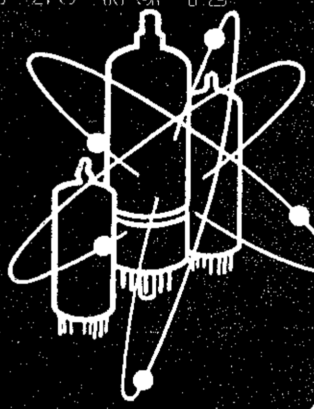
VOL. 23 No. 12 DECEMBER, 1958 ONE SHILLING

ELECTRONIC VALVES



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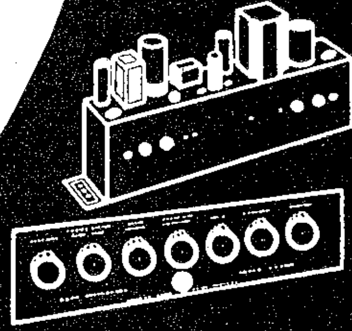

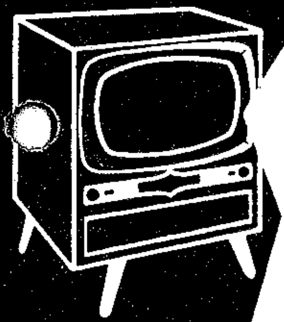

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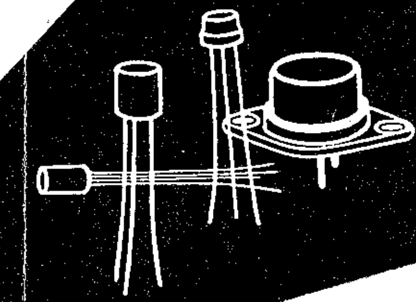
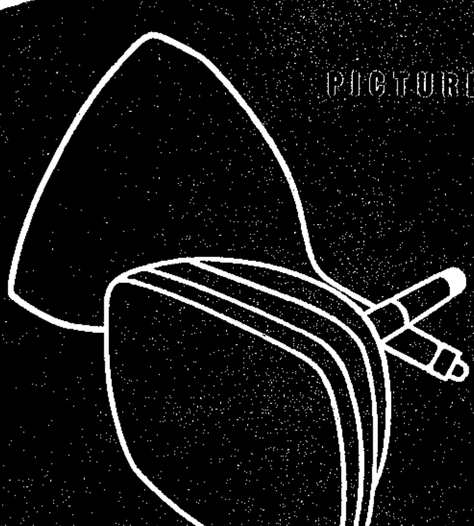
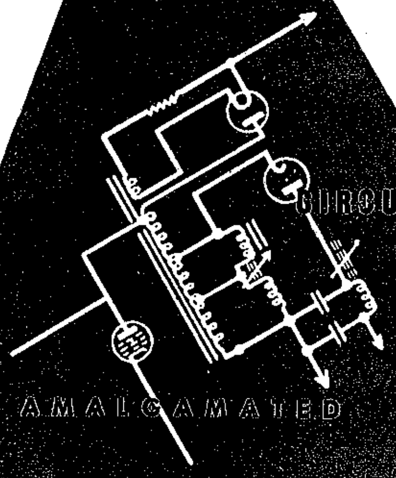


RADIOTRONICS

PICTURE TUBES





CIRCUITRY

AMALGAMATED WIRELESS VALVE COMPANY PTY. LTD.

Amalgamated Wireless Valve Company Pty. Ltd.

BOX 2516, G.P.O.

45-47 YORK STREET, SYDNEY

December, 1958.

Dear Reader,

With this issue we come to the end of what we hope has been an interesting and successful year with "Radiotronics". The "Radiotronics" staff takes this opportunity of wishing you a happy and prosperous year in 1959.

