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Shop Practices and Service Techniques

RADIO

MARCH, 1951

VIBRATOR POWER SUPPLY SYSTEMS
And Suggested Methods For Vibrator Test

From time to time many questions are asked as to the reason why certain vibrator troubles occur and what method or test can best be used for determining improper functioning of vibrators. This article is therefore being presented to illustrate a method of vibrator test by oscilloscope waveform observation and also to acquaint the service personnel with some of the problems encountered in vibrator power supply systems. It must be kept in mind, however, that although the oscilloscope check can determine good and bad vibrator action, it will not always show up all mechanical defects which can give trouble. Some of these latter troubles show up as short period mechanical breakdowns sometimes occurring only when the vibrator reaches a certain temperature during operation. Excessive "A" voltage resulting from improper voltage regulator operation in the car will almost certainly result in short time vibrator failure. With 6 Volt car battery systems, car radios are generally designed to operate with a *maximum* of 8 Volts at the "A" input terminal but even at this voltage the life of tubes and vibrator is materially shortened. Regulator action should maintain a maximum car generator voltage somewhere between 7.0 and 7.5 volts. The voltage at the radio input will then be a few tenths less than this due to 1R drop in the car cables and accessory switch.

VIBRATOR TYPES

There are two basic types of the full wave, 4 contact vibrators used in Philco auto radios. These vibrators supply "A" current alternately to two halves of a center tapped power transformer primary winding and the mechanical construction of each is illustrated in figures 1a and 1b. Also shown is an accompanying schematic of each as wired into a power transformer.

Figure 1a illustrates what is commonly known as a "shunt drive" type vibrator where one end of the electromagnetic drive coil is connected to the vibrating reed (normally the grounded side of the system) and the other end of the coil is connected to an insulated contact on the electromagnetic pull or "power" side of the reed. As shown, the two insulated contacts are open when the vibrator is at rest but when "A" voltage is applied to the transformer primary center tap, current flows through the vibrator drive coil and causes the reed armature to be pulled toward the pole piece. One set of contacts then close which short the drive coil electrically and thereby releases the pull on the reed. The mechanical energy stored up in the reed then causes a reverse swing and inertia carries it beyond center to close the other set of contacts. Current flow is again building up in the drive coil during the inertia swing period and imparts a peak pull to the armature again after the reed starts returning from closing the *inertia contacts*. The cycle is then repeated. It might be noted at this point that the voltage applied to the driving coil after starting is approximately 12 Volts when using a 6 volt "A" power source. This is due to auto transformer action in the tapped primary winding.

Philco car radio vibrators #83-0025, 83-0035 and 45-6307 are examples of the "shunt drive" type.

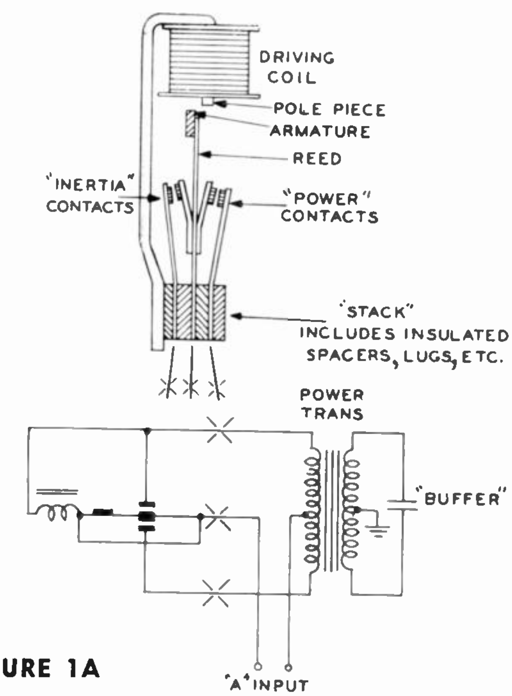

FIGURE 1A

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PRINCIPLE AND SERVICE OF PHILCO SCRATCH ELIMINATOR

Although the Philco scratch eliminator is no longer used in Philco radio-phonographs, a description of its operation and service proceedures will be in order, since this circuit was used in the deluxe models of a few years ago. Due to the quality of the sets incorporating the device, it is reasonable to expect that service men will be called upon to handle these models for many years to come.

