THE EVOLUTION OF TUBE TESTING

Technical Analysis of Supreme Radio Tester

Models 89

WHEN vacuum tubes were first introduced to take the place of crystal detectors for radio reception, the popular mind considered a tube as being operable as long as the filament of the tube was intact and capable of being illuminated. Even today, there are radio users who will question the wisdom of a radioman who recommends the replacement of a tube which is "still burning," and radiomen often receive calls from customers who assure them that "the tubes are all right, because they are all burning."

This popular misconception of the index of operating qualities of radio tubes in glass envelopes is excusable for laymen, of course, because they quite naturally associate radio tubes with incandescent lamps which are designed for the primary purpose of illumination. It is natural to expect that this popular misconception does not exist where metal tubes are used.

The first tube testers were based on the incorrect idea that a tube was operable as long as the filament was intact, and were so designed that they were nothing more than continuity testers of the filament circuit. It is probable that most "old timers" of the radio servicing profession can remember an old home-made tube tester with a flash-light bulb in series with the filament circuit. If the flash-light bulb was illuminated when a tube was inserted in the tester socket, the tube was good; if the flash-light bulb failed to illuminate when the customer's tube was "tested," the customer was convinced that he would have to pay $7.50 (or more) for a new tube. Those were the first "English-reading" tube testers!

The professional radioman knows that the illumination of an element of a radio tube is only incidental to its primary purpose of emitting electrons which are attracted or repelled by other elements in the tube, and that the degree of illumination is not necessarily directly related to the electron-emitting qualities of the filament or cathode element of the tube. It was soon learned, too, that a tube could be "paralyzed" even though the filament be illuminated as brightly as ever, and still be inoperable because the illuminated filament would no longer emit enough electrons for satisfactory operation. Most tubes of those days were constructed with thoriated filaments, and could be easily "paralyzed" by overload potentials; the real "gyp" artist was the man who could use a monkey-gland "rejuvenator" to "re-activate" his old stock of "paralyzed" tubes, accumulated from hapless customers, and re-sell them as new tubes.

After it had become an accepted fact among the more technical of the radio fraternity that filament illumination was not a true indication of tube merit, it became necessary to devise some means other than a filament continuity tester to indicate the quality of a radio tube. Before the advent of the use of alternating current for filament (or heater) energy, there were no rectifier tubes, and the very few popular types of tubes were what are technically known as triodes; that is, tubes having three elements known as (1) the filament, (2) the plate, and (3) the controlling grid. By establishing the correct values for negative controlling grid potentials and for positive plate potentials, the earlier types of general purpose tubes could be used either as detectors or amplifiers, and it became customary to test these tubes as amplifiers. Since mutual conductance is related to amplification, it became the practice to test amplifier tubes by the well-known "grid shift" method, whereby a small change is made in the negative controlling grid potential so as to cause a corresponding change in the plate current, the amount or magnitude of the plate current change being considered as an indication of the mutual conductance of the tube.

Since a small change in negative controlling grid potential produces a relatively large change in plate current it is seen that an amplifier tube has a "trigger action," and may be crudely compared to a gun in which the stored up energy in the cartridge represents the filament battery, the trigger represents the grid, and the discharge represents the plate current. Another crude analogy which has been used consists of comparing the function of an amplifier tube to that of the ordinary city fire engine which takes water from low-pressure mains and "steps up" the pressure for the fire hose. The additional power is supplied from the energy stored up in the fuel used in the fire engine which may be compared to the filament battery of stored up electrical energy.

The "grid shift" method of testing tubes is well known as it has been used for several years. **It is wrong, however, to refer to a "grid shift" test as being a mutual conductance test, unless rated D.C. potentials are applied to a tube during the test.** Any variation from rated D.C. potentials will produce corresponding variations in mutual conductance ratings. This is proved by a casual observation of a table of tube characteristics such as that published by any tube manufacturer. For example, it may be observed that the type 01A tube has a rated mutual conductance value of 725 micromhos when operated with a negative controlling grid potential of 4.5 volts and with a positive plate potential of 90 volts; but when the applied negative controlling grid potential is 9.0 volts and the applied positive plate potential is 135 volts, the mutual conductance is rated at 800 instead of 725 micromhos.

It is noted that the change in rated mutual conductance has been effected by changing both controlling grid and plate potentials; what would happen if only one of these potentials were changed? It is obvious that any departure from any rated potential will result in a departure from rated mutual conductance, and that a mutual conductance tester which is designed to test tubes by mutual conductance measurements for comparison with rated values must be so designed as to enable the application of rated D.C. values. When it is remembered that there are almost innumerable combinations of filament (or heater), plate, controlling grid, screen grid, suppressor grid, pontode, etc., potentials, it is readily appreciated that a mutual conductance tube tester, made up as a single unit, would be quite complicated in its design and operation, and would be too expensive for practical commercial purposes.

Such a tester would require batteries or a D.C. "power pack" with good regulation and designed to supply all of the D.C. potentials and currents listed by tube manufacturers, with a control for each tube element, plus one or more controls for the metering circuit. As applied to an 8-element tube, the tester would require about ten controls, would cost several hundred dollars, and require about an hour to test a set of tubes. Imagine spending 30 minutes to an hour to test a customer's tubes to make a 60-cent sale with a profit of 24 cents! How long would it take to pay for such a tester in profits from tube sales?

The high cost and operating complications of a true mutual conductance tester have resulted in efforts on the part of testing equipment design engineers to make such compromises in absolute accuracy as are necessary to strike a balance between absolute accuracy and practical utility; such a practical compromise involves (1) a commercially acceptable selling price, (2) a reasonable degree of simplicity of operation, and (3) a practical degree of accuracy. This results in a departure from the use of the various rated D.C. values to a compromise of a few average values which can be applied to all tubes alike, thereby lowering the number of controls and providing the desired element of simplicity of operation, without a serious sacrifice of accuracy, so that the practical radioman can obtain, at a cost under $50.00, a simple tester with an accuracy in the order of 90% instead of having to pay several hundred dollars for a more complicated tester with an accuracy of 95% or more; but never 100%, as perfection can only be approached but never attained by human effort.

The "grid shift" tester with its compromise of applied potentials was simple enough until the sudden avalanche of about 150 types of new multiple-element tubes, when the simple "grid shift" tester had to take on a larger number of sockets, or a larger number of controls, or both, with additional compromises with ac-

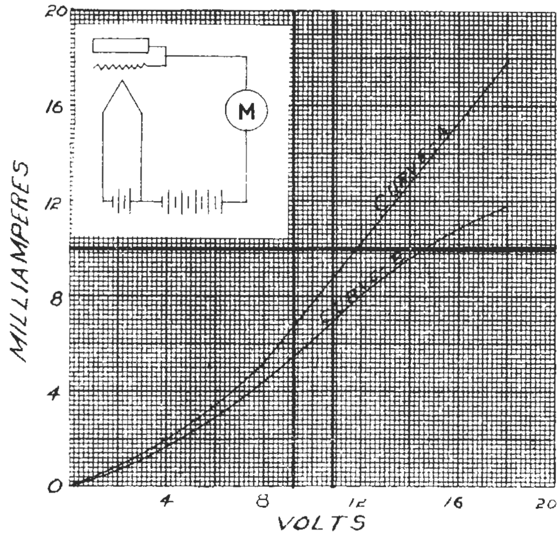


FIGURE-1

curacy. It was then that the design engineers began to study the possibilities of other types of testers which could be designed with a more desirable element of operating simplicity, without too much sacrifice of the desirable element of practical accuracy.