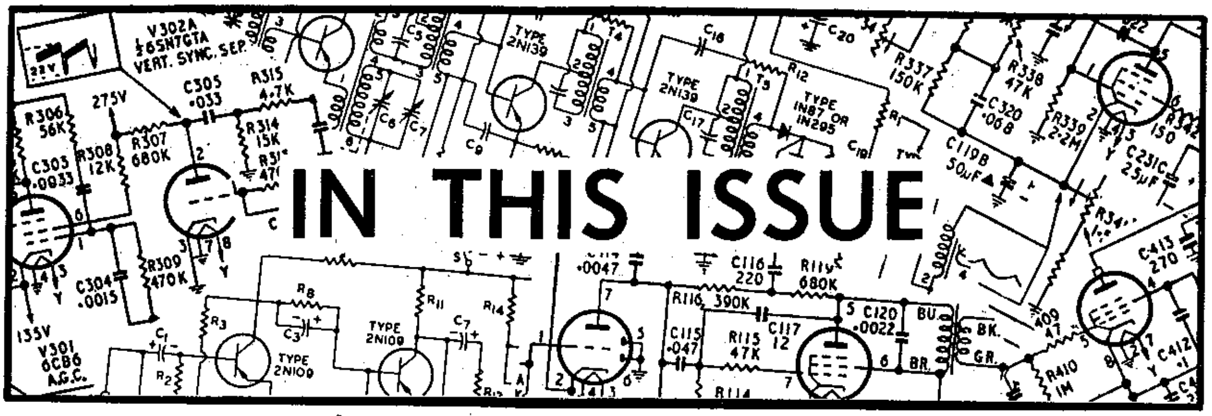
We are striving constantly to maintain and where possible improve the standard of content and presentation. Moreover, the "Radiotronics" staff is always ready to help you with your valve data and application problems, and in fact, in any way possible.

Plans for the future, of which further details will be announced later, include a cumulative index to date as a lift-out supplement, and a reader's reprint and photostat service. As an example of the material under preparation for you, we will bring you, starting early in the new year, a series on transistor fundamentals and applications, designed to give engineers and technicians a quick course in transistor theory.

Yours sincerely,
AMALGAMATED WIRELESS VALVE CO. PTY.LTD.

Bernard J. Simpson

Bernard J. Simpson,
Editor, Technical Publications.



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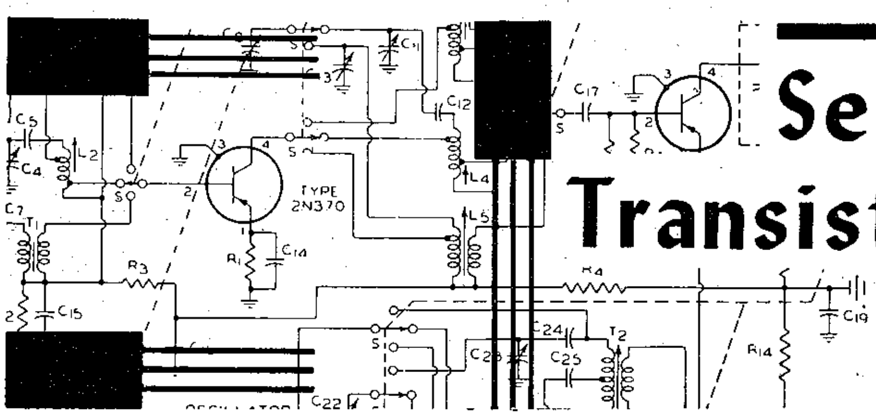


Servicing Transistorized Radios

By B. J. Simpson

GENERAL CONSIDERATIONS

Transistor radios are appearing in ever increasing numbers, and many servicemen approach the first few transistor sets that appear on their bench as a "black box". It isn't a black box — it's still a superhet, with converter, if amplifier, second detector and audio stages. Sometimes there is an rf amplifier stage, and almost invariably to-day, a ferrite rod aerial. Servicemen of greater maturity will recognise an old friend of the 1930's, the Class B audio output stage, brought back into use because of its low no-signal current drain.

The major difference, of course, is the replacement of the thermionic valve with a crystal valve or transistor. Both of these devices perform the same function, but whereas in the thermionic valve, the cathode-anode current flow is regulated by the small grid voltage, in a transistor (Common-emitter circuit) the emitter-collector current flow is regulated by the much smaller emitter-base current. The thermionic valve is thus voltage-controlled and the transistor current-controlled

Both transistors and thermionic valves are biased, but the application of bias differs in practice. A thermionic valve may be biased to cut off, whereas the transistor is cut off when no bias is applied, that is, the transistor is "forward biased". To put it another way, a thermionic valve is biased to reduce plate current to the required value, whereas the transistor is forward biased to increase collector current.

Before attempting to service transistorized equipment it goes without saying that an understanding is necessary of the transistor and how it works. Another important point is the ability to recognise or identify whether transistors in a set on the bench are p-n-p or n-p-n type as this will, of course, determine the polarities of voltages which one will expect to find in the set, and will influence selection of alternative transistors where necessary. Where the manufacturer's data does not state the type used, an inspection of the circuit diagram will reveal the required information.