The Philco scratch eliminator is designed to eliminate the scratch noise inherent in ordinary phonograph reproduction. Basically, this device is, in effect, a variable condenser across the audio circuit or phonograph input into which the pick-up is operated.

USES SIMPLE PRINCIPLE

Because the impedance of a capacitor decreases with an increase in frequency, or in other words, because a condenser offers less impedance to high frequencies than it does to low frequencies, the condenser across the audio line will tend to by-pass the higher frequencies to ground. Generally speaking, by varying the capacitance of this condenser across the line, we can control the high frequency response of the amplifier into which the audio line feeds.

Since scratch, in common with most other forms of noise, is of a relatively high-frequency nature, it was determined that if a variable capacitance could be designed to vary with the amplitude and high-frequency content of the input signal, it could effectively eliminate scratch without noticeably imparing the high frequency response.

By referring to the block diagram, Figure 1, we can follow the signal through a high-pass filter consisting of a resistor-condenser network, into an audio frequency amplifier — then into another high-pass filter, and to another amplifier. The third high-pass filter removes all remaining low frequencies, before the signal is rectified, to produce a d-c control voltage. The schematic of this circuit is shown in Figure 2.

This control voltage varies with, and is proportional to, the amount of high frequencies in the input signal, since the high-pass filters remove all except the high frequencies. In other words, as the high frequency content of the input signal increases, the control voltage increases. This control voltage is negative, since it is developed from a diode plate, and acts as a variable bias. The bias is applied to the variable capacitance, and as the