Some of these research efforts were directed towards a design consisting of an r.f. oscillator combined with an output meter, so as to make comparative tests of tubes in operative radios. This method, however, has not been accepted as having any outstanding merit, because its application requires (1) an operative radio, is (2) based on the assumption that all new tubes, with which old tubes are to be compared, are perfect and that no new tubes are damaged in transit, and (3) this method is quite deceptive when applied to radios in which A.V.C. circuits are involved to compensate for the differences between the tubes which are subjected to the test.

Furthermore, the use of an oscillator and output meter combination for tube testing is restricted almost altogether to shop work, as the average radio owner would not want to listen to the weird noises emitted by the loud speaker of his radio while the oscillator is connected thereto when the tube testing operations are performed in the customer's home.

As the result of the practical necessity for eliminating the oscillator and output meter combination for general tube testing practices, the emission tester came into favor, because it was found that a well-designed emission tester may be more accurate than a so-called "grid shift" or "power output" tester with compromised potentials and controls. After all, about all that can happen to a radio tube, within the realm of probability, after the tube is placed in service, is a depreciation of the emitting qualities of the cathode element, so why not test a tube by measuring the emission current?

There are other possible causes of tube failure, of course, as lightning strokes, air leakage through the glass envelopes, etc., but we are speaking of probabilities and not of extremely unlikely possibilities, so that it is quite practical to conclude that an amplifier tube loses its mutual conductance in service by reason of a lowering of the emission incidental to the prolonged service; in other words, all tubes, amplifiers and rectifiers, depreciate with a loss of emission, and a measure of the emission of an amplifier tube is a measure of its operating merit, just as a measure of the emission of a rectifier tube is a measure of its operating merit.

Having arrived at the conclusion, then, that a well-designed emission tester is as reliable as a "grid shift" tester and having confirmed the accuracy of this conclusion by laboratory comparisons of the two types of testers, we are ready to study the details involved in a well-designed emission tester circuit, such as that incorporated in the Supreme Models 89-Counter, 89-DeLuxe, 89-Standard, and "385-Automatic."

For the purpose of analyzing the factors involved in the design of a tube tester of this type, it is convenient to resolve tube characteristics into equivalent resistance values; because, under a given set of conditions, a particular tube will act as a resistance except that it will pass current in only one direction. In order to better understand the resistive characteristics of tubes, let's refer to Figure 1 which represents a type 01A tube with varying positive potentials applied to all of the elements, except the cathode, connected together so as to attract practically all of the electrons emitted by the cathode. Curve A represents potential and current values of a new tube, while Curve B represents the same tube after it has been depreciated.

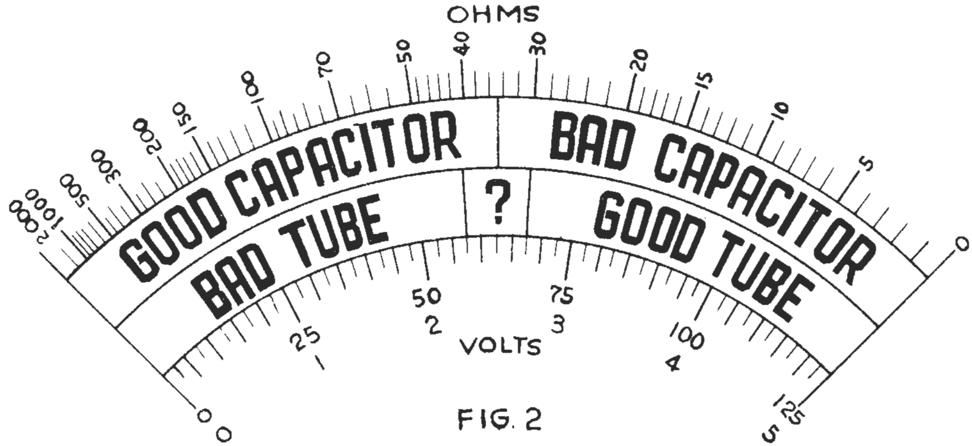


FIG. 2

Now observe that any one of the potential values taken horizontally from Curve A and divided by the corresponding current value, taken vertically from the same curve, will indicate the resistance value of the tube under the particular load conditions. It is seen that, with an applied potential of 18 volts, the current load on Curve A is 17.8 milliamperes, from which we derive, by Ohm's Law, a resistance value of 101 ohms. Similarly, with 18 volts on Curve "B," the current load is 11.8 milliamperes, from which we derive a resistance value of 152.5 ohms. We can determine the percentage of depreciation at 18 volts by subtracting 11.8 milliamperes from 17.8 milliamperes, and dividing the difference by 17.8 or by subtracting 101 ohms from 152.5 ohms and dividing the difference by 152.5; in either case, the tube depreciation from Curve "A" to Curve "B" is found to be about 34% at 18 volts. Accordingly, Curve "A" can be said to represent the resistance of a normal tube and Curve "B" can be said to represent the resistance value of the tube after its emission has depreciated.

A further consideration of the factors presented in the last paragraph leads us to conclude that our tube testing circuit should be capable of indicating the load changes which are directly related to the changes in effective internal resistive values of tubes as they depreciate in emitting quality so that, when the rated load of a normal tube is indicated in the "GOOD" sector of a meter scale, such as that shown in Figure 2, the reduced load resulting from depreciation of the same tube to a degree beyond satisfactory operation will be indicated in the "BAD" or "?" sector of the meter scale.

Since a potential value of 30 volts has been accepted, generally, as a satisfactory value to be applied between the cathode and all other elements of all tubes to produce an approximate normal load for each tube, it is necessary, when using this fixed potential value for all tubes, to provide some means for varying the indicating range of the meter to cover all normal loads which may be expected of the different types of radio tubes which the tester will be required to accommodate. The most simple circuit for accomplishing such results is that indicated in Figure 3. Since current will pass through the tube only in the direction of the arrow in Figure 3, one side of the secondary winding is indicated as being negative and the other side is indicated as being positive, and it will be observed that the indicating range of the meter may be controlled over a wide range of load values, determined only by the basic sensitivity of the meter and by the resistance value of the rheostat, R. If a meter having a full scale load value of 10.0 milliamperes (0.010 ampere) with an internal resistance value of 10.0 ohms be used with a 100-ohm shunting rheostat, the indicating range of the meter would be controllable for any ordinary load value above 11.0 milliamperes. While the resultant measuring range would be inadequate for the requirements of a modern tube tester, the values indicated will serve the present purpose of discussing the design features of tube testers.

