INSTRUCTIONS

On

THEORY AND USE

of

MODEL OD-2

VACUUM TUBE ANALYZING EQUIPMENT

CONTRACT NO. NOS – 56258 CONTRACT DATED AUG 11, 1937

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I
INTRODUCTION

A. TESTING VACUUM TUBES.

Each vacuum tube purchased by the Navy is subjected to more than fifteen electrical and mechanical tests which are designed to insure that vacuum tubes supplied to the Service are satisfactory in every respect.

It is seldom that tubes, during shipment or handling, are subjected to mechanical shocks of sufficient magnitude to dislocate or dismember the electrodes; however, it is desirable to have available a means for quickly and easily testing vacuum tubes prior to placing them in service.

The end of useful life of vacuum tubes is usually occasioned by a reduction of electron emissivity of the cathode which reduces the amplifying ability or conductivity of the tube. In receiving equipment this decadence of a tube results in loss of sensitivity and, in the case of rectifier tubes, with a reduction of the rectified output voltage. Whenever receiving equipment operates sub normally, it is desirable to have available a means for testing each vacuum tube so that the defective one may be replaced, if the fault lies in the tubes, and so that the remainder may be retained to deliver additional useful life.

To fulfill this need, the service has been provided with the Model OD-2 vacuum tube analyzer.

This analyzer was not designed to equal the accuracy of expensive laboratory equipment because the end of useful life for any vacuum tube is a variable quantity dependent on the equipment in which it is used and on the performance required of the equipment under given circumstances. In general, the accuracy of measurement obtainable is a function of the skill of the operator in adjusting the applied voltages and in reading the instrument indications. The indications of the potential and current instruments used with this equipment are, in common with all 3.5 inch instruments, guaranteed to be accurate to only 2 percent of their full scale readings. Should all instruments errors happen to be cumulative, such errors are of little moment in deciding whether or not a vacuum tube is still operative.

B. APPARATUS AND DATA

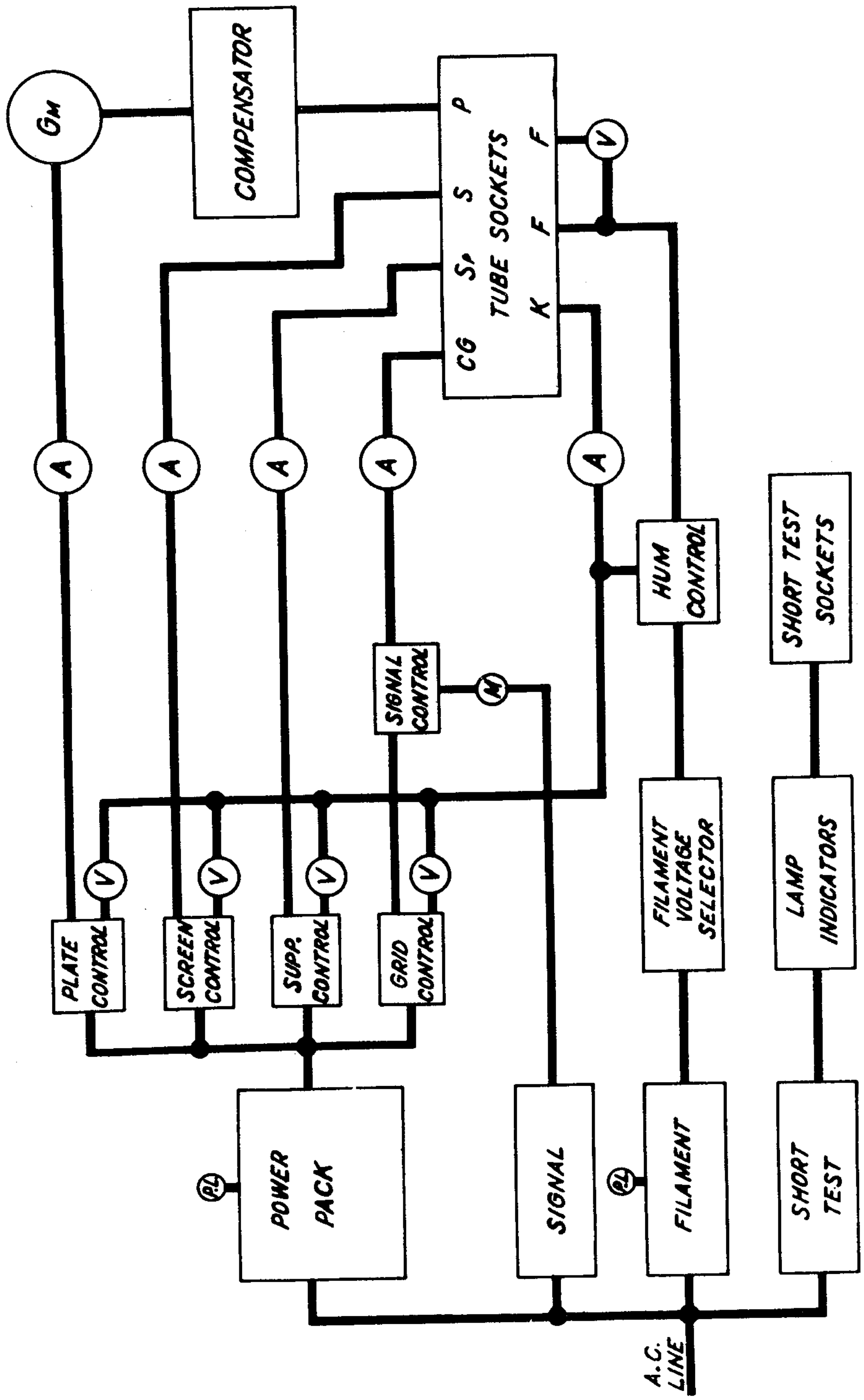
In brief, the Model OD-2 equipment consists of the following apparatus: A plurality of vacuum tube sockets designed to accommodate 4-pin, 5-pin, 6-pin, 7-pin or 8-pin octal tube bases; a transformer supplying 60 cycle power at any one of several standard filament potentials; patch cords for connecting filament power to any pair of socket terminals; a power rectifier supplying filtered direct potential to a system of potentiometers and thence, by way of patch cords, to any desired socket terminals; a plurality of electrical indicating instruments suitable for indicating potentials between socket terminals and currents flowing through socket terminals; and a plurality of vacuum tube sockets interconnected with indicating lamps designed to indicate the presence of short circuited tube elements. A block diagram of the general circuit arrangement is included herein.

The data necessary for effective tube testing is tabulated elsewhere in this instruction book and consists of a statement of the proper potentials to be applied to the elements of each type of tube and a statement of the present accepted value of the function which determines the end of useful life. The latter values are based on data which are not considered to be complete in their application to all types of service equipment and for this reason service organizations are urged to submit additional data based on observations of the minimum values of life factors which may be tolerated in various types of service equipment.

C. THE METHOD

Of the many measurable characteristics of a vacuum tube, the transconductance is the one most closely associated with operating performance. For this reason, the factor which determines the end of useful life of a vacuum tube is generally taken to be the transconductance except in the case of diodes which have no grids and except in the case of certain other tubes the transconductance of which is not conveniently measured. The factor which determines the end of useful life of these last mentioned tubes is generally taken to be the cathode emission current measured under specified conditions.

The Model OD-2 equipment measures transconductance by measuring the alternating current produced in the plate circuit by a 60 cycle signal applied to the grid of the tube under test. The grid signal has an effective value of one volt and as transconductance is the ratio of the value of alternating plate current to the value of the



SCHEMATIC BLOCK DIAGRAM

alternating grid signal which produced it, it is evident that the instrument which measures the alternating component of the plate current may be calibrated in terms of micromhos of transconductance instead of microamperes of alternating current.