The symbols used for the two types are basically similar, but the arrow on the the emitter connection is pointing towards the base for p-n-p type, away from the base for an n-p-n type. See Fig. 1. Note that some sets use a mixture of the two types.

Alternatively, in the descriptions "p-n-p" and "n-p-n" read negative for n and positive for p; then the required polarity on the collector is given by the centre letter. A check with the circuit diagram may reveal a negative voltage or perhaps 7 to 9 volts on the collectors. From the foregoing then we recognise the transistors in the set as p-n-p types.

The emitter voltage is small, and of opposite polarity (with respect to the base) to that on the collector. It may not be obvious from Fig 1 that the base is the reference, but this is so, and voltages are normally quoted with respect to base. If the collector bias is applied with incorrect polarity, a destructively large current will flow, limited only by the dc resistance in the base and collector circuits. Collector breakdown will occur if the bias (of correct polarity) is applied at too high a voltage. The emitter-base junction is forward-biased. Incorrect polarity may permanently damage some transistor types having a low emitter-to-base breakdown voltage rating.

SERVICE PRECAUTIONS

Before doing any service work on a transistor radio, all components and wiring should be given an intense visual inspection. Look for broken leads, poor soldered joints, corroded or bent battery terminals, solder or dirt between leads, breaks or cracks in printed circuitry, and similar faults. The largest single reason for service requests on transistor radios is a run-down battery. Test the battery under load, as many circuits are very sensitive to voltage supply.

Transistors are operationally very rugged devices, and when used within the manufacturer's