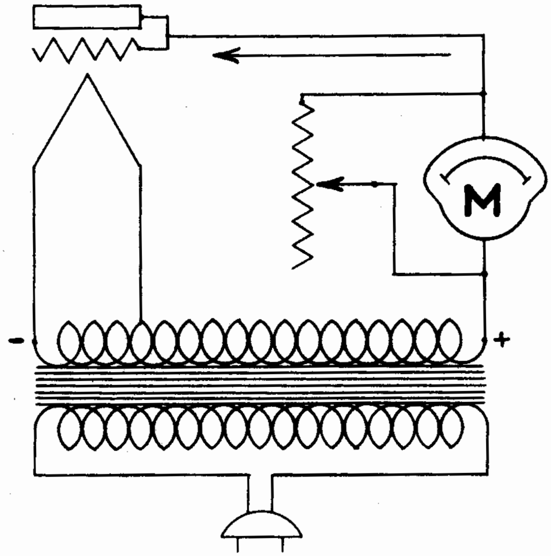


FIG. 3

Referring again to Figure 3, let's observe what might happen if a short-circuited tube were placed in the test circuit. A short-circuited tube would have zero resistance, so that the only appreciable resistance remaining in the circuit would be that of the meter, across which the total circuit potential value of 30 volts would develop. The normal full scale potential drop across the meter is 100 millivolts (0.1 volt), obtained by multiplying the full scale current load of the meter by the resistance value of the meter. Therefore, a 30-volt potential value developed, because of a short-circuited tube, across a 0.1-volt meter would impose upon the meter a load which is about 300 times that for which the meter is designed to normally register. With such an overload, what would happen? It would be "good-bye" meter! And if the meter were to stay intact, then the transformer would soon pass out of the picture. This contingency suggests, then, that some means must be provided to protect the meter and transformer against short-circuited tubes. A fuse is a logical suggestion, but a burned out fuse is an invitation to some people to use a brass lug or a bridging wire when a new fuse is not immediately available, so that the necessity for protecting the circuit with a fuse should be eliminated if such elimination be practicable.

Since meters are generally designed to withstand loads which are 10 times normal full scale loads, we may assume that the meter will safely withstand an applied potential of 1.0 volt, which would produce a current load of 100.0 milliamperes through the 10.0-mil. meter, regardless of the resistive value of the rheostat shunted across the meter. This safe overload limit suggests that, instead of using a fuse to protect the meter, we may introduce enough "limiting resistance" into the circuit to develop a potential drop of 29 volts, in the case of a short-circuited tube, leaving the safe value of 1.0 volts developed across the meter. A meter load of 100 milliamperes would produce a potential drop of 1.0 volt across the meter, and the circuit load would be limited to this value by a total circuit resistance value of 300 ohms, obtained by applying Ohm's Law and dividing 30 volts by 100 milliamperes (0.100 ampere). Since the joint resistance of the meter and rheostat cannot exceed 10 ohms, this small value may be considered as negligible, and a 300-ohm resistor used as in Figure 4.

The tube testing circuit represented by Figure 4 has the advantages of simplicity and safety; it has been used, with minor variations in several commercial tube tester types. In fact, the basic principles involved are incorporated in a so-called standard tube tester which is being considered by all tube and tube tester manufacturers. Offhand, the average technician and most engineers who are not experienced in tube tester design problems, can see nothing wrong with the circuit and constants of Figure 4 as a tube tester of the emission type. What does the reader see wrong with it? The 300-ohm limiting or "load" resistor will reduce the potential applied to a tube, the amount of the reduction depending upon the conductivity of the tube; but that is not, in itself, objectionable; in fact, that may be desirable in some cases, so what's the objectionable feature?

We have already observed, in our discussion of Figure 1, that any tube may be considered as having a definite resistance value under definite load conditions, so let's analyze the test of a tube in which the effective internal resistance may be 600 ohms and which is subjected to test in the tester circuit represented by Figure 4. The ratio between the internal and external resistance values is, obviously, 600:300 or 2:1. When the tube depreciates to such an extent that it is just half as good as normal, its internal resistance will be about 1200 ohms; the ratio between the internal and external resistance values will then be 1200:300 or 4:1.

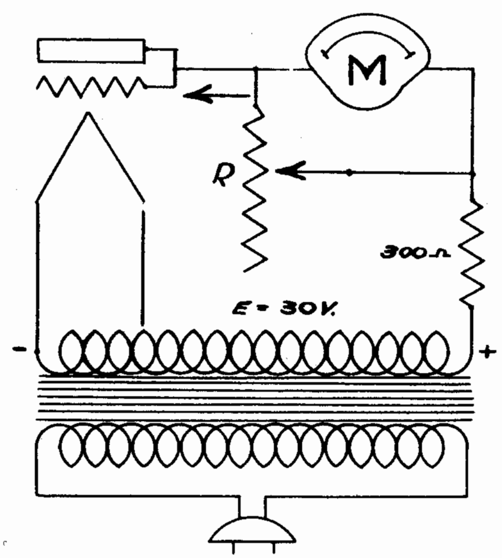


FIG. 4

The total resistance of the circuit, including that of the normal tube, was originally 900 ohms; after the tube resistance is doubled by depreciation, the total resistance of the circuit, including that of the depreciated tube, is 1500 ohms. It is observed that, while the tube resistance has doubled by depreciation, the total circuit resistance has not doubled, so that the meter current will not be reduced in half; therefore, the meter reading will be deceptive, because it will indicate the tube as being better than it really is. If the same circuit with a fixed 300-ohm resistance value be used for testing a tube which has a normal internal resistance value of 100 ohms, the meter indication of a depreciated tube will be even more deceptive. With a 100-ohm tube, the ratio between the internal and external resistance values is 100:300 or 1:3; when the tube resistance is doubled, the ratio is 200:300 or 2:3. Normally, the total of the two resistance values is 400 ohms; but when the internal resistance value of the tube is doubled by depreciation to a value of 200 ohms, the total circuit resistance is 500 ohms, or an increase of only 100 ohms in 400 ohms. If the meter reading before the tube is depreciated be 77 in the center of the "GOOD" sector of the meter scale of Figure 2, the meter reading, after the tube is depreciated, will be four-fifths of 77 or 61.6; or still in the "GOOD" sector of the scale, although the tube is only about half as good as it was and should register about 38.5. The error is different for each tube load, and is greatest when the tube resistance is less than the external circuit resistance. So now, we see what is wrong with the popular circuit of Figure 4.

It is obvious, from the analysis of the circuit represented by Figure 4, that the maximum degree of accuracy is obtainable when the external load resistance is considerably less than the effective internal tube resistance value of every tube, and that the ratio between internal tube resistance values and external circuit resistance values should be constant for all types of tubes; so, let's analyze the Supreme tube testing circuit, shown in Figure 5, which is developed to incorporate these desirable features.