II
DETAILED DESCRIPTION OF THE EQUIPMENT

A. GENERAL

The case is of heavy metal, held together by screws in corner pieces and with a removable back. An angle iron leg at each side is arranged so that the unit may be bolted to a table. A cord and plug emerging from the bottom of the back is arranged to furnish all of the various currents required.

B. THE RECTIFIER SYSTEM

The incoming power supply feeds four separate transformers, the short testing transformer, the signal transformer, the filament transformer and the D.C. power pack. The left-hand bottom toggle switch controls the entire power supply and when in the DOWN position cuts off the circuit completely. When raised, the filament transformer is energized and the circuit to the other portions of the device may be completed by their individual switches. The green pilot at the left of this switch indicates when the switch is turned on.

The short-test, filament, and the signal supplies come directly from the transformers and will be described below under their individual paragraphs.

The high voltage power supply consists of a suitable transformer feeding a Type 38180 rectifier tube. This transformer energizes the filament of the tube and has a high voltage center tapped plate winding. After rectification by the tube the pulsating direct current is smoothed in a filter system consisting of two iron cored chokes and a total of 12 m.f. of oil filled condensers. This system furnishes a smooth D.C. power supply which will give up to 275 volts at not over 60 MA. And up to 100MA. At somewhat lower voltages. Within the requirements of this apparatus it is free from ripple.

C. THE CONTROLS

The short test transformer on the upper panel is controlled by the SHORT TEST toggle switch at the right of the upper panel. The short test transformer is connected to the upper row of sockets and referring to the diagram, it will be noted that there is a secondary winding in series with a neon lamp connected between each pair of pins on the upper row of sockets. When turned on, all of the neon lamps should glow since this upper switch marked LAMP TEST places a short on this circuit. This is for the purpose of indicating definitely that all of the lamps are functioning and if one of them does not light it should be checked. See that it is screwed tightly into its socket; exchange it with another lamp which does light in order to check as to whether or not it is the circuit or the lamp which is at fault. If the lamp is at fault it may be replaced by one of the spare lamps located in back of this panel for this purpose.

With the SHORT TEST switch on and all of the lamps lighted, a tube may be plugged into one of the upper row of sockets. Pull down the LAMP TEST switch. If the tube is clear and has no shorts, all of the lamps will go out except the one on the extreme left which indicates filament continuity. This lamp is so marked and should stay lighted if the filament is intact. It does not indicate a short circuit in the tube. If any of the other lamps light, it indicates a short circuit between certain of the electrodes. There are a few tubes having another filament connection on some prong other than the normal heater pins and, of course, if one of these is being tested a short circuit will be indicated between these prongs, and this should be taken into account.

Tubes must show no short circuits or a normal condition as to expected special filament connections before being tested further.

The right-hand toggle switch controls the high voltage direct current rectifying system and when it is turned on the red pilot at the right is lighted, indicating that the high voltage is available. It will take a few seconds for the tube to heat and a few minutes for the system to become stabilized.

Referring to the complete diagram, the operation of the several potentiometers or voltage adjusters can be noted, these being in effect slide resistors across the high voltage.

The plate voltage, brought out ultimately to the plate jacks at the top of the large panel, is controlled by the lower right-hand rheostat marked PLATE VOLTAGE ADJUSTER. Its voltage is measured on the ELEMENT VOLTAGE meter when the switch just below it points to PLATE. The scale used is either 150 or 300 volts depending upon the position of the toggle switch just below this instrument at its left. Plate current then flows thru a shunt circuit and the amount of the current is indicated on the ELEMENT CURRENT meter on the range to which the switch knob below it points. Since this instrument is used for several circuits, to read plate current, the switch below this meter and to the left should point to PLATE. The several jacks marked PLATE are tied together so that a group of electrodes may be connected to this circuit for the reading of emission currents when desired.

In a similar fashion the SCREEN GRID VOLTAGE ADJUSTER picks off a voltage across a slide resistor and this appears ultimately at the SCREEN GRID jack. To measure this voltage the switch below the ELEMENT CURRENT meter should point to SCREEN and again the reading may be taken on the 150 or 300 volt range as determined by the toggle switch below the instrument and to the left. The current in the screen circuit is indicated on the ELEMENT CURRENT meter, on the range selected by the switch below it, and with the switch just to the left on the position marked SCREEN.

The SUPPRESSOR GRID VOLTAGE ADJUSTER also picks voltages off a third slide rheostat ultimately appearing at the SUPPRESSOR GRID jack. Its voltage is indicated with the switch below the ELEMENT VOLTAGE meter on the SUPP. Position and the current flowing in this circuit is indicated on the ELEMENT CURRENT meter, on the range selected by the switch below it and with the switch at its left on the position marked SUPP.

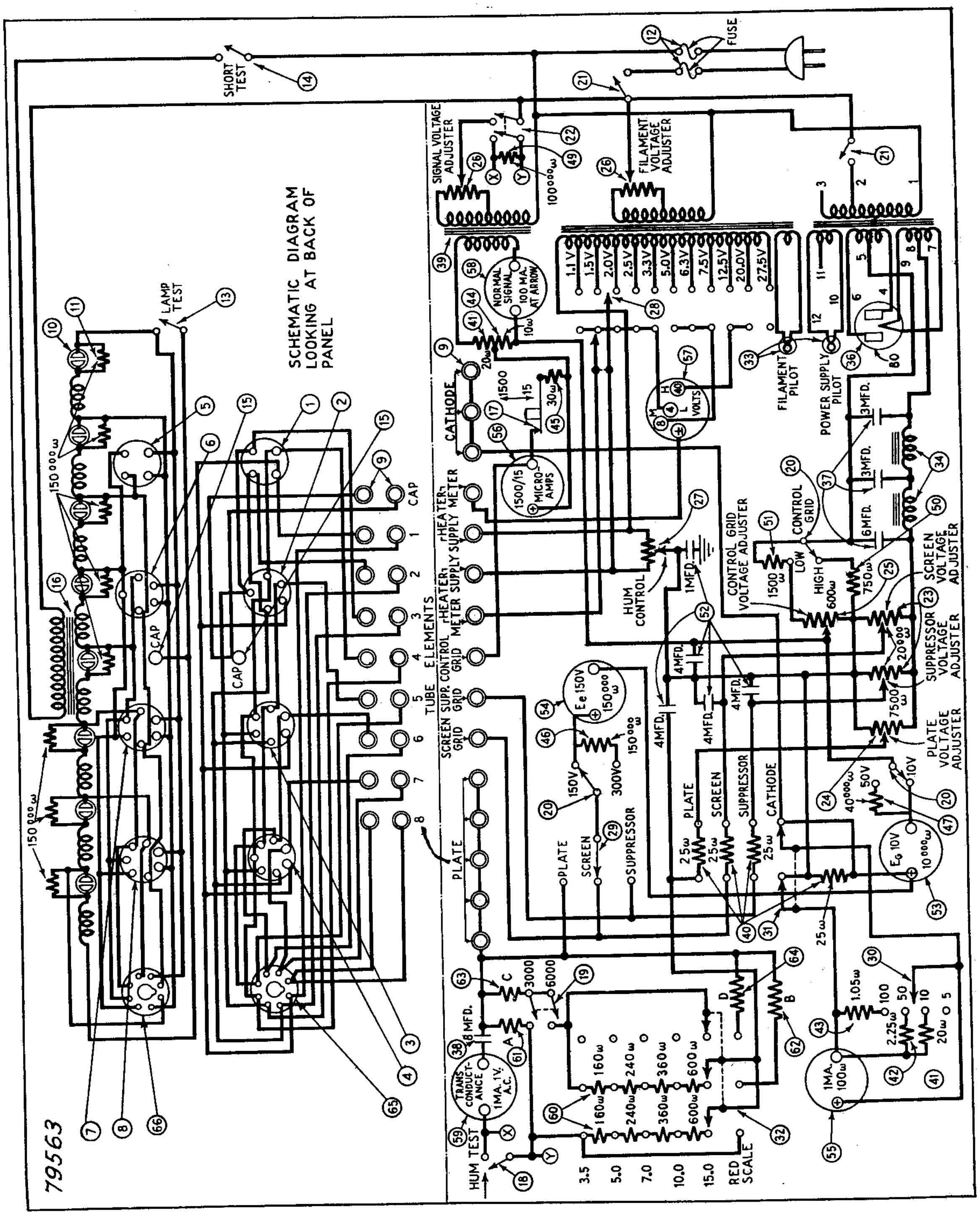
The CONTROL GRID VOLTAGE ADJUSTER at the left of the lower row of rotary controls adjusts a negative potential which ultimately appears at the CONTROL GRID jack. This voltage is obtained by a slide rheostat across the total current flowing in the return circuit and for this reason the voltage will vary somewhat with the amount of current in the other circuits. This means that the adjustment of the control grid voltage will have to be varied with different current drain. This voltage may be varied over a low range up to something over 10 volts with the bottom toggle switch marked CONTROL GRID LEVEL in the LOW position; with this switch in the HIGH position the control grid voltage may be varied up to something over 50 volts. This double value arrangement is extremely convenient for the accurate control of both low and high grid voltages.