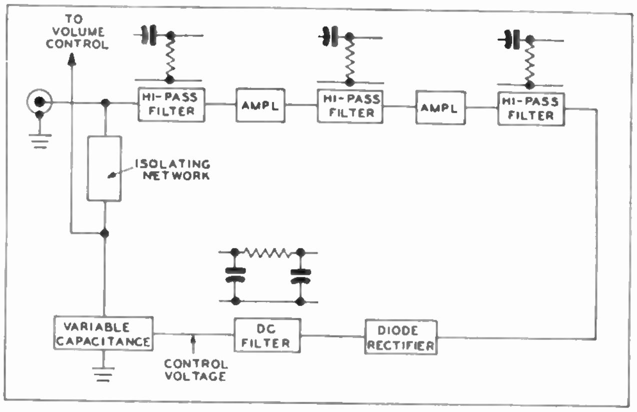


FIGURE 1

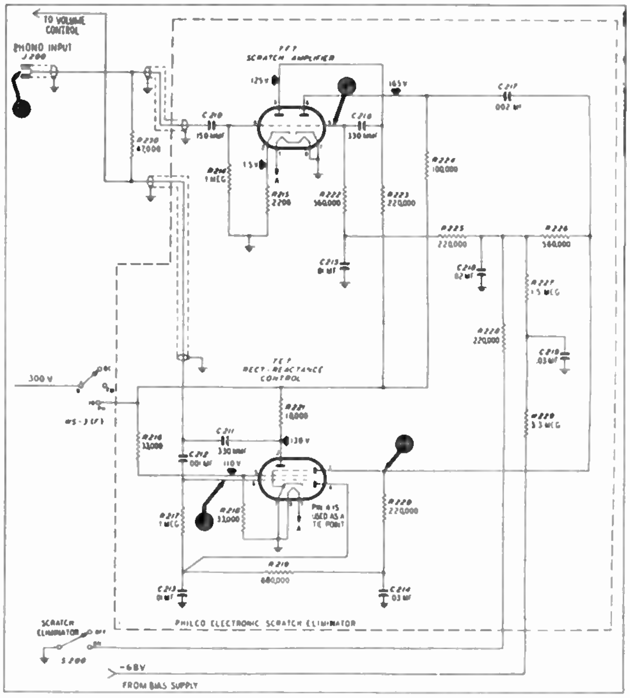


FIGURE 2

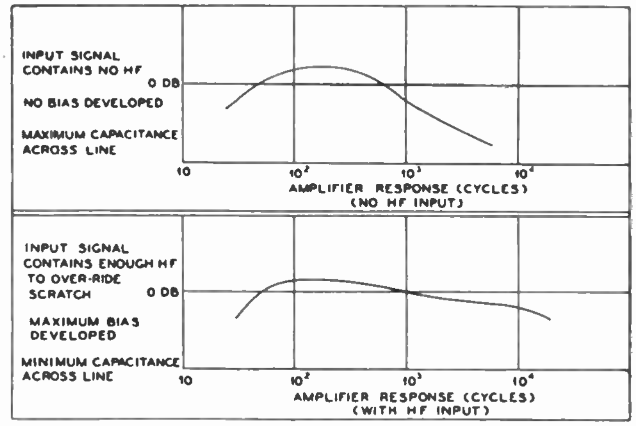


FIGURE 3

voltage increases negatively (as the bias voltage increases), the effective value of the capacitance decreases, or becomes smaller, and allows more high frequencies to pass through the line to the audio amplifier.

LESS HF — LESS BIAS

Conversely, as the high-frequency content of the input signal decreases, the amount of bias voltage developed becomes smaller, and the capacitance increases in value.

This variable capacitance is nothing more than a variable - mu pentode acting as a reactance tube, controlled by the variable bias. At low volume, when needle scratch is noticeable, the bias is small, causing the capacity to increase, and by-passing the scratch noise to ground. At high volume, the bias is great, causing the capacity to decrease, since there is no need for by-passing as the input signal tends to swamp the scratch noise.

VARIABLE Mu NECESSARY

The thing that actually happens when a variable bias is applied to the grid of the tube is that the amplification factor (mu) of the tube is varied. It is interesting to see how this takes place. The grid of a variable-mu tube is wound with varied spacing of the grid wires. The wires are spaced closely together at the top of the tube, and the spacing gradually increases toward the bottom. This means that each part of the grid has a different controlling effect on the electron flow between the cathode and the plate. Each part of the grid may be cut off, that is, the electron flow may be stopped, by a different value of negative bias applied to the grid, as shown in Figure 4.

BIAS CONTROLS TRANSCONDUCTANCE

When the bias is zero, the entire grid acts, and has the greatest control over the flow of electrons to the plate. When the bias is increased to a point where part of the grid is cut off, the balance of the grid, because the average spacing between the wires is greater, has less control over the electron flow. In other words, it requires a greater change in grid voltage to cause a given change in plate current.

Considering the tube factors given above under varying bias conditions, we will notice that, as the bias increases, the transconductance decreases. Transconductance is the ratio of the increments of change of plate current to bias voltage. Therefore, transconductance is an indication of stage gain, since stage gain, M, is equal (approximately) to transconductance, gm, times the load resistance, R(Load); (M=gm RL). When the entire grid has been cut off, the transconductance becomes zero,

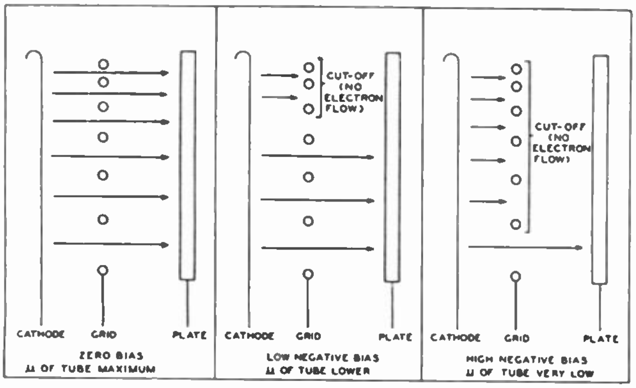


FIGURE 4

since no plate current flows and $gm = \frac{di(plate)}{de(grid)}$ Going back to the calculation of stage gain, M=0 when gm=0.

INPUT "REFLECTS" LOAD

The character of the input impedance of a tube is determined by the character of the output (load) impedance of the tube. When the load impedance of the tube is an inductance or a capacity, the input impedance will be equivalent to that of a capacitance and a resistance in parallel from grid to cathode. When the load impedance is a resistance, the input impedance is a capacity.