In Figure 5, a resistance value of 4220 ohms is added to the meter armature resistance value of 113 ohms, making a total resistance value of 4333 ohms. Since the tester is calibrated for normal tube readings at the center of the "GOOD" sector of the meter scale (shown in Figure 5), which is 77% of the full scale deflection, the current load is 77% of 1.0 milliampere, or 770 microamperes (0.00077 ampere). The current load of 0.00077 ampere multiplied by the total meter circuit resistance value of 4333 ohms produces a potential drop of 3.3 volts across the metering circuit, regardless of the setting required for the 1000-ohm potentiometer to produce a 77% meter scale reading. In other words, when the potentiometer setting is adjusted to accommodate the load conditions of any normal tube, with the meter pointer deflected 77% of its range, the potential drop across the meter is 3.3 volts, leaving 30 volts of the total potential value of 33.3 volts to be applied across the tube. Therefore, the ratio of the tube voltage to the meter

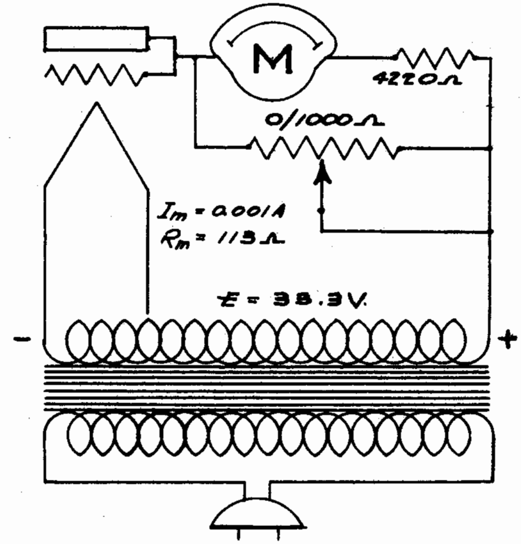


FIG.5

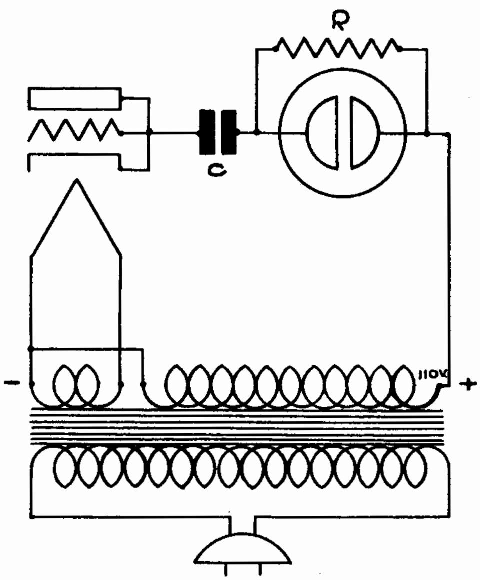


FIG. 6

voltage, or of the internal tube resistance to the external circuit resistance, is constantly 30:3.3 or 9:1 for any tube, regardless of the load.

Now, let's see what happens, in the circuit of Figure 5 when a short-circuited tube is encountered. Since there can be no potential drop across a short circuit, the 33.3-volt applied potential must develop across the metering circuit. With a resistance value of 4333 ohms and a full scale load value of 1.0 milliampere, the full scale potential of the meter is 4.3 volts. Since the meter can safely withstand 10 times its normal load an indefinite number of times, its overload potential limit is 43.3 volts, so that an applied potential of 33.3 volts, caused by a short-circuited tube, would be 10 volts under the safe overload limit of the meter.

Returning to our previous analysis of the test of a tube which has a normal internal resistance value of 100 ohms, and which was tested with an error of 60% by the tester shown in Figure 4, let's see how the tester circuit of Figure 5 will react to the same tube when it is depreciated to such an extent that its internal resistance is doubled. Keeping in mind that, when the tester is calibrated for normal tubes, the ratio between tube and circuit resistance is 9:1, we can determine the joint resistance of the meter and potentiometer, as follows:

$$9:1 = 100:x$$
$$9x = 100$$
$$x = 11.1 \text{ ohms}$$

Therefore, the total circuit resistance, when the tube is normal, is 111.1 ohms; and, when the tube resistance is depreciated so that its effective internal resistance is doubled, the total circuit resistance is 211.1 ohms. After depreciation, the meter reading will be 52.6% of the normal reading of 77, or 40.5 in the "BAD" sector of the meter scale shown in Figure 5. The tube is correctly classified as being "BAD," and the error in the actual meter reading is negligible. With this arrangement of balanced ratio between internal tube and external circuit resistance values, the meter reading drops in proportion to tube depreciation, so that "BAD" tubes which test "GOOD" on the usual tube tester types are correctly indicated as being "BAD" on the new Supreme testers which should enable more replacement tube sales than are enabled by older types of tube testers. It may be expected that other manufacturers of tube testers will soon revise their designs so as to incorporate the advantages of balanced ratio between tube and circuit resistance values.

Having discussed the "QUALITY TEST" features of this new tube testing circuit, we will now proceed to analyze the tube "LEAKAGE TEST" features which were pioneered by Supreme engineers and which are now being rapidly incorporated in competitive designs. It is the purpose of Figures 6 and 7 to indicate the circuit arrangement for indicating a leakage between the heater and the cathode, or one of the other elements of a tube. Figure 6 represents the circuit arrangement which results from depressing the "F" push button of the tester while testing a type 27 tube, when the neon lamp will glow if a leakage exists between the heater and one of the other elements. If the "F" button be released, and the No. "4" button be depressed, the circuit arrangement will be that of Figure 7; and, if the neon lamp still glows, it should be concluded that the leakage is between the "F" (heater) and the No. "4" (cathode) elements. By similarly depressing the remaining push buttons, any leakage between any two elements of any tube may be indicated, and the panel markings associated with the switch buttons will indicate to the user just what two elements are involved in the leakage.

It will be observed, in Figures 6 and 7, that a 110-volt A.C. potential is applied in series with a neon glow lamp, a blocking capacitor, "C," and the tube under test. The tube cannot rectify the applied poten-

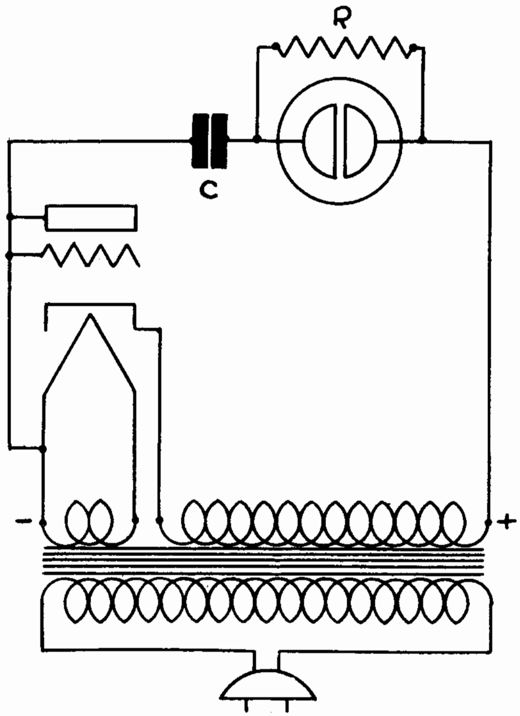


FIG. 7

tial because of the blocking capacitor which will not allow a continuous passage of pulsating current, but which will pass alternating current, only. However, an alternating current cannot pass through the tube, unless there be a leakage through the tube, in which case the neon glow lamp will indicate the passage of the A.C. leakage current by a glow of both elements of the neon lamp. A large full-sized neon lamp is used, rather than the miniature lower-priced neon lamp which is used in other types of tube testers. The glows from the larger lamp are more visible, and the larger lamp is more rugged in construction, thereby assuring longer and more consistent service.