The control grid voltage as adjusted is read on the CONTROL GRID VOLTAGE meter, on either a 50 or 10 volt range depending on the position of the toggle switch to the lower left of this instrument. The current passes thru the GRID CURRENT meter at the upper left and indicates on the 1500-0-1500 microampere range. When it is desired to measure extremely small values of grid current, the spring return toggle switch to the right of this instrument marked MICROAMPERES is pulled down, opening a shunt and causing this meter to read on a 15-0-15 microampere range. Great care should be taken not to pull this switch down unless the indication on the high range is not greater than the red line, one division each side of the center zero.

Filament voltage is selected as to nominal value by the FILAMENT VOLTAGE switch. This voltage is controlled by the FILAMENT VOLTAGE ADJUSTER which functions on the primary of this transformer. Both terminals of the filament voltage transformer appear at the HEATER SUPPLY jacks at the top of the panel. The filament voltmeter is not connected to this circuit but is connected directly to the two HEATER METER jacks so that the potential at the tube socket itself may be measured and it is necessary, therefore, to plug in four patch cords for the filament circuit, two to lead the current to the normal heater terminals H and I and the other two bringing back potential from the other jacks also labeled H and I to the meter terminals. The filament voltmeter is read on the scale indicated on the FILAMENT VOLTAGE switch. This switching is done automatically and brings into play the most suitable range on the instrument.

The compensating switch in the transconductance meter circuit is marked SET TO NEAREST AMP. FACTOR. This switch brings into play portions of the resistance network as indicated in the wiring diagram, and should be set to the nearest value corresponding to the value of amplification factor for the tube under test as indicated in the Tube Data Chart. If the amplification factor is under 20, the instrument is read on one of its black scales; if the amplification factor is 20 or over, this switch is set to its right-hand position RED SCALE and the instrument indicates transconductance on one of its red scales. The range of 3,000 or 6,000 micromhos is selected by the toggle switch directly below the large fan shaped instrument marked TRANSCONDUCTANCE MICROMHOS.

The HUM CONTROL rheostat below the grid current meter is used only on filament type tubes, that is, tubes



Wiring Diagram

not having an indirectly heated cathode. It is simply a rheostat bridged across the filament circuit, the moving arm carrying the several element currents and bringing them back to an effective center position with respect to the filament. It is adjusted as explained under “Operation” with the switch at the right marked HUM held down.

The last control, the SIGNAL VOLTAGE ADJUSTER controls the value of the normal signal and serves to bring the NORMAL SIGNAL meter above it to the center position marked with an arrow when the SIGNAL SUPPLY toggle switch at the bottom center of the panel is held up. This adjuster is effectively a rheostatic control on the signal transformer and allows for the adjustment of the signal, which is interposed in the grid circuit, to exactly one volt.

D. THE TRANSCONDUCTANCE METER

This is a rectifier type A.C. instrument and is connected into a network as shown on the wiring diagram in such a manner that it correctly indicates transconductance by measuring the A.C. component at the plate current flowing thru the 8 m.f. condenser and thru the instrument itself. It is a highly sensitive instrument and is protected by a 100,000 ohm series resistor which is shorted out by holding up the SIGNAL SUPPLY switch or holding down the HUM switch.

E. THE SOCKET PANEL

The socket panel carries the short test transformer with its lamps and socket wires as shown in the diagram. These sockets are all in parallel. It also carries the row of test sockets wired to the several jacks below them again as shown in the diagram. Dummy jacks are provided at the left in which the patch cords should be kept at all times when not in use so that none of them will be lost. Twelve (12) patch cords are supplied which are ample for any purpose.

F. SPARE LAMPS AND FUSES

On the back of the upper panel is a small bakelite plate carrying four blank lamp sockets in which are placed spare lamps for the short test circuit. Three (3) spare fuses are also mounted on this panel.

III
OPERATION
THE TESTING OF VACUUM TUBES

A. UNPACKING AND SETTING UP

The Model OD-2 equipment is shipped in a double wooden crate. To unpack, open the outer box carefully, remove the top layer of packing material and remove the inner wooden box. A small package will be found in the outer packing material carrying the angle iron feet and the cap screws and lock washers used for fastening them in place.

The inner box should then be opened by carefully removing the screws from the boards on the large face and one end of this box should also be removed by taking out the screws holding it in position. The strips holding the panel can then be lifted out and the unit itself carefully removed and set upright on a table. The angle iron legs may then be attached to the sides using the cap screws and lock washers.

Remove the back plate by taking out the screws around its edges and remove the enclosed package containing the rectifier tube and the short test lamps. Insert the rectifier tube in its socket on the bottom, place four of the small lamps in the spare sockets on the back of the upper panel, see that the fuses are in place on the bottom as well as the spare fuses just below the spare lamps. Insert the six short test lamps on the face of the panel. The back should be replaced at this time because of the high voltages generated in the rectifier circuit and the device is ready for use.

B. POWER SUPPLY

Insert the plug in a power supply outlet capable of furnishing up to 3 amperes at a nominal potential of 115 volts, 50 to 60 cycles, first noting that the line switch and grid and plate supply switch are in the down or OFF position.

See that all potentiometers are rotated to the left, then throw the line switch up which should cause the green pilot at its left to light. If the pilot does not light, unscrew the cap over this lamp and see that the lamp itself is screwed in place. If it still does not light, exchange it with the lamp under the red cap at the right. These pilot lights burn at a voltage considerably under their rating and should have an extremely long life.

With the LINE switch turned on try out the short test circuit by raising the SHORT TEST switch on the top panel which should cause the six neon lamps to glow. Pulling down the LAMP TEST switch should cause the lamps to go out and a check of the short test circuit may be made by plugging one of the patch cords across one of the short test sockets.

Turn on the GRID AND PLATE SUPPLY switch, turn the VOLTMETER SWITCH (directly below the element voltage meter) to the PLATE position and after a few seconds rotate the plate voltage Potentiometer. Voltage should be indicated rising in value as the plate voltage adjuster is rotated clockwise. In a similar fashion bring up the screen grid and suppressor grid voltages, shifting the VOLTMETER switch to these positions. If everything has functioned satisfactorily so far, a tube should be tested to prove out the remainder of the circuit and to become familiar with the operation of the unit.

C. TESTING AN AMPLIFIER TUBE

Select a tube to be tested. It is recommended that one of the simpler types be tried first such as the 38001 and the more complicated types can be checked later. First make a short test of the tube. See that the LINE switch is turned on. Turn on the SHORT TEST switch by raising it so that the lamps glow. Plug tube into the correct socket in the upper row. Pull down the LAMP TEST switch. All of the lamps except the one on the extreme left indicating filament continuity will go out if the tube is clear of internal short circuits. If any of the other lamps continue to glow, the tube is shorted and should not be tested further unless it has a third filament connection as indicated in the base chart.