In the case of the scratch eliminator, the load impedance is a resistance.

MILLER EFFECT USED

The "Miller Effect", determined by a Mr. J. M. Miller in 1919, is that the input capacity (between grid and cathode) of a tube is not equal to just the internal (or inter-electrode) capacity between grid and cathode. It was found that the input capacity is equal to the grid-cathode capacity plus the stage gain times the grid-plate capacity. This is shown in the equation:

$$C\ input = C(grid\text{-}cathode) + (M+1)C(grid\text{-}plate)$$

Thus, by varying the value of the stage gain we have an effective means of varying the value of the shunt capacitance across the phono input as shown in Figure 5. This value of shunt capacitance will, under conditions of strong high-frequency input, approach the value of the grid-cathode inter-electrode capacity which at audio frequencies has no appreciable effect; while with no high-frequency input the shunting effect is sufficient to by-pass all scratch, leaving the reproduced music free of noise.

SERVICING THE PHILCO SCRATCH ELIMINATOR

The following chart will be found helpful in testing and repairing the scratch eliminator. Included with the trouble-shooting chart is a base view identifying the parts replacement. The symbolization is correlated with the schematic shown in Figure 2.

SCRATCH-ELIMINATOR TESTS

Set the tone control fully counterclockwise. Turn the band (wafer) switch to the phono position. For all steps except 1(b), set the volume control to maximum; for this step, adjust the volume control as directed in the chart.

Turn the scratch eliminator on or off as indicated in the chart. (The scratch eliminator is on when the two-position switch is turned clockwise.)

Connect an output meter across the *primary* of the output transformer.

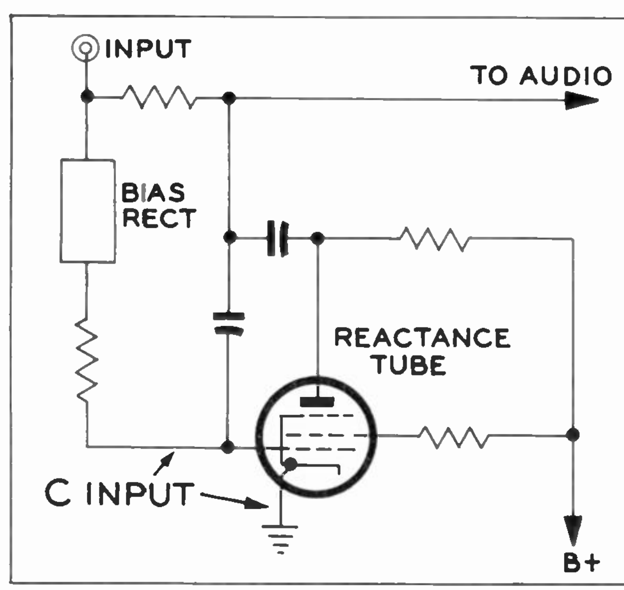
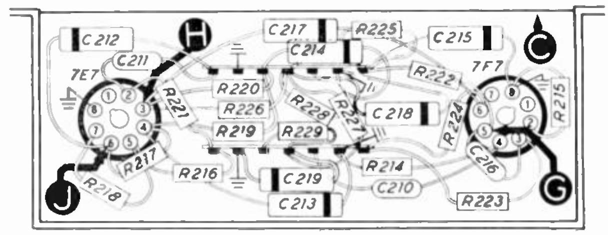


FIGURE 5

IMPORTANT! For all steps except step 4, use the 0—10-volt output meter range; for step 4 only, use the 0—50-volt range. If the proper ranges are not used, erroneous readings will result.

Connect the ground lead of an audio signal generator to the chassis, test point C, and connect the output lead through a .1-mf. condenser to the test points indicated in the chart. Set the generator for 5000 cycles. Adjust the generator output as directed in the chart.