It may be asked why an A.C. potential is used for tube leakage tests when a D.C. potential could be taken from the self-contained rectifier tube which is used for the power supply adjustments; because it appears, at first thought, that the use of a D.C. potential with the positive side connected to the cathode and the negative side connected, to the other elements, in turn, would eliminate the necessity for using the blocking capacitor shown in Figures 6 and 7. The answer is found in the fact that a D.C. test would, in some cases, be deceptive, because it would respond to rectification currents which are not considered detrimental, and which would be erroneously interpreted as detrimental leakages. Actually, it is found that such rectification currents exist between the different elements of some tubes, in the opposite direction to that theoretically expected; for example, heater types of tubes are found in which the heater element and the cathode are both emitting electrons, so that a direct current will pass from either element which is made positive to the other element which is made negative. In this circuit, when the neon lamp indicates the presence of a current between any two elements of a tube, the user knows that the indication represents the presence of leakage rather than the presence of ordinary rectification currents.

Most tube manufacturers, who originally used a D.C. test for leakages, are now using the A.C. test with neon lamps, in their production tests, for the reasons outlined, and to detect open-circuited elements as well as short-circuited and leaky conditions between elements.

The use of the A.C. test with a blocking capacitor for the purpose of "blocking out" permissible rectification currents produces what are termed "surge flashes" on one element of the neon lamp as the various push buttons are operated during the "LEAKAGE TESTS." These "surge flashes" are criticised by one or two competitive tube tester manufacturers who designate them as "false flashes." However, it should be remembered that the presence of "surge flashes" evidences the use of a blocking capacitor to prevent the response of the neon lamp to permissible rectification currents, and that these "surge flashes" are not confusing, because they are observed on only one element of the neon tube at a time; leakages are always indicated by flashes or glows of both elements of the neon lamp, at the same time.

The "surge flashes," instead of being confusing or "false," are useful for indicating the proper internal connections to the tube elements. It was stated in a preceding paragraph that tube manufacturers use the neon lamp—the same identical type used in the testing circuit under discussion—to detect open-circuited elements. While using the tester to detect inter-element leakages, it may, at the same time, be used to determine whether or not any particular element is open-circuited, simply by observing whether or not a "surge

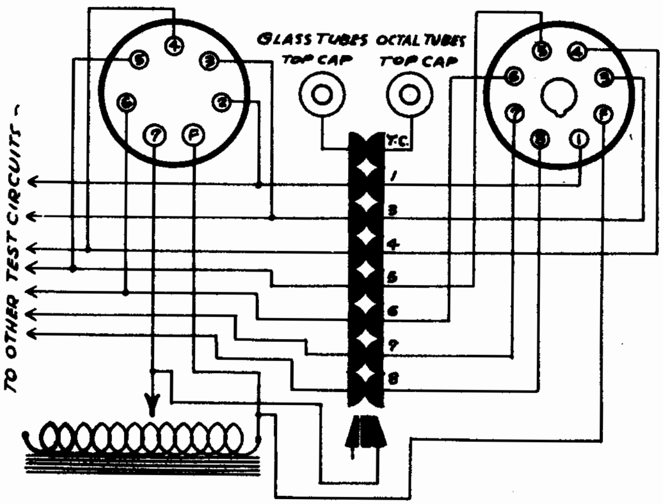


FIG. 8

flash" is obtained for that element when the corresponding push button is depressed immediately following a depression and release of the cathode button. What happens during such tests is an alternate charge and discharge, in opposite directions, of the blocking capacitor.

When two or more anode elements are connected together for a test in any tester, it is to be expected that the proportion of the current load carried by the respective elements will be directly related to the degree of proximity of the elements to the cathode element. In other words, the element which is farthest from the cathode may carry the least proportion of the load, and it is possible that the element which is farthest away may be open circuited without affecting the meter pointer deflection enough to cause the tube to be indicated as being "BAD." Open-circuited tubes are extremely rare, but such tubes can be easily and instantly detected, with the tube testing circuit under discussion, by observing the "surge flash" tests described above.

A resistor, R, shown in Figures 6 and 7, is shunted around the neon lamp so as to reduce the sensitivity of the lamp in order that permissible leakages of almost infinite values will not be indicated. It should be remembered that every material which is used for insulation purposes has some conductive properties, and electrical leakages can be detected through any insulating medium, including bakelite or dry air, if a sufficiently sensitive means be employed for detecting such leakages. In the design of a tube tester, it is necessary to limit the leakage-detecting capabilities of the tester so as not to reveal minute leakages which do not impair the proper functioning of a radio tube; otherwise, the tester might reveal leakages in new tubes of all types, although the tubes are normal in every respect and operate satisfactorily in any radio. The manufacturers of some tube testers, not realizing the importance of having an "upper limit" to leakage detection and anxious to imitate the most successful tube tester ever designed for professional radiomen, are demonstrating far and wide their products which are heralded as being "twenty times more sensitive," while ignoring the protests of responsible tube engineers to the effect that useless confusion and definite harm to legitimate trade practices is being done by such demonstrations and sales claims.

By having each tube element controlled by a push button switch, any element of any tube can be tested, separately, or any number of the elements can be tested in combinations, at the discretion of the user, so that the diode elements of full wave detector tubes, or the plates of full wave rectifier tubes, can be compared, separately. The flexibility of the elemental switching arrangement, combined with the fundamental circuit features described in the preceding paragraph, enables (1) complete "QUALITY" tests, (2) reliable "LEAKAGE" tests between any two elements and (3) "open circuit" tests of any element, of all radio receiving types of tubes, with adequate provisions for probable future tube developments.

The tester is provided with five sockets, ranging from four to eight contacts per socket, connected in parallel, with the connections to the 8-hole socket connected through a circuit-breaking "FILAMENT RETURN SELECTOR" switch, as shown in Figure 8. In order for us to better understand the purpose of this switch, it may be helpful for us to briefly review the evolution of tube pin terminal arrangements, as related to the application of filament or heater potentials.

For a number of years, the design of tube testing apparatuses presented no serious problem insofar as the application of filament or heater potentials was concerned. This was because the filament pins of all popular types of tubes, prior to the advent of the new octal tubes, were adjacent to each other, usually larger than the other pins, and served as the "guide" pins, so that one of the filament contacts of the tester sockets could be connected directly to the "common" terminal of the filament winding of the tester transformer, and the other filament contact of the sockets could be connected directly to the movable contact of a tap switch which enabled a selection of any required filament potential supplied by the transformer through the tap switch.

With the advent of the octal tube types, tube engineers have abandoned the idea of having the filament or heater pins adjacent to each other, and instead of using the filament or heater pins as "guide" pins, a large keyed bakelite locator pin is used in the center of the tube base of octal tubes and the pins are numbered from the key ridge of the bakelite guide pin. Looking at the base of an octal tube, with the guide key uppermost, the pins are numbered consecutively in a clockwise direction, beginning with the first pin clockwise from the guide key.