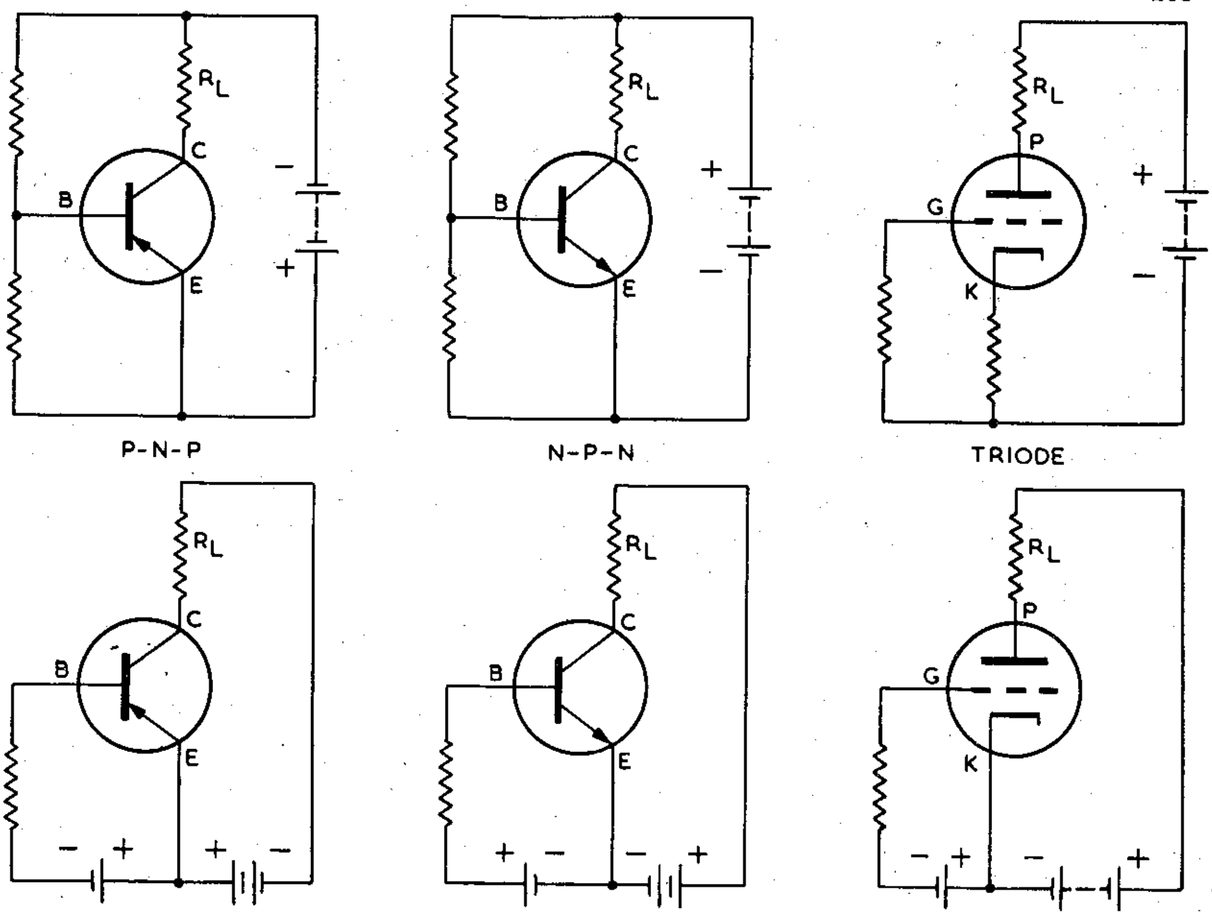


FIG. 1

ratings, may be expected to have a very long life in service. They are, however, easily damaged by careless handling, excessive heat and by the application of incorrect potentials and currents. A number of precautions must be taken in the servicing of transistor radios, and a number of practices long common in the testing and repair of thermionic valve sets must be discarded. The well-known practice of shorting out components in the set to check whether certain stages are operating will certainly lead to damage, by shorting out transistor bias resistors, generating damaging surges, and other effects. This will leave the serviceman with the more difficult problem of repairing both the original fault plus those he has caused himself. The same applies to the attempted measurement of voltages by short-circuiting them with a screwdriver, which would not in any case be feasible, due to the low voltages used in transistorized equipment.

Indiscriminate probing and prodding in the set whilst it is switched on may give rise to damaging current surges. Shorting of transistor connections together or to the chassis will disrupt the bias arrangements and may cause fusing of the transistors by the resulting current surge. No disconnection should be made anywhere in the set whilst switched on. If working on a set employing negative feedback from voice coil to output stage emitters, the speaker must be connected at all times when the set is switched on. Transistors operate instantly on application of power, and no time is lost by switching off during servicing operations.

The removal or replacement of transistors in a set whilst it is switched on may give rise to damaging current surges. Similarly, the disconnection of one transistor lead whilst power is still applied to the other two connections may ruin the component.

Transistors are sensitive to heat, and temperatures in excess of 90° C. (less than that of boiling water) can cause permanent damage. When soldering transistor leads, always work as quickly as possible and provide a protective heat sink for the transistor by gripping the lead in a pair of "telephone" pliers between the transistor case and the soldering point. If soldering to transistor holders, always remove the transistor during the process. Care must also be taken even when working on other components that the body of the soldering iron is not placed too close to a transistor.

The implementation of the precautions mentioned here requires, among other things, the careful selection of test equipment. The requirements of equipment for use in servicing transistor radios will now be discussed.

SERVICE EQUIPMENT

General

The usual care should be taken in providing an efficient earth to the frame of any mains-driven item of test equipment. In addition, the output or input circuits of such items as signal generators, BFO's and CRO's should be such that no voltage is present on the terminals, and there is no low-impedance dc path between "hot" and "earthy" terminals.

These precautions ensure that there is no possibility of applying a damaging voltage to a transistor circuit, or of damaging the transistor by allowing high current to flow. Both precautions can be implemented by the use of good quality capacitors of suitable value in series with the "hot" lead connection.

Assuming an input impedance of 1000 ohms, a suitable value of capacitor would be one offering a capacitive reactance at the operating frequency appreciably lower than 1000 ohms.

Ohmmeters

Transistors can be damaged by the application of potentials present in many widely-used types of ohmmeter or multimeter. Even when the ohmmeter voltage is low enough to render the instrument safe on transistor circuits, the presence of the transistors in the set can lead to misleading readings when circuit checking. The transistors may conduct under the influence of the applied ohmmeter voltage, and the more reliable procedure is to disconnect the transistors from the circuit when checks of circuit values have to be made. It should be noted that transistor radios are fitted with quite low-voltage electrolytic capacitors, and the open-circuit voltage of many test meters is sufficient to damage these components. The polarity of the ohmmeter leads should be checked, as even the comparatively low voltage used in ohmmeters can damage the low-voltage electrolytic capacitors when applied in the wrong polarity. Transistors also, of course, can be damaged by the application of voltages of incorrect polarity.