NOTE: For steps 2, 3, and 4, connect the positive lead of a 20,000-ohms-per-volt, d-c voltmeter to the chassis, test point C; connect the prod end of the negative lead through a 100,000-ohm isolating resistor to the "VOLTMETER" test points indicated in the chart.

STEP	TEST POINT	SIG. GEN. OUTPUT	VOLT-METER	SPECIAL INSTRUCTIONS	POSSIBLE CAUSE OF ABNORMAL INDICATION
1(a)	F	Adjust for 10v output-meter reading, with scratch-eliminator off.		Turn scratch eliminator on; output voltage should drop to 6.5v (approx.).	Trouble in scratch-eliminator circuits. Isolate by the following tests.
1(b)	F	Same as for 1(a).		Reduce volume control to obtain output-meter reading of 1v. Increase generator output for output-meter reading of 10v. Turn scratch eliminator on; output voltage should not drop below 8.8v (approx.).	
2	G	See SPECIAL INSTRUCTIONS.	H	With scratch eliminator on, increase generator output for voltmeter reading of 8.8v, negative; failure to obtain this value indicates trouble.	Defective: 7F7, 7E7 (diode section), WS-3(R). Open R224, R222, R226, R228, C217, S200.
3	G	Same setting which produced 8.8v reading in step 2, with scratch eliminator on.	J	With scratch eliminator on, voltage at point J should be 2v, negative.	Open: R220, R219, R217. Shorted: C213, C214, C212.
4	F	Same as step 2.	H	With scratch eliminator on, voltage at point H should be approx. 28v, negative.	Defective: 7F7. Open C210, C216, R214, R215, R223. Shorted or leaky: C216.
5	F	Adjust for 10v output-meter reading, with scratch eliminator off.		Turn scratch eliminator on; output voltage should drop to 6.5v (approx.).	Defective: 7E7 (pentode section). Open: R221, R216, R218, C211, C212. Shorted: C211, C212.

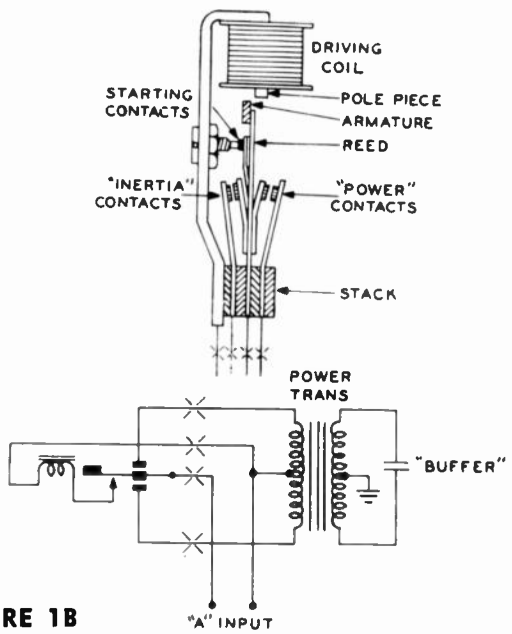


FIGURE 1B

Figure 1b illustrates another vibrator commonly known as a "separate driver" or "series drive" type. This differs from the "shunt drive" type mainly in that it has an extra pair of contacts which are normally closed when the vibrator is at rest. These contacts form a ground return connection to one end of the drive coil while the other end of the coil is connected directly to the "A" voltage source. You will note that one of the vibrator socket prongs must be connected to "A" voltage with this vibrator but this prong has no connection in the "shunt drive" type. When "A" voltage is applied, the reed armature is pulled toward the "pull or power" side contacts which at the same time breaks the driver coil contacts. The reed then moves to close the opposite contacts due to inertia as described for the "shunt drive" type.

Philco car radio vibrator 83-0026 is an example of the "series drive" type and it might be well to note some trouble shooting hints concerning the two types at this time.