Aside from the established practice of using the #1 pin to terminate the metal shield and the #2 pin as one of the filament or heater pins, the other filament terminal may be the top cap or any pin from #3 to #8. This means, that, if a single 8-hole socket is to be used in which to test all elements of all octal tubes, it is necessary to select the contact of the octal tube to which the one side of the filament potentials may be applied, in addition to selecting the filament or heater potential to be applied; otherwise, a separate 8-hole socket or adapter would have to be added for each new pin combination.

The filament or heater circuits terminate at what are known as the pins numbered 2 and 7 on the octal tubes which were included in the preliminary announcements of metal tubes. Subsequently, the metal tube type 5Z4 was announced with a filament circuit terminated by pins numbered 2 and 8, and a later type 6P7 was announced with a heater circuit terminated by pins numbered 2 and 3, so that a tester socket in which the filament or heater potentials are applied to the contacts numbered 2 and 7, only, cannot be used for testing the later types in which the filament is terminated by pins numbered 2 and 3 or 2 and 8.

If the "FILAMENT RETURN SELECTOR" switch, shown in Figure 8, or its equivalent, were not used, three 8-hole sockets would be required to enable a test of all of the elements of the first few octal tubes already in use; it would be possible for the user to insert an 8-pin tube in the wrong socket, and the tester would be partially obsolete in the event a metal tube were announced in which neither pin numbered 3, 7 or 8 were used as one of the filament or heater pins. Hence, the advisability of using a "FILAMENT RETURN SELECTOR" switch through which the filament or heater current, which may be considered as entering the number 2 pin of the octal tubes, can return through the "top cap" terminal or through any one of the numbered pins of such tubes. By using this switch, no adapters are required, and only one 8-hole socket is needed for all present or future octal tube types in which the filament currents may return through the top cap terminal or through any pin other than the number 2 pin through which the filament or heater currents may be considered as entering octal tubes.

Variations in power supply potentials may be compensated (1) by means of a power rheostat in the primary circuit, or (2) by means of a tap switch used with a tapped primary transformer winding. When a rheostat is used, the unwanted power is dissipated in heat losses, and the rheostat must be re-set for each load imposed by a tube test. The tapped transformer arrangement, which is more expensive in original cost, is more economical in operation, and does not require a re-setting operation for each tube test load, is used with the tester circuits under discussion. A type 01A tube is used as a rectifier tube in series with the meter for power supply adjustments. Since the rectifier load is only 0.0005 ampere (one-half milliampere), the tube is never overloaded and should last indefinitely.

In the preceding paragraphs, we have discussed the outstanding features of the tube testing functions which are incorporated in Supreme Model 89 Tube Testers. The remaining paragraphs will be devoted to those features of the Model 89-DeLuxe which are not directly related to tube testing operations and which are not included in the Models 89 Counter and 89 Standard Tube Testers.

The portable Model 89-DeLuxe Tube Tester is designed for the progressive radio service engineer who does not particularly care for the Counter model, or who wants the DeLuxe features of D.C. voltmeter ranges,

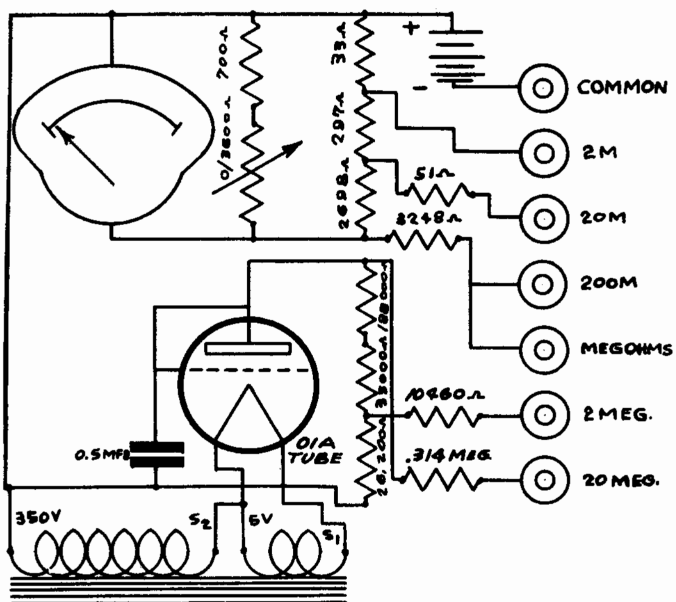


FIG. 10

ohmmeter ranges, and capacitor leakage-indicating ranges in addition to the tube testing functions of the portable Model 89 Standard Tube Tester. While his analyzer is being used on other service work, this Model 89-DeLuxe Tester can be used on service calls for tube tests and for the other preliminary tests which are usually necessary for estimating purposes in customers' homes. The complete circuit diagram of the Model 89-DeLuxe is shown in Figure 9 on the last page.

Four D.C. potential-measuring ranges of 0 to 5, 0 to 125, 0 to 500, and 0 to 1250 volts, at 1000 ohms per volt, enable a complete coverage of all of the D.C. potential values which are encountered in radio receivers, and a single "OHMS" scale is used for resistance measurements within ranges of 0 to 2,000, 0 to 20,000 and 0 to 200,000 ohms. These ranges are generally considered as being adequate for all practical service requirements, and are powered with a self-contained 4.5-volt flashlight battery which should last indefinitely, because the intermittent load imposed upon the battery is extremely low. The lowest division of the "OHMS" scale represents 1 ohm, and the center division represents 35 ohms, so that the ohmmeter is ideally suited for continuity tests, and for measurements of low resistance values. In addition to the resistance-measuring ranges which are powered with the self-contained 4.5-volt battery, 2 ranges of 0 to 2 megohms and 0 to 20 megohms are powered with a self-contained miniature "power pack" for measurements of extremely high resistance values. The resistance-measuring circuits are shown in Figure 10.

The condition of an electrolytic capacitor is indicated on a "GOOD CAPACITOR—BAD CAPACITOR" scale, shown in Figure 2, of the meter which is connected into a circuit arrangement indicated in Figure 11. The required D.C. potential is supplied by the self-contained rectifier tube and filter arrangement through the resistance R, which limits the current to a safe value for good capacitors and protects the meter against short-circuited electrolytic capacitors. Supreme originated the English-reading electrolytic capacitor leakage test which will probably be copied in competitive designs later on.

For electrostatic (paper) capacitor leakage tests, the tester circuits are resolved into the scheme suggested by Figure 12. The required D.C. potential is supplied by the self-contained rectifier tube. After the initial surge through an "unknown capacitor," there should be no current through the neon lamp unless there be a leaky or short-circuited condition within the unknown capacitor to pass direct current. If the unknown capacitor be short-circuited or if it has very low D.C. resistance, one element of the neon lamp will glow continuously, indicating the presence of a direct current through the unknown capacitor. If the unknown capacitor is not short-circuited, but has a high resistance leakage, the leakage resistance will periodically discharge the accumulated charges of the known capacitor, C, through the neon lamp and the rectifier tube, so that the presence of such a leakage within the unknown capacitor will be indicated by intermittent glows of one element of the neon lamp. This arrangement is the best known practical method for indicating leakages in electrostatic (paper) capacitors.

