To remove any knob, remove 6BA screw and spring washer. To remove knob spindle and skirt release locking pin. The switch nut is now accessible. To adjust skirt, slacken lock nut, rotate skirt to desired position, and re-tighten lock nut. Reverse procedure to replace.

Setting the mA/V Dial

34. With the link open, and the SET mA/V dial at rest, turn RV1 to its maximum anti-clockwise position (viewing from the front panel) and adjust friction tight the locking nuts of the U shaped stirrup. Connect Valve Voltmeter, set to a suitable range across R5 and advance SET mA/V dial to a reading of 5. Rotate the RV1 spindle further, by means of the stirrup, in a clockwise direction until the D.C. Valve Voltmeter shows a reading of 105mV. If this reading is achieved without further clockwise advancement of the stirrup, or if its procurement necessitates an anti-clockwise movement of the stirrup, then investigate the accuracy of R1, R2, R5 and RV1. The locking nuts on the stirrup should now be tightened, and the reading of 105mV on the voltmeter checked. Again check that the D.C. millivolts developed across R5 at the 2mA/V and 10mA/V settings of the dial are 260mV and 52·5mV $\pm$ 3%. Check that the dial can now be rotated to its 1mA/V position and that motion is eventually arrested by the stop screw on the dial, and not by the stop at the end of the potentiometer track.