The tube having been found to be free of shorts, it may be placed in the proper socket in the lower row AFTER THE LINE SWITCH has been turned off.

Refer to the table of vacuum tube test data which tabulates the proper test voltages for each electrode of each type of tube and which shows in parentheses, after the voltage value, the pin number which connects to the associated element. It will be noted that the grid bias specified for filamentary types of tubes is larger by half the filament potential than would be specified were the filament supply DC instead of AC. A tube gase chart is provided to aid in visualizing the relative positions of the electrodes within each tube.

Connect the filament or heater circuit by patching from the heater, meter and supply jacks to the double jacks carrying the numbers corresponding to the filament pins as shown on the tube base charts. The jacks numbered 1 through 8 and “cap” are wired directly in parallel with the corresponding jacks above them and, therefore, the patch cord from the heater jack marked ”meter” may be put in the lower or numbered element jack, and the “supply” patch cord in the upper jack.

Patch across the plate circuit. In the case of the 38001 tube the plate circuit is terminal #2 and a patch cord should connect between jack #2 on the upper panel and one of the PLATE jacks in the lower group.

The grid terminal on the tube is #3 and #3 jack on the upper panel is connected to the CONTROL GRID terminal on the lower group

The complete circuit is now connected and the various potentials are next to be turned on.

See that all of the ADJUSTER SWITCHES are turned completely to the left.

Rotate the FILAMENT VOLTAGE switch to the filament voltage of the tube under test, in this case 5 volts, noting that this is to be read on the 8 volt scale as indicated on this switch.

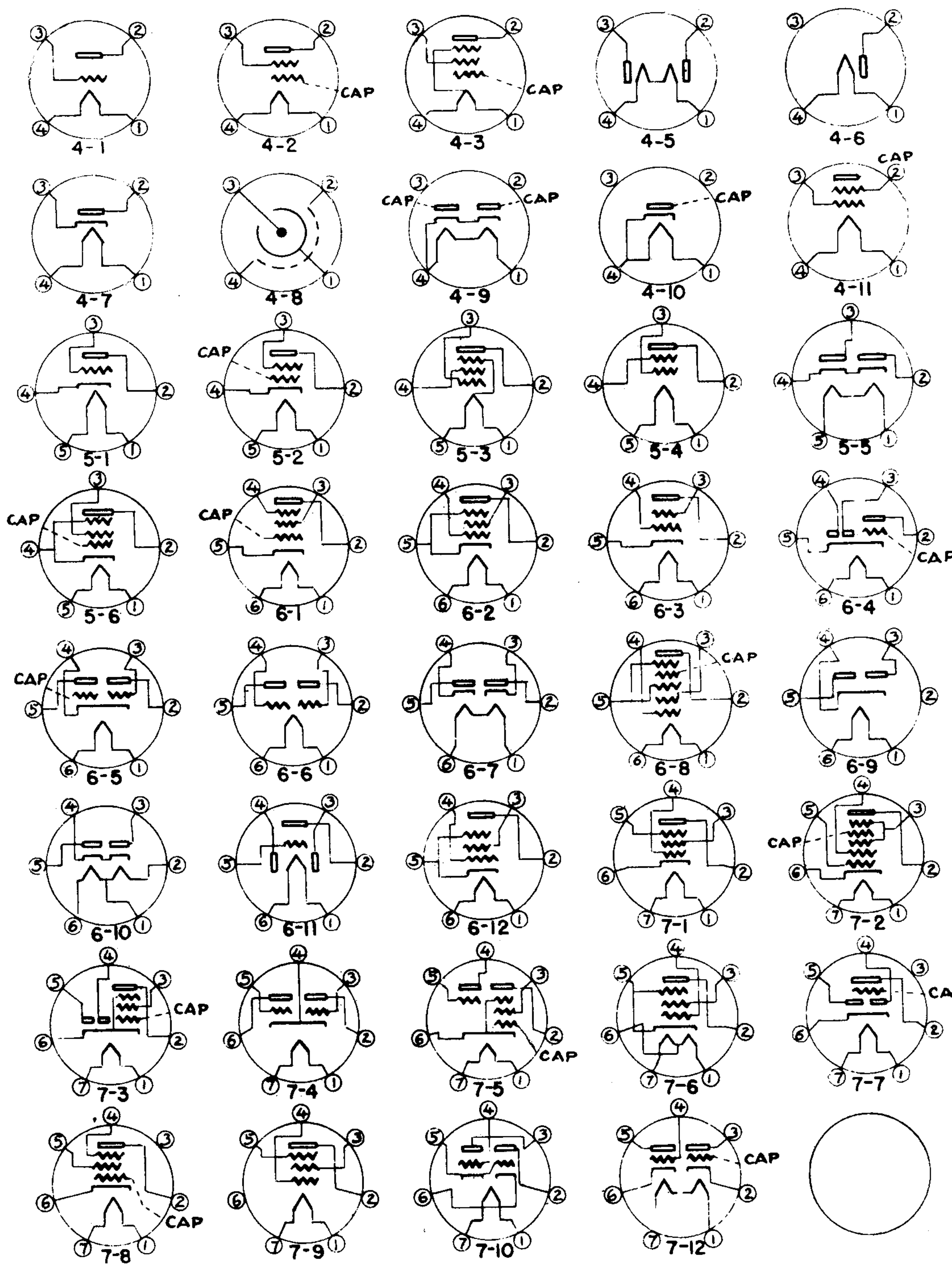
Turn on the LINE SWITCH by raising it.

Rotate the FILAMENT VOLTAGE ADJUSTER which will bring up the filament voltage from something under the nominal value until it reads exactly the normal filament voltage, in this case 5 volts.

The grid voltage should next be brought up so that it will control the tube and prevent excessive current flowing when the plate voltage is applied. Since the grid voltage is –11.5 volts, which is greater than 10 volts, keep the CONTROL GRID VOLTAGE switch up and the switch to the left of the CONTROL GRID VOLTAGE meter up also. Bring up the control grid voltage by rotating the CONTROL GRID VOLTAGE ADJUSTER until the instrument indicates 11.5 volts on its 50 volt scale. It will be noted that the value of control grid voltage indicated by the meter will change when the plate voltage is brought up, due to the current drawn by the tube and it will probably be necessary to readjust the control grid voltage. Nevertheless it must be brought up first to prevent excessive plate current from flowing.

TUBE BASE CHART

LOOKING DOWN ON TOP OF SOCKET



TUBE BASE CHART

NAVY STANDARD TUBES

NAVY TYPE	COMM. TYPE	BASE	NAVY TYPE	COMM TYPE	BASE	NAVY TYPE	COMM. TYPE	BASE
38001	01A	4-1	38050	50	4-1	38181	81	4-6
38012	12A	4-1	38053	53	7-4	38182	82	4-5
38015	215A	4-1	38056	56	5-1	38183	83	4-5
38022	22	4-2	38057	57	6-1	38184	84	5-5
38024	24A	5-2	38058	58	6-1	38213	2A3	4-1
38027	27	5-1	38059	59	7-1	38215	2A5	6-2
38030	30	4-1	38064	864	4-1	38222	RK22	4-9
38031	31	4-1	38071	71A	4-1	38233	--	7-12
38032	32	4-2	38075	75	6-4	38255	25Z5	6-7
38035	35	5-2	38076	76	5-1	38266A	836	4-10
38036	36	5-2	38077	77	6-1	38274	874	4-8
38037	37	5-1	38078	78	6-1	38593	5Z3	4-5
38038	38	5-6	38085	85	6-4	38616	6A6	7-4
38039	39	5-6	38089	89	6-1	38617	6A7	7-2
38040	40	4-1	38101	801	4-1	38627	6B7	7-3
38041	41	6-12	38110	10	4-1	38636	6C6	6-1
38042	42	6-12	38142	--	4-1	38646	6D6	6-1
38045	45	4-1	38165	865	4-11	38667	6F7	7-5
38047	47	5-4	38180	80	4-5			