1. The "series drive" type will vibrate mechanically even though the power transformer primary center tap and end leads are open. This is not true of the "shunt drive" type since current to energize the starting coil must flow through 1/2 of the transformer primary and the complete circuit must be OK to establish full driving coil voltage.
2. Philco car radios are wired and service schematics show wiring for the "series drive" vibrator since the "shunt drive" type will also work with these connections. The two type vibrators have been used interchangeably in production in some radios.
3. The replacement vibrator sold through our accessory dept. (part #45-6307) is a "shunt drive" type as mentioned previously but its mechanical construction is similar to the "series" type. It therefore combines some of the features of both types and can be used in the standard 4 prong socket wired for either type. This vibrator also has a metal strap connected between the ground base pin and is not provided for grounding the vibrator case, this ground strap is necessary to prevent excessive "hash" radiation.

CIRCUIT OPERATION AND TEST

In order to correctly interpret vibrator power supply wave shapes the function and purpose of the timing capacitor or "buffer" condenser must be understood. This capacitor is the one shown connected across the power transformer secondary in figures 1a and 1b and it, in conjunction with the secondary inductance and reflected or leakage inductance of the primary, forms a resonant circuit. This is illustrated by figure 2a where the developed voltage waveform is shown through the power contact make (M1) contact breaks (B1) and inertia contact make (M2). At the instant of contact break (point 2) an extremely rapid voltage reversal would take place with resultant high arcing and contact deterioration if it were not for the oscillation developed by the resonant circuit. This oscillation causes the voltage to reverse more or less gradually until the other set of contacts make at point 3. If the contacts (M2) did not make, however, due to faulty construction or excessive wear, the oscillation would continue as shown by the dotted line until the first set of contacts make again at point 5. Figure 2A illustrates action with no B+ load or with the rectifier tube removed, but with a B+ load the oscillation is damped before reaching point 3. The resultant waveform under loaded conditions is shown by figure 2b and this condi-

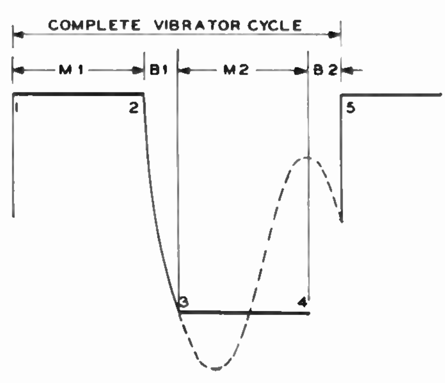


FIGURE 2A

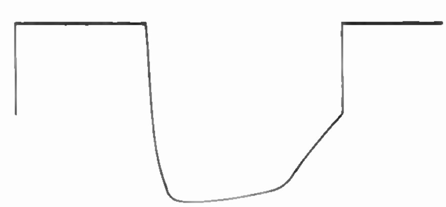


FIGURE 2B

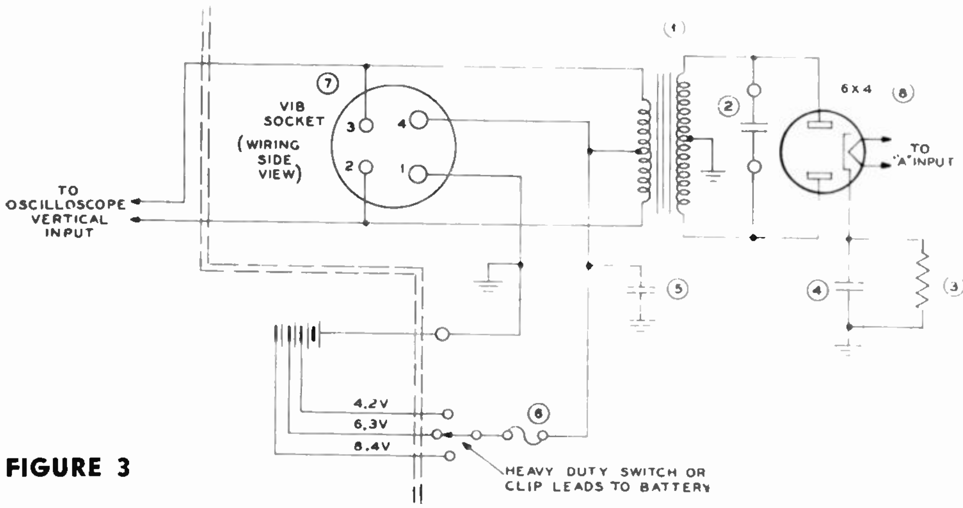


FIGURE 3

tion where only one set of contacts "make" is known as "single footing". The "A" input starting current is excessively high while B+ output is little more than 1/2 its normal level.