All commercial receiving types of tubes which are in general use are listed with an outline of the simple testing procedure, on a "Tube List" card which is mounted in the cover of the beautiful, natural-finished, hard-

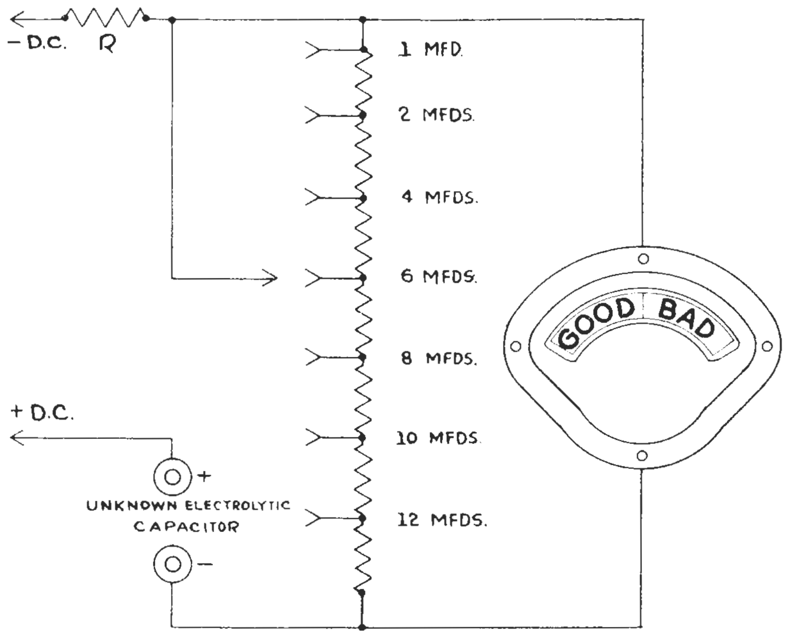


FIG. 11

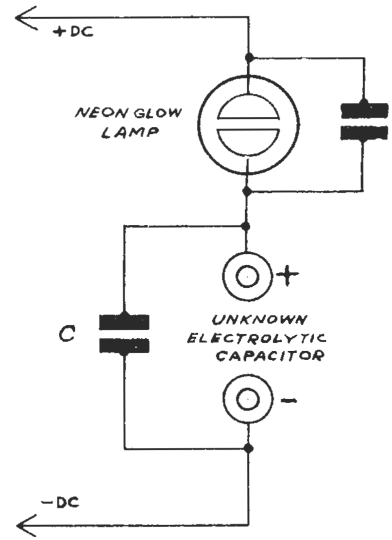


FIG. 12

wood carrying case. The cover is slip-hinged so that it may be easily detached whenever it is desired to do so. A richly finished and verichromed bakelite panel adds to the beautiful appearance of this tester which inspires confidence on the part of the radio service engineer's customers who will appreciate the good judgment he exercises in his choice of Supreme testers.

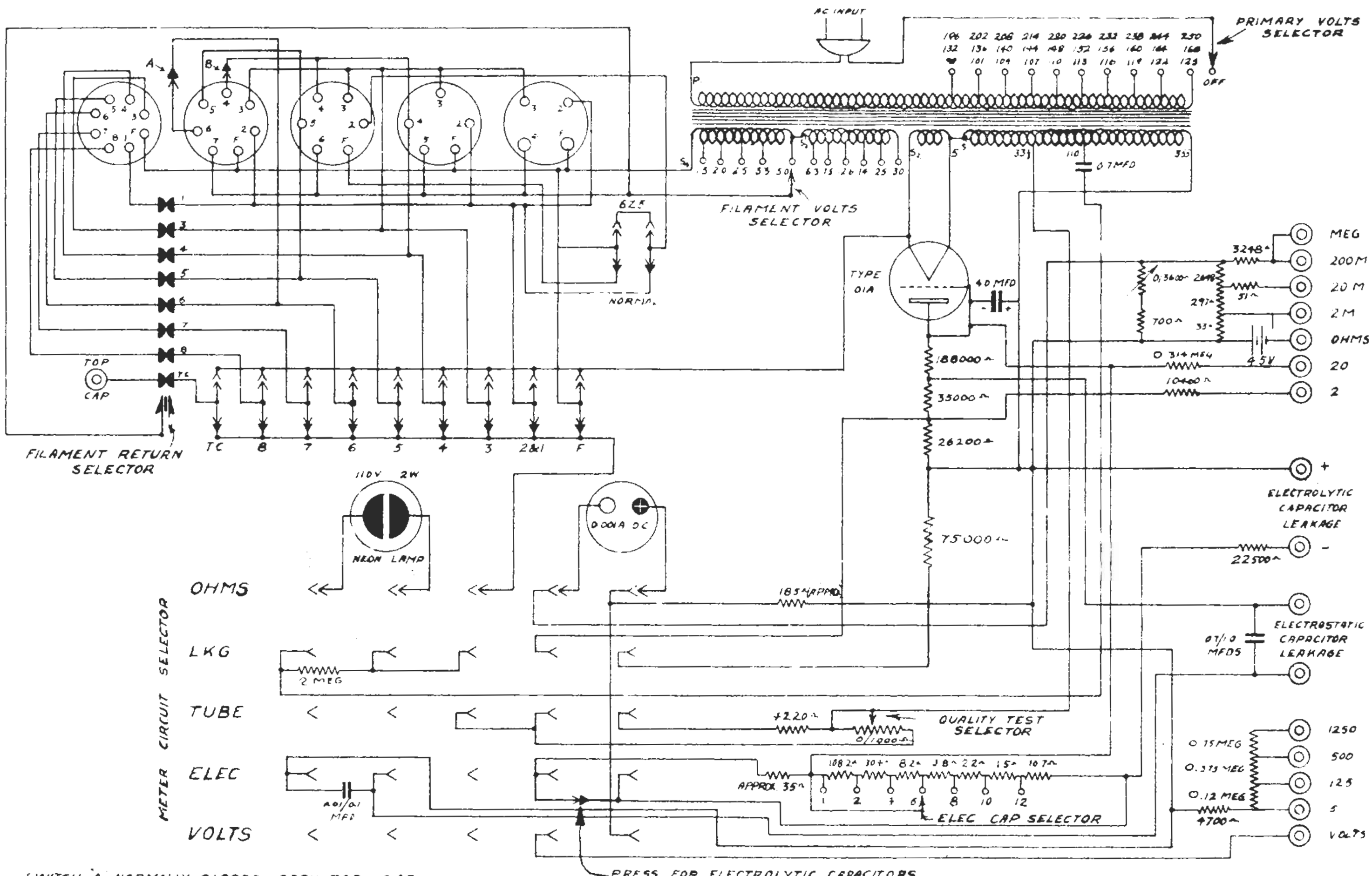
The tester is 5 1/2 x 11 1/4 x 12 3/8″ and weighs only 13 pounds. For 98/125-volt, 60-cycle power supply unless otherwise ordered at slight additional cost.