MISCELLANOUS TUBES

TUBE	BASE	TUBE	BASE	TUBE	BASE	TUBE	BASE
00A	4-1	6E7	7-8	33	5-3	96	4-7
1A6	6-8	6F7	7-5	34	4-2	98	5-5
1B5	6-11	6Y5	6-9	43	6-3	182B	4-1
1C6	6-8	6Z3	4-7	44	5-2	183	4-1
1V	4-7	6Z4	5-5	46	5-4	213	4-5
2A3	4-1	6Z5	6-10	48	6-3	216B	4-6
2A5	6-2	12A5	7-6	49	5-4	482A	4-1
2A6	6-4	12Z3	4-7	51	5-2	482B	4-1
2A7	7-2	12Z5	6-10	52	5-3	483	5-1
2B6	7-10	14	5-2	55	6-4	484	5-1
2B7	7-3	14Z3	4-7	64	4-1	485	5-1
2Z2	4-6	15	5-2	65	5-2	585	4-1
5Z3	4-5	17	5-1	67	5-1	586	4-1
6A4	5-3	18	6-3	68	5-2	864	4-1
6A6	7-4	19	6-6	69	6-2	950	5-3
6A7	7-2	20	4-1	79	6-5	951	4-2
6B7	7-3	25Y5	6-7	84	5-5	AD	4-7
6C6	6-1	25Z3	4-7	G84	4-6	AF	4-5
6C7	7-7	25Z5	6-7	90	6-2	AG	4-5
6D6	6-1	26	4-1	92	6-2	LA	5-3
6D7	7-8	29	6-2	95	6-3	PZ	5-3
						PZH	6-3

With the switch below the ELEMENT VOLTAGE meter on PLATE and the ELEMENT CURRENT meter also switched into the PLATE CIRCUIT and on a scale well above the expected value of plate current, in this case using the 10 MA. Range since the normal plate current is 3 MA., rotate the PLATE VOLTAGE ADJUSTER to the right bringing up the plate voltage. Since the plate voltage is 135, have the switch to the left of the ELEMENT VOLTAGE meter down for 150 volts full scale.

Plate current should be indicated, its nominal value for this tube being 3 MA.

The AMP. FACTOR switch should be brought to its correct value and since this changes resistance in the plate circuit it is usually desirable to set this first. The amplification factor of this tube is 8 and the switch should be set at “7”, the nearest value. Make readjustments on plate and grid voltage to bring them to their exact stated values of 135 volts and –11.5 volts, respectively, to get stated conditions.

To adjust the HUM control or center tap lead, pull and hold down the HUM test switch with the HUM control in its center position. Adjust the HUM control to a minimum or zero deflection on the transconductance meter. Since it is frequently difficult to get the true effective minimum or zero position of the HUM control, more accurate results will be had by adjusting it so that the transconductance meter reads a definite amount, say 10, and note this, the first position of the HUM control. Rotate the HUM control so that the transconductance meter pointer passes through its minimum reading and again reads up to the same position (10) as before, and note the second position of the HUM control. The final setting of the HUM control for most accurate results will be half-way between its first and second positions, which may readily be figured, and for accurate results this method should be used on all filament type tubes, that is, tubes not having a cathode. Make this setting and release the HUM test switch.

See that the switch below the transconductance meter is on the correct scale, in this case 3,000 since the expected transconductance of this tube is about 800. Raise the SIGNAL SUPPLY switch and rotate the SIGNAL VOLTAGE ADJUSTER until the instrument above it indicates directly over the arrow in a vertical position.

The transconductance of the tube under test in micromhos will now be indicated on the center instrument, in this case on the black scale. Note that two zeros must be added to the reading.

The grid current meter at the left indicates the current in this circuit and if any perceptible deflection is noted but still less than one division, pull down the switch next to it which will then allow grid current to be indicated on the 15 microampere scale. Excessive reverse grid current usually indicates gas or leakage.

The transconductance of the tube having been noted, its comparison with the tabulated value for end of useful life may be used as a basis for determining its future usefulness.

Tubes of other types are tested in similar fashion. Where a tube has a screen grid, this grid should be connected to the screen grid jack and the screen grid voltage brought up the rated value. Screen grid current may be taken by switching the milliammeter into the screen grid circuit on a suitable range and screen current may be compared with the normal values listed in the chart.

In the case of heater type tubes having cathodes, the cathode is patched across to one of the several cathode jacks and where this is the case it is not necessary to manipulate the HUM CONTROL or the HUM TEST switch since all of the electron flow is from the cathode which constitutes the normal return circuit.

In testing double tubes connect each section in turn as a single tube and make the test. The other electrodes should be considered as inactive and should be grounded to the cathode.

Since the voltmeter in the element circuit takes some current to operate, and this current is added to the element current proper and indicated on the ELEMENT CURRENT meter it is desirable for accuracy to compensate for this factor. A red scale has been added to the ELEMENT VOLTAGE meter running from 0 to 1 MA. Where element currents are low the current indicated on the ELEMENT VOLTAGE meter should be subtracted from the current

Indicated on the ELEMENT CURRENT meter both instruments being switched into the same circuit. It is advisable to make this correction when reading the ELEMENT CURRENT meter and record only the true value.

The SUPRESSOR GRID VOLTAGE ADJUSTER with its associated instrument positions is used where a third grid must have another voltage placed on it. The controls function exactly the same as the screen grid or the plate. It is essentially a spare control and may be used for supplying screen voltage if desired.

Note that for grid voltages of less than 10 volts the CONTROL GRID LEVEL SWITCH should be down and the CONTROL GRID VOLTMETER switched to the 10 volt scale.

D. RECTIFIER TESTS

Rectifier tubes should be tested for short circuits in the same manner as any amplifier tube and should show clear before testing further.

In order to reduce drop in the plate circuit as much as possible set the AMP. FACTOR switch to RED SCALE and the switch below the transconductance meter to 6,000.

Patch across the filament or heater with the four cords as explained under “Amplifier Tubes”. Patch across the plate and in the case of double tubes check one plate at a time while the other is grounded to the cathode jack.

Excite the filament circuit, leaving the grid circuit off by rotating the CONTROL GRID VOLTAGE ADJUSTER all the around to the left. The ELEMENT CURRENT meter should be placed on its 100 MA. Scale in the plate circuit and the ELEMENT VOLTAGE meter on its 150 volt scale also in the plate circuit.

Increase the plate voltage until the plate current reaches the value specified as indicating the end of useful life. If the plate voltage exceeds the Value specified in the table, the tube is no longer useful. In no case should the emission current exceed the nominal value specified. In order not to damage the tube, emission tests should be of short duration.

Double plate rectifier tubes should have approximately the same drop thru each section. If the drops in the two sections differ materially, hum may come thru a filter system designed on the basis of full wave rectification since an unbalanced tube allows a half wave component to appear in its total output.