An ohmmeter used on a transistor radio must be of the low-current type, and should not pass a current through the external circuit greater than 1 ma on any range. Check this by using a separate low-resistance milliammeter in series with the ohmmeter leads. As regards open-circuit voltage, it is, in general, safe to use an ohmmeter which uses a battery of 3 volts or less, provided a high-ohms range is used. It may be advisable to construct a simple low-voltage ohmmeter for use with transistor sets.

Voltmeters

Voltmeters used on transistor radios must have a high impedance to avoid misleading results caused by shunting effects, and a voltmeter of 20,000 ohms/volt (50 ua fsd) is recommended. In servicing transistor radios, circuit checks using an accurate voltmeter and the comparison of the results with the manufacturer's typical figures given in the service data will provide a more useful indication than ohmmeter checks of the circuit. The voltage checking can also be carried out without disconnecting the transistors, and is therefor more economical in time. Note that the figures given by the manufacturer are generally taken under no-signal-input conditions. This type of checking is dealt with in more detail later when dicussing "Static Meter Tests".

Hand Tools

Because the sets and components are small, and in view of the danger of heat-damage to the transistors, only a small soldering iron should be used, of the order of 30 watts or less. The small "pencil" type instrument irons are admirably suited, and have the additional advantage of operating on a low ac voltage derived from a transformer.

Low insulation resistance between the element and bit of a soldering iron could cause the application of a destructively excessive reverse voltage to the transistor junctions. A low-voltage soldering iron would minimise this risk, even when the insulation is poor, and particularly if a transformer is used which has an earthed shield between windings. Needless to say, the iron bit and casing should be effectively earthed. In general, tools smaller than those normally found in a serviceman's kit will be most useful, including tweezers and "telephone" pliers with very fine points.

STATIC METER TESTS

Two types of static meter tests are described here, a current consumption test and an individual stage voltage check. The measurement of the total current drain of the set, and then the measurement of the total current drain with each transistor in turn removed from the set in analogous to a check on a valve heating and passing current in a thermionic valve set. It must, of course, be remembered that the fact that a transistor does not draw current does not necessarily mean that it is faulty — the fault may lie in an associated component. The test is, however, easily carried out and at least serves to isolate a faulty stage if nothing more.

Voltage tests at the electrode terminals of the transistors will reveal many types of faults, and at the same time provide a check on the circuitry. Manufacturers of transistorized radios almost invariably quote the electrode voltages on the circuit diagram. Unless specifically stated in the manufacturer's data, make static meter tests with the volume turned fully on, and the set tuned to a spot where there is no active station.