A vibrator tester schematic is shown in figure 3 that is recommended for use in conjunction with an oscilloscope having a variable frequency horizontal sweep such as the Philco scope Model #7019. Voltage for waveform presentation is taken across the total primary winding and applied to the oscilloscope vertical input terminals. Since one of these terminals is usually grounded to the scope housing, the tester and oscilloscope cannot have a common ground connection.

Since all production parts have certain tolerance values between which their characteristics can vary, it is extremely important that the tester power transformer and "buffer" condenser have centerline electrical characteristics. These parts comprise the tuned circuit as mentioned before and thereby affect the electrical closure between break of one set of contacts and make of the other. Part of the purpose of this tester is to determine whether the vibrator is adjusted within its tolerance limits, therefore, associated components must have no deviation from specified center values. Electrical centerline transformers and condensers must therefore be used so as not to introduce error in the test. The Philco accessory division supplies these parts in a special kit Part No. 45-9601. Note that a .0068 ufd "buffer" is required when testing the 83-0026 and 45-6307 vibrators and a .0047 ufd "buffer" is used when testing the 83-0025, and 83-0035 vibrators. This is due to a difference in contact time efficiency which is a percentage of the total time required for the two contact *make* periods to the total time required for a complete cycle. This is approximately 70% for the 83-0026 and 45-6307 vibrators and 78% for the 83-0025 and 83-0035 vibrators. In many cases these vibrators are used interchangeably in production sets without changing "buffer" condenser value since the operating differences are not usually great enough to materially affect vibrator life.

Also note the 10,000 ufd minimum 25 volt electrolytic capacitor in the tester "A" input circuit (⑤). This capacitor is a necessity if a battery eliminator is used for "A" power or if leads to a battery are long enough to offer appreciable resistance (the capacitor somewhat approximates the storage battery capacity). All wiring in the primary circuit, such as fuse holder, switches, wire, etc. must present as low DC resistance as possible. Wire should be 14 gauge or heavier. The vibrator socket should be mounted with screws so that it can easily be replaced since continued insertion of vibrators will eventually spread the contacts. The fuse holder should be mounted so that the fuse is visible and a 14 ampere fuse should be used.

Provision must be made for switching "A" input voltages to the tester. These voltages from a fully charged battery should be approximately 4.2, 6.3, and 8.4. Oscilloscope waveforms are to be observed with an input of 6.3 volts.

VIBRATOR TESTS

After a vibrator and the proper "buffer" capacitor are plugged into the tester, an "A" input voltage of 4.2 volts should be switched in. If the vibrator blows a fuse at this voltage or subsequent higher voltages it is to be rejected even though jarring the vibrator may clear the short temporarily. If the vibrator does not start at 4.2 volts the next higher voltages should be switched in successively and if it then starts, input voltage should be removed and the 4.2 volts then reapplied. An oxide coating may have developed on the contacts during shelf life which will be removed by a short period of operation at higher voltage (the "shunt" drive vibrator is more susceptible to this type of "no start" condition). If the vibrator still fails to start at 4.2 volts it should be rejected.

After it has been determined that the vibrator starts OK it should be subjected to 8.4 input volts to insure that no fuse blowing or "sticking" occurs. The vibrator should be jarred or tapped to make sure that possible wire ends or loose particles will not cause shorts.