VACUUM TUBE TEST DATA

TYPE NO.	FILA. VOLTS H-1	CATH-ODE TERMI-NAL	CONTROL GRID VOLTS	PLATE VOLTS	SCREEN VOLTS	AMP. FAC-TOR	NOMI-NAL PLATE MA	END FACTOR	USEFUL LIFE FACTOR NOMINAL	END
38001	5.0	--	-11.5(3)	135(2)	--	8	3	Sm	800	470
38012	5.0	--	-15(3)	180(2)	--	6.6	7.7	Sm	1800	1000
38015	1.0	--	-10.5(3)	100(2)	--	6	1.6	Sm	380	250
38022	3.3	--	-3.15(C)	135(2)	45(3)	160	1.7	Sm	375	240
38024	2.5	(4)	-3(C)	250(2)	90(3)	630	4	Sm	1050	800
38027	2.5	(4)	-21(3)	250(2)	--	9	5.2	Sm	975	675
38030	2.0	--	-14.5(3)	180(2)	--	9.3	3.1	Sm	900	585
38031	2.0	--	-31(3)	180(2)	--	3.8	12.3	Sm	1050	550
38032	2.0	--	-4(C)	180(2)	67.5(3)	780	1.7	Sm	650	465
38035	2.5	(4)	-3(C)	250(2)	90(3)	420	6.5	Sm	1050	800
38036	6.3	(4)	-3(C)	250(2)	90(3)	595	3.2	Sm	1080	800
38037	6.3	(4)	-18(3)	250(2)	--	9.2	7.5	Sm	1100	600
38038	6.3	(4)	-25(C)	250(2)	250(3)	120	22	Sm	1200	675
38039	6.3	(4)	-3(C)	250(2)	90(3)	1050	5.8	Sm	1050	800
38040	5.0	--	-5.5(3)	180(2)	--	30	0.65	Sm	400	200
38041	6.3	(5)	-16.5(4)	250(2)	250(3)	150	34	Sm	2500	1300
38042	6.3	(5)	-16.5(4)	250(2)	250(3)	220	34	Sm	2500	1300
38045	2.5	--	-56(3)	250(2)	--	3.5	30	Sm	2100	1050
38047	2.5	--	-16.5(3)	250(2)	250(4)	150	31	Sm	2500	1700
38050	7.5	--	0(3)	250(2)	Plate current test			Ip	110	100
*38053	2.5	(4)	+50(3)(5)	50(2)(6)	Emission test			Is	125	60
38056	2.5	(4)	-13.5(3)	250(2)	--	13.8	5	Sm	1450	700
38057	2.5	(5&4)	-3(C)	250(2)	100(3)	1500	2	Sm	1225	920
38058	2.5	(5&4)	-3(C)	250(2)	100(3)	1280	8.2	Sm	1600	1200
38059	2.5	(5&6)	-18(4)	250(2)	250(3)	100	35	Sm	2500	1500
38064	1.1	--	-10(3)	135(2)	--	8.2	3.5	Sm	645	500
38071	5.0	--	-43(3)	180(2)	--	3	20	Sm	1700	650
*38075	(6.3	(5)	-2(C)	250(2)	--	100	0.9	Sm	1100	820
	(6.3	(5)	--	10(3&4)	--	--	--	Ip	1.0	0.8
38076	6.3	(4)	-13.5(3)	250(2)	--	13.8	5	Sm	1450	700
38077	6.3	(4&5)	-3(C)	250(2)	100(3)	1500	2.3	Sm	1250	930
38078	6.3	(4&5)	-3(C)	250(2)	125(3)	990	10.5	Sm	1650	1075
*38085	(6.3	(5)	-20(C)	250(2)	--	8.3	8	Sm	1100	700
	(6.3	(5)	--	10(3&4)	--	--	--	Ip	1.0	0.8
38089	6.3	(4&5)	-25(C)	250(2)	250(3)	125	32	Sm	1800	750
38101	7.5	--	+100(3)	100(2)	Emission test			Is	100	60
38110	7.5	--	+100(3)	100(2)	Emission test			Is	100	60
38142	7.0	--	+50(3)	50(2)	Emission test			Is	50	30
°38165	6.0	--	+125(C)	125(C)	125(2)	--	--	Is	125	75
*38180	5.0	--	--	75(2&3)	Emission test			Is	170	50
38181	7.5	--	--	85(2)	Emission test			Is	150	85
38182	Don't test in Model OD. End life is failure to rectify.									
38183	Don't test in Model OD. End life is failure to rectify.									
*38184	6.3	(4)	--	25(3)	Emission test			Is	60	40
38213	2.5	--	-45(3)	250(2)	--	4.2	60	Sm	5250	2625
38215	2.5	(5)	-16.5(4)	250(2)	250(3)	220	34	Sm	2200	1300
*38222	2.5	--	--	10(C)	--	Emission test		Ip	90	60
*38233	6.3	(2&6)	-16.5(C&4)	250(3&5)	--	10.5	8.3	Sm	1375	890
*38255	25	(3&4)	--	18(2&5)	--	Emission test		Ip	130	50
*38266A	2.5	--	--	10(C)	--	Emission test		Ip	90	60
38274	(See paragraph III F.)									
*38593	5.0	--	--	50(2&3)	--	Emission test		Ip	100	50
*38616	6.3	(4)	+50(3&5)	50(2&6)	--	Emission test		Ip	125	60
38617	6.3	(6)	Pins 2,3,4,&5; 50 volts.			Emission test		Is	80	70
*38627	(6.3	(6)	-3(C)	250(2)	125(3)	730	9	Sm	1125	725
	(6.3	(6)	--	10(4&5)	--	Emission test		Is	1.0	0.8
38636	6.3	(4&5)	-3(C)	250(2)	100(3)	1500	2	Sm	1225	920
38646	6.3	(4&5)	-3(C)	250(2)	100(3)	1280	8.2	Sm	1600	1200
*38667	(6.3	(6)	-3(5)	100(4)	--	8	3.5	Sm	500	275
	(6.3	(6)	-3(C)	250(2)	100(3)	900	6.5	Sm	1100	800
°38842	6.0	--	+100(3)	100(2)	--	Emission test		Is	100	60

*Test two sections separately.
°Note Filament Volts are less than normal.
Sm = Transconductance (micromhos)
Ip = Plate current (milliamperes)
Is = Emission Current to all electrodes (milliamperes).

E. DIODE DETECTOR TESTS

A diode used as a detector is essentially a rectifier but operating at a very low current level. The customary test for a diode is to pass at least 0.8 MA. At 10 volts.

The tube should have its heater or filament connected normally and one diode at a time connected to the plate circuit. With the ELEMENT VOLTAGE meter on 150 volts plate bring the plate voltage up to 10 volts or four divisions: with the ELEMENT CURRENT meter on the 5 MA. plate range the reading should be at least 0.8 MA. or four divisions. Diodes normally pass considerably greater current, some as high as 2 or 3 MA. but since they are usually in very high resistance circuits, the 0.8 MA. limit is considered as a satisfactory minimum current value.

F. OTHER TESTS

Type 38274 voltage regulator tubes may be tested as follows: Insert tube in the short-test socket which will cause the extreme left hand neon lamp to light because terminals 2 and 4 are connected within the base. No other neon lamps should light. Remove the usual heater and filament voltmeter patch cords and patch between socket terminal #1 and the cathode jack. Patch between socket terminal #3 and one of the plate jacks. Switch the ELEMENT CURRENT meter into the PLATE CIRCUIT and on the 100 MA. scale. Slowly increase the plate voltage until the plate current suddenly increases from zero to some readable value. If the plate voltage exceeds 130 volts, <u>just before</u> the plate current flows, then the tube has reached the end of its useful life. The plate current should at no time be allowed to exceed 50 MA.

Total emission when specified as the factor determining the end of useful life may be measured by connecting the heater or filament with the four patch cords, tying the cathode if any, to the cathode jack, and bringing all of the other active electrodes to the several plate jacks. The remainder of the test is conducted as described for rectifier tubes.

Plate resistance may be taken by noting the plate current with normal grid and other electrode potentials, and then shifting the plate voltage a given amount and noting the change in plate current. Plate resistance is defined as the change in plate voltage divided by the change in plate current, and if the latter is in MA. instead of amperes, multiply the result by 1000.

A convenient change in plate voltage is 25 volts and the change may be either up or down.

It will be difficult to take the plate resistance of screen grid tubes in this manner since the plate resistance is so very high that the plate current will change but little. Nevertheless the test is available.