Supreme Model 89 DeLuxe Tube Tester

DEALER'S NET CASH WHOLESALE PRICE **$45.95**

Supreme Model 89 Standard Tube Tester

DEALER'S NET CASH WHOLESALE PRICE **$34.95**



SWITCH 'A' NORMALLY CLOSED, OPEN FOR 12A5
SWITCH 'B' NORMALLY CLOSED, OPEN FOR 12Z5

FIG. 9

QUICK FACTS

GENERAL

1. Exclusive design 5-inch Supreme fan type meter.
2. Meter fully protected.
3. Only five sockets for all tube testing—no adapters—including testing all eight pin metal tubes.
4. Exclusive filament return selector switch by which all octal tubes may be tested in one standard octal socket.
5. Obsolescence probabilities reduced to a minimum.

QUALITY TEST

6. Simple, accurate line voltage adjustment.
7. Simple three step tube testing operation.
8. Accurately indicates all tubes as "good," "?" or "bad" on English reading scale.
9. Tests all tubes at approximately **rated load** for utmost accuracy.
10. Allows separate tests of any and all elements of tubes (diodes, full-wave detectors, rectifiers and all other multi-element tubes).
11. Constant ballast ratio between tube and circuit resistance values.

LEAKAGE TESTS

12. Full-sized neon lamp used for leakage tests.
13. Leakage tests made in same socket as Quality tests.
14. Tube leakage tests made while tubes are heated.
15. Neon leakage test between **all** tube elements.
16. Indicates automatically elements between which leakage exists.
17. Does not indicate leakages beyond permissible values.
18. Detects open-circuited elements.

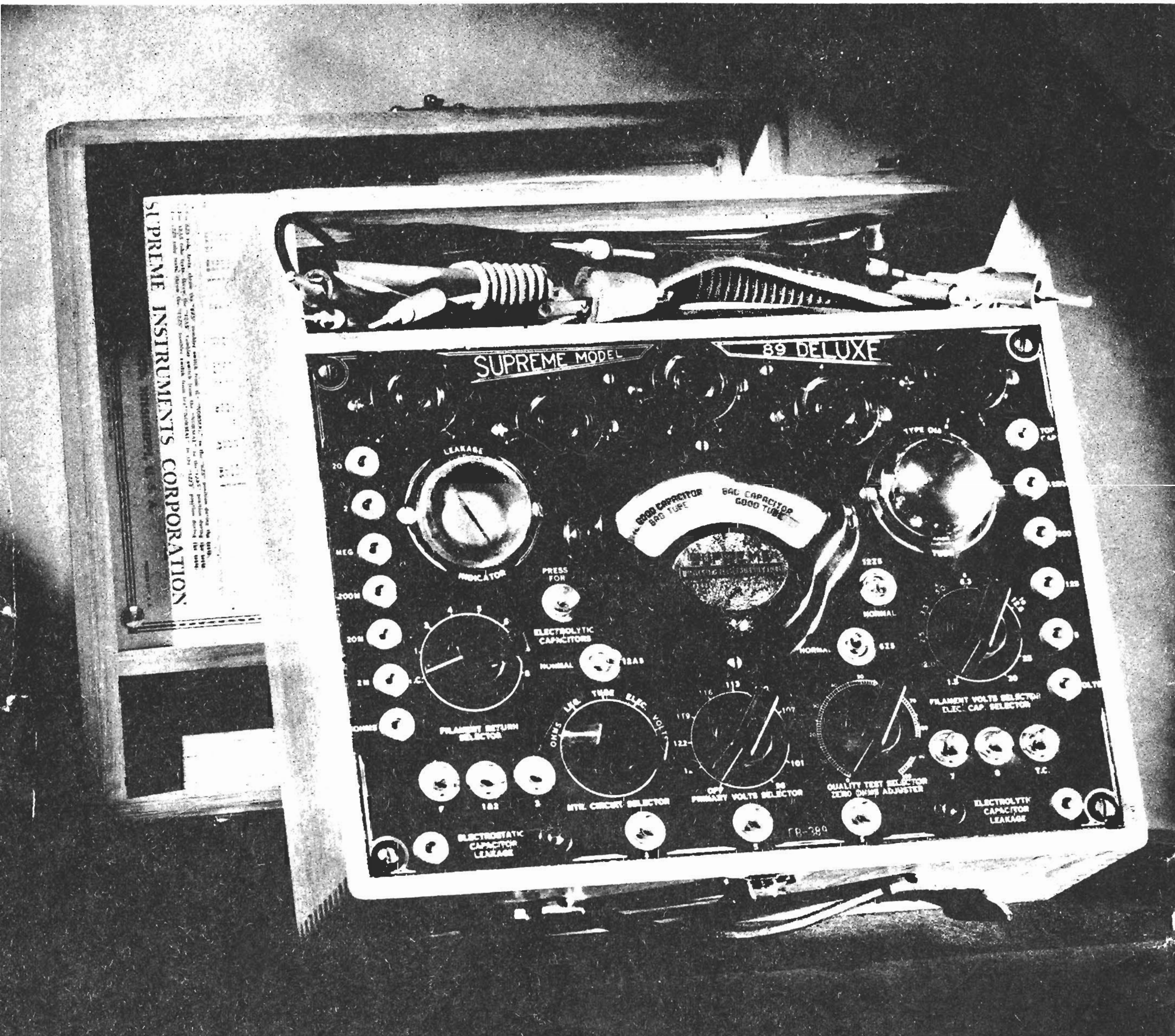
DELUXE FEATURES OF MODEL 89-D

19. Four D.C. volts ranges—
    - 0-5 volts
    - 0-125 volts
    - 0-500 volts
    - 0-1250 volts
20. Five resistance ranges—
    - 0-2,000 ohms
    - 0-20,000 ohms
    - 0-200,000 ohms
    - 0-2,000,000 ohms (2 megohms)
    - 0-20,000,000 ohms (20 megohms)
21. English reading scale ("good capacitor" or "bad capacitor") for electrolytic capacitor leakage tests.
22. Tests any ordinary electrolytic capacitor up to 12.5 mfds. as to its leakage characteristics.
23. Tests all electrostatic (paper) capacitors for leakage.

Supreme Instruments Corporation

Greenwood, Mississippi, U. S. A.

Export Dept., Associated Exporters Co., 145 West 45th St., New York City. Cable Address, LOPREH, New York


SUPREME MODEL
89 DELUXE
SUPREME INSTRUMENTS CORPORATION
LEAKAGE
INDICATOR
GOOD CAPACITOR
BAD TUBE
BAD CAPACITOR
GOOD TUBE
PRESS FOR
ELECTROLYTIC
CAPACITORS
NORMAL
FILAMENT RETURN
SELECTOR
PRIMARY VOLTS SELECTOR
QUALITY TEST SELECTOR
ZERO OHMS ADJUSTER
FILAMENT VOLTS SELECTOR
ELEC. CAP. SELECTOR
ELECTROSTATIC
CAPACITOR
LEAKAGE
ELECTROLYTIC
CAPACITOR
LEAKAGE