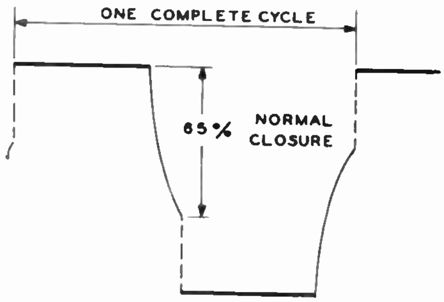


FIGURE 4A

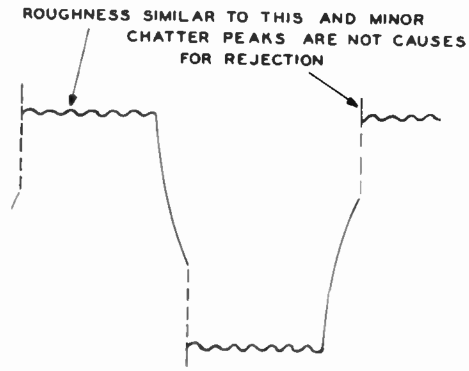


FIGURE 4B

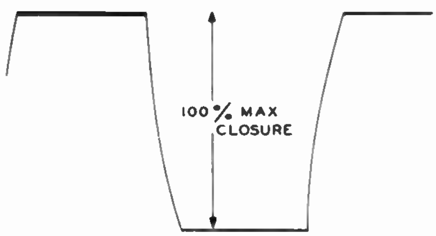


FIGURE 5A

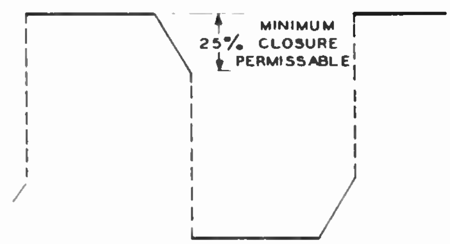


FIGURE 5B

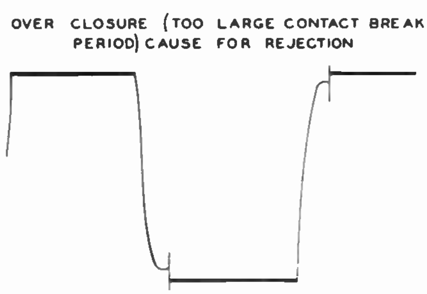


FIGURE 6A

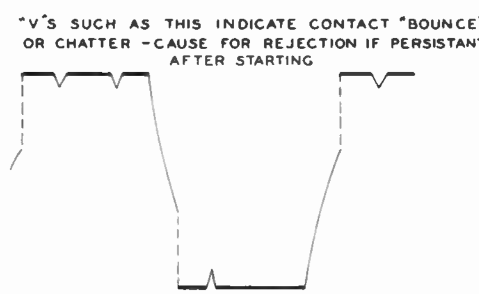


FIGURE 6B

Input voltage should then be switched to 6.3 volts and the waveform observed on an oscilloscope. Following are illustrations of allowable waveform variations with a few examples of reject waveforms. The oscilloscope horizontal sweep frequency and vertical amplitude should be adjusted to give approximately the same proportionate waveform shown. These illustrations all show waveforms under loaded conditions, that is, with rectifier tube in and B+ load.

Figure 4a illustrates a normal or center design waveform where the oscillation frequency determined by the "buffer" condenser causes a gradual voltage reversal during contact break. The smooth voltage reversal in this instance occurs for approximately 65% of the total voltage change and is called the percent of closure.

Figure 4b shows the same percentage of closure and also shows irregular but unbroken contact "make" periods. The irregularity is not cause for rejection since it represents minor variations in contact resistance during the "make" which will minimize or disappear after a short running period. Minor contact chatter at the start of contact "make" also is not cause for rejection.

Figure 5a represents a 100% closure condition and figure 5b a 25% closure. These are the maximum and minimum extremes allowable for contact closure variations. A condition where one contact break period has 100% closure and the other contact break period has 25% closure is also acceptable.

Figure 6a represents a condition known as "overclosure" where the contact "break" periods have too great a duration. This allows the oscillation frequency wave to reach a peak and start to reverse before the next contacts make and is cause of rejection.

Figure 6b illustrates breaks in the waveform during contact "make" periods which are caused by contact bounce. If these breaks do not disappear after a short period of operation, the vibrator should be rejected.

As a final reminder, the waveform of any given vibrator in the tester will be observed under centerline or normal conditions. With operation in a production radio, the same vibrator waveform may vary due to necessary production tolerances of other components.