Amplification constant, the ratio of plate voltage change to grid voltage change for constant plate current may also be taken. With an amplifier tube operating in the set under normal conditions, change the plate voltage a given amount, say 25 volts. The plate current will change. Shift the control grid voltage until the until the plate current is brought back to its first value. Note the change in grid voltage. The ratio of the plate voltage change to the grid voltage change is then the amplification constant. Again, in screen grid tubes this may be very high and somewhat difficult to take. Since the amplification constant is basically a design factor dependent upon the mechanical positioning and spacing of the several electrodes, it is not very often taken when testing but usually assumed from design data. In the case of tubes with unknown characteristics, however, its measurement may be of interest.

It should be remembered that the Transconductance decreases as the plate resistance increases. For example, if the plate resistance (R_p) increases 56% the transconductance will decrease to 64%.

The transconductance (S_m) is generally the limiting factor as it takes in the amplification factor (μ) also.

Any change in the rated amplification factor (μ) for example 20% would indicate a shifting of the electrodes.

The mathematical connection between transconductance in micromhos, plate resistance in ohms and amplification factor, which is a ratio, should be noted. It may be stated as

Amplification Factor = Transconductance x Plate Resistance.

In the above transconductance is in mhos, but since usually measured in micromhos it is necessary to divide the above equation by one million if the value in micromhos is used. The several equations coordinating these three factors are given below

$$S_m = \frac{M_u}{R_p} \times 1,000,000, M_u = \frac{S_m \times R_p}{1,000,000}, R_p = \frac{M_u}{S_m} \times 1,000,000$$

Where S_m = Transconductance in micromhos
R_p = Plate resistance in ohms
M_u = Amplification constant

The accuracy of the Model OD equipment can be stated as follows: All of the flush type meters on this panel are guaranteed to be within 2% at full scale. The fan shaped meter (Model 269) on this panel is guaranteed at 3% at full scale. However, the accuracy of the final reading of transconductance depends directly upon the sum total of all the individual meter errors.

IV

GENERAL NOTES

A. PRECAUTIONS

DON'T ATTEMPT TO TEST a tube unless it has been found clear in the short test.

DON'T attempt to patch the circuit unless all switches are off.

DON'T INSERT A TUBE until sure that the FILAMENT VOLTAGE SWITCH is set on the correct value for that tube. Check with the test data Chart.

DON'T INSERT A TUBE IN THE TEST CIRCUIT UNLESS ALL VOLTAGE ADJUSTERS ARE ROTATED AROUND TO ZERO. This may be waived if testing a group of identical tubes although even here it is desirable to lower the plate voltage to make sure that overloads do not occur.

DON'T TEST RECTIFIERS beyond their maximum current carrying capacity.

DON'T run diodes over 10 volts or their emission may be lost.

DON'T MAKE TOTAL EMISSION TESTS at currents greater than the values specified. Make emission tests quickly to minimize damage to the tube. Abnormal currents will frequently remove all the coating from the filaments or cathodes.

DON’T FAIL TO BRING UP THE GRID VOLTAGE FIRST since high plate voltage without any grid voltage may draw abnormally high currents, so high as to even damage the instrument.

DON’T fail to set the AMPLIFICATION CONSTANT switch at the nominal value for the tube under test in order to get an accurate reading.

DON’T fail to shut the device off completely when thru using it and return all patch cords to the blank jacks at the left.

B. REPLACEMENT PARTS

Should one of the neon lamps fail to operate, one of the four spares in the back may be used. Lamps may be purchased as 1/4 watt candelabra base neon glow lamps T-4 1/2 bulb.

Don’t fail to keep the device properly fused. If replacement fuses are required, use one of the spares in the back of the upper panel, or any 3 ampere fuse of the suitable size thereafter.

The rectifier tube is a standard type 38180 and may be replaced by such a tube if it fails.

The device is wired in cable and should any difficulties with the circuit be had it is not difficult to trace the connections. Make certain, however, that connections are not broken or changed unless the difficulty is definitely known.

LIST OF PARTS

MODEL OD-2

VACUUM TUBE ANALYZER

No. Used	Description	Weston No.	W. D. Part No.
1	Top Panel	D-79584	
1	Bottom Panel	D-76307	
1	Right Side Plate Assem.	D-76431	
1	Bottom Plate Assem. with Support Rods	D-76432	
1	Top Plate Assem. with Support Rods	D-76314	
1	Shelf Assembled	D-76315	
96	#6-32 x 1/2” F.H. Brass Mach. Screws (black finish) for plates	ND-19245	
14	#6-32 Hex. Stop Nut for Plates (Nickel Finish)	ND-20541	
2	#6-32 x 5/8” F.H. Brass Mach. Screws for Shelf to Rear support rods (Nickel Finish)	J-9547-13	
13	#8-32 x 1/2” R.H. Brass Mach. Screws for Panel to support rod (Black Finish)	ND-1462	
2	#8-32 x 3/4” R.H. Brass Mach. Screws for Panel to support rod (Black Finish)	ND-19573	
1	Back Plate Assem. D-76324		
18	#6-32 x 5/16” R.H. Brass Mach. Screws for Back Plate (Black Finish)	ND-19647	
18	Lock Washers for back plate	ND-10599	
2	Feet for Mtg. Completed Device	D-74777	
6	Screws for Feet (Black Finish)	D-9363	
6	Lock Washers	ND-8668	
1	4 Prong Socket Engraved	D-74740	1
1	5 Prong Socket Engraved	D-74741	2
1	6 Prong Socket Engraved	D-74742	3
1	7 Prong Socket Engraved	D-74743	4
1	8 Prong Socket Engraved	D-76887	66
1	4 Prong Socket Plain	D-76427	5
1	5 Prong Socket Plain	D-76428	6
1	6 Prong Socket Plain	D-76429	7
1	7 Prong Socket Plain		8
1	8 Prong Socket Plain	ND-20794	65
4	#5-30 x 3/8” R.H. Br. Screws for Mtg. Sockets & Transformer (Black Finish)	ND-10598	
16	#5-40 x 3/8” R.H. Br. Mach. Screws for Mtg. Sockets (Black Finish)	ND-20139	
16	#5-40 Hex Nuts	ND-17098	

No. Used	Description	Weston No.	W.D. Part No.
20	Lock Washers	D-27771	
1	Nameplate for (“Line Switch”)	D-74713	
1	Nameplate for (“Signal Supply”)	D-74714	
1	Nameplate for (“Control Grid Level”)	D-74715	
1	Nameplate for (“Grid & Plate Supply”)	D-74716	
1	Nameplate for (“Control Grid Voltage Adjuster”)	D-74717	
1	Nameplate for (“Suppressor Grid Voltage Adjuster”)	D-74718	
1	Nameplate for (“Screen Grid Voltage Adjuster”)	D-74719	
1	Nameplate for (“Plate Voltage Adjuster”)	D-74720	
1	Nameplate for (“Signal Voltage Adjuster”)	D-74721	
1	Nameplate for (“Filament Voltage Adjuster”)	D-74722	
1	Nameplate for (“Filament Voltage”)	D-74723	
1	Nameplate for (“Volts – Supp., Screen, Plate”)	D-74724	
1	Nameplate for (“Volts – 50, 10”)	D-74725	
1	Nameplate for (“Volts – 300, 150”)	D-74726	
1	Nameplate for (“Micromhos – 6,000, 3,000”)	D-74727	
1	Nameplate for (“Hum Control”)	D-74728	
1	Nameplate for (“Set to Nearest Amp. Factor”)	D-74729	
1	Nameplate for (“Milliamperes – Cath., Supp., Screen, Plate”)	D-74730	
1	Nameplate for (“Milliamperes – 5, 10, 50, 100”)	D-74731	
1	Nameplate for (“Microamperes”)	D-74732	
1	Nameplate for (“Hum Test”)	D-74733	
1	Nameplate for (“Short Test”)	D-74734	
1	Nameplate for (“Lamp Test”)	D-74735	
1	Nameplate for (“Lower row of Jacks”)	D-74736	
1	Nameplate for (“Short Test Lamps”)	D-79615	
1	Nameplate for group of Jacks at left	D-74739	
1	Nameplate for (“Tube Elements”)	D-79589	
1	Navy Department Nameplate	D-79640	
88	Screws for Nameplates (Black Fin.)	D-74767	
59	Pin Jacks (Nickel Finish)	D-74708	9
1	Short Insulating Strip	D-79588	
1	Long Insulating Strip	D-74709	
28	Insulating Bushing for Jacks	D-39825	
50	Hex. Nuts for Jacks (Nickel Fin.)	D-2688	
24	Lock washers for Jacks	ND-17769	
28	Shakeproof Terminals	ND-19562	

No. Used	Description	Weston No.	W.D. Part No.
4	Insulating Washers (for Grid Test Jacks	D-44322	
2	Bushing (for Grid Test Jacks)	D-74710	
1	Short test Lamp base assem.	D-79587	
1	Guard for Lamps	D-79586	
3	#5-40 x 5/8” R.H. Br. Mach Screws (Black Finish) for Lamp Base	J-6257	
3	Lock Washers for Lamp Base	D-27771	
3	#5-40 Hex. Nuts for Lamp Base	ND-17098	
12	Neon Candelabra Lamps	ND-20284	10
8	150,000 Ohm Resisters for Lamps	ND-20543	11
1	Terminal and Spare Fuse Black Assem.	D-74746	
5	5 Ampere Auto Type Fuses	ND-19207	12
1	Toggle Switch S.P.S.T. Spring back normally on (“Lamp Test”)	ND-20528	13
1	Toggle Switch S.P.S.T. (“Short Test”)	ND-19950	14
2	Cable assem. with Cap for Control Grid Lead	D-76888	15
1	Short Test Transformer assembled	D-79584	16
2	Posts for Mtg. Transformer	D-74779	
2	#8-32 x 1-1/4” R.H. Br. Mach. Screws for Mtg. Transformers (Nickel Fin.)	ND-17281	
2	Lock Washers for Mtg. Transformer	ND-17920	
1	Toggle Switch S.P.S.T. Spring back normally on (“Microamps.”)	ND-20528	17
1	Toggle Switch S.P.S.T. Spring back normally off (“Hum Test”)	ND-205529	18
1	Toggle Switch D.P.S.T. (“Micromhos”)	ND-19951	19
3	Toggle Switch S.P.D.T. (“Volts – 50, 10”) (“Volts – 300, 150”) (“Cont. Grid Level”)	ND-20178	20
2	Toggle Switch S.P.S.T. (“Line Switch”) (“Grid & Plate Supply”)	ND-19950	21
1	Toggle Switch D.P.S.T. Spring back normally off (“Signal Supply”)	ND-20530	22
2	20,000 Ohm 150 Watt Rheostat with handle	D-74770	23
1	7,500 Ohm 150 Watt Rheostat with handle	D-74771	24
1	600 Ohm 150 Watt Rheostat with handle	D-74772	25
2	350 Ohm 25 Watt Rheostat with handle	D-76347	26
1	175 Ohm 25 Watt Rheostat with handle	D-76348	27
1	Filament Switch & Transformer Assem.	D-74707	28
1	Rotary Switch assem., with handle (“Volts – Supp., Screen, Plate”)	D-74773	29
1	Rotary Switch assem., with handle (“MA. – 5, 10, 50, 100”)	D-74774	30
1	Rotary Switch assem., with handle (“MA. – Cath., Supp., Screen, Plate”)	D-74775	31

No. Used	Description	Weston No.	W.D. Part No.
1	Rotary Switch assem. with handle for transconductance	D-74776	32
2	Pilot Lamp Bases	D-74711	
4	#6-32 x 3/4” O.H. Br. Mach. Scr., for Lamp Base (Black Finish)	J-5597	
4	Bushing for Lamp Base	D-73736	
4	Lock Washers for Lamp Base	ND-10599	
2	6 Volt Miniature Base Pilot Lamps	ND-19698	33
1	Red Jewel	D-72406	
1	Green Jewel	D-74712	
1	Double Choke, for filtering D.C. Power	ND-20538	34
1	Power Transformer, supplying D.C. Power & ’80 Filament	ND-20539	35
1	Rectifier Tube, Type 80	ND-20533	36
4	3 mfd. Condensers	ND-20525	37
1	8 mfd. Condenser	ND-20526	38
10	Lock washers, for Condensers	ND-10599	
10	#6-32 x 1/4” R.H. Br Mach. Screws, for Condensers	ND-17587	
1	Signal Transformer	D-74748	39
2	Bushings; for Mtg. transformer	D-76349	
2	#8-32 x 1 1/2” R.H. Br. Mach. Screws, for Mtg. Transformer	ND-19101	
2	Lock Washers for Mtg. Transformer	ND-17920	
2	Washers, for Mtg. Transformer	D-27743	
4	Resistance Spool, 25 Ohms	D-76337	40
2	Resistance Spool, 20 Ohms	D-76338	41
1	Resistance Spool, 2.25 Ohms	D-76339	42
1	Resistance Spool, 1.05 Ohms	D-76340	43
1	Resistance Spool, 10 Ohms	D-74764	44
1	Resistance Spool, 30 Ohms	D-74763	45
1	Resistance Spool, 150,000 Ohms	D-68060	46
1	Resistance Spool, 40,000 Ohms	D-68065	47
4	Screws, for Mtg. 25 ohm Spools	D-47462	
12	#5-40 x 5/8” R.H. Br. Mach. Scrs., for Mounting Spools	J-6257	
16	Lock washer, for Mtg. Spools	D-27-83	
1	Stackpole Resistor, 100,000 ohms, 1/2 watt	ND-20079	49
1	Ohmite Resistor, 750 Ohms, 30 Watt	ND-20531	50
1	Ohmite Resistor 1500 Ohms, 55 watt	ND-20532	51
4	#5-40 x 1/2” R.H. Br. Mach. Scr., for Mounting Resistors	ND-10598	
4	Bushings, for Mtg. Resistors	D-73139	
4	Lock washers, for Mtg. Terminals	D-27771	
4	Terminals	D-42773	
1	14 Mfd. Special Condenser	ND-20527	52
12	Patch Cords Assem.	D-74778	

Meter Requirement No. Used	Description	Weston No.	W.D. Part No.
1	Model 301, Scale 0-10-50 Volts, 1000 Ohms per Volt, Self-contained for 10 Volts, Flush type, Bakelite case, “Control Grid Voltage”.		53
1	Model 301, Scale 0-150-300 Volts, 1000 Ohms per Volt, Self-contained for 150 Volts, Flush type, Bakelite case, “Element Voltage”.		54
1	Model 301, Scale 0-5-10-50-100 Milli-amperes, adjusted to 1 MA., 100 Ohms Flush type, Bakelite case, “Element Current”.		55
1	Model 600, Scale 150-15-0-15-150 Micro-amperes, Zero Center, adjusted to low scale, flush type, Bakelite case, “Grid Current”.		56
1	Model 476, Scale 0-4-8-40 Volts, all Self-contained, 4 Studs, Flush type, Bakelite case, “Filament Voltage”.		57
1	Model 476 Milliammeter, 150 MA., adj-usted to 100 Ma. at arrow center of scale, Flush type, Bakelite case.		58
1	Model 269, Scale 0-3,000-6,000 Micro-mhos, Special rectifier type, Surface type, Metal case with Resistance Spools “A”, “B”, “C”, “D”.		59
2	Compensator Resistors 160-240-360-600		60
1	Resistance Spool “A”	D-76343	61
1	Resistance Spool “B”	D-76344	62
1	Resistance Spool “C”	D-46918	63
1	Resistance Spool “D”	D-76346	64