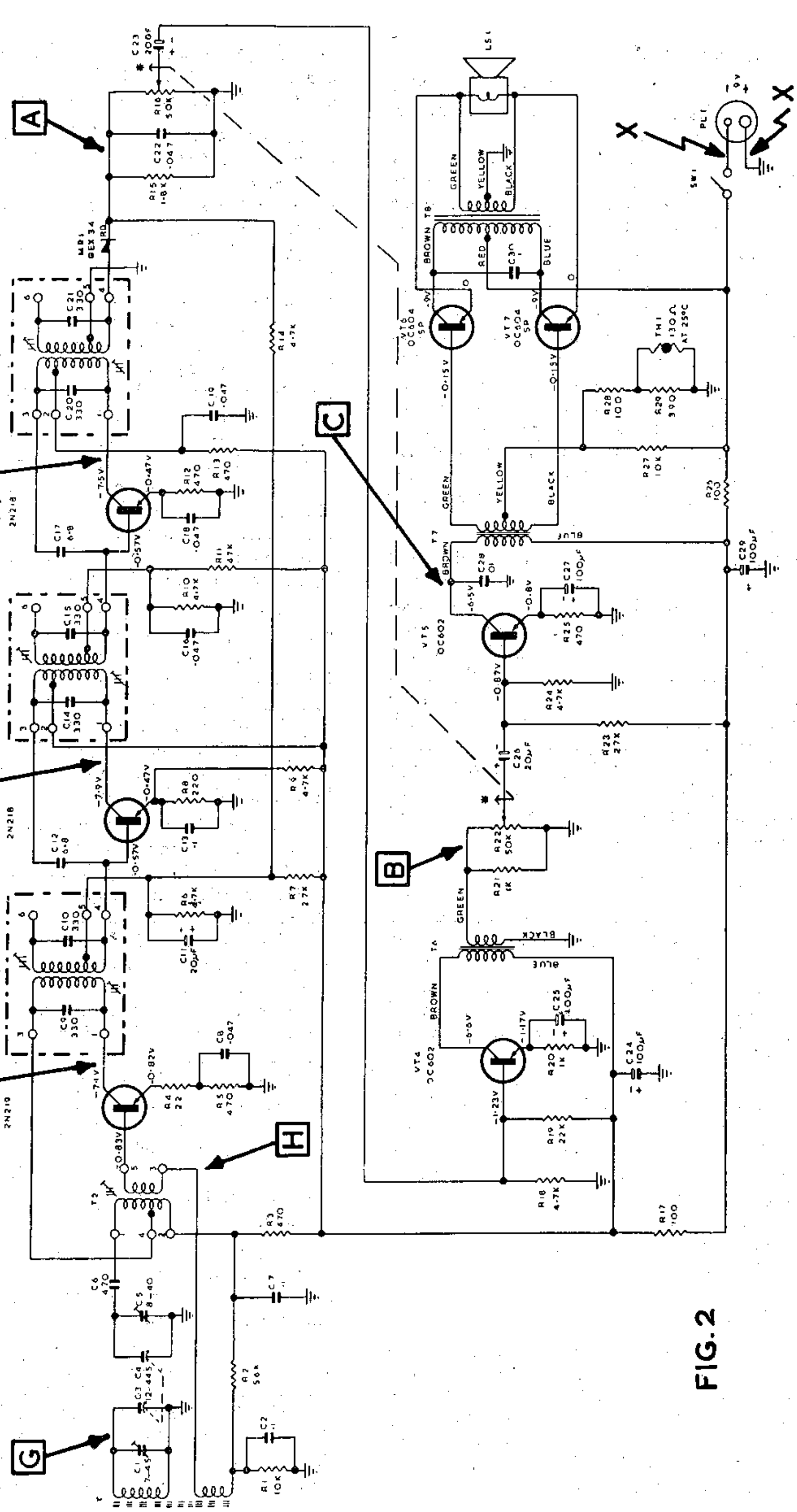

A
B
C
D
E
F
G
H
VT1 2N219
VT2 2N218
VT3 2N218
VT4 OC602
VT5 OC602
VT6 OC604 SP
VT7 OC604 SP
MR1 GEX34
GREEN
YELLOW
BLACK
BROWN
RED
BLUE

FIG. 2

CURRENT CONSUMPTION

A typical transistorized radio is shown in Fig. 2. The load on the battery consists of the seven transistors and also several bleed circuits designed to provide various operating potentials throughout the set. The battery load portion of the receiver has been drawn to show the various dc current paths served by the battery, and the result is seen in Fig. 3.

The procedure for this test is to break the battery lead, say at either of the points marked X on the diagram, and insert a milliammeter. Use the highest possible range on the meter. Although the resistance of the meter will probably be quite low, the added resistance in the battery circuit may give trouble, such as audio oscillation in a set with single-ended output stage. Such troubles can usually be eliminated by shunting the meter with a low voltage electrolytic capacitor of fairly high value, observing correct polarity.

If the set is now switched on, the meter will indicate the total no-signal current drain. In the case of the receiver of Figs. 2 and 3, it is approximately 15 ma. The drain is now checked with each transistor in turn removed, switching off the set each time, of course. A fall in total current drain of the order of 0.25 to 1.0 ma should be observed in each case with one transistor removed, depending on battery voltage and other design features of the set. Failure to produce a change in battery current by removing a transistor points to a faulty transistor or components associated with the stage in question.

Electrode Voltage Check

A high-resistance voltmeter or VTVM may be used to check individual electrode voltages on the transistors in the set, comparing the readings against those published in the manufacturer's data. Note that the published figures are typical figures, to which a reasonable tolerance of say 20% should be applied before assuming a fault. The readings must be made under no-signal conditions unless otherwise stated. A signal input will vary electrode voltages due to increased current drain, agc action, and other effects. Any other circuit voltages quoted in the data, such as at fixed potentiometers, should also be checked out. The polarities as well as the magnitudes of the voltages are, of course, very important, and must be carefully checked.

DYNAMIC TESTING

It seems likely that dynamic testing will prove even more popular in locating faults in transistor radios than with sets employing thermionic valves. The trend to dynamic testing is given extra impetus by the increased difficulty of making point-to-point circuit checks in transistorized equipment, and by the fact that there is a natural reluctance to indulge in extensive soldering operations in order to carry out tests. Where printed circuitry is used, the tendency is even more understandable.

It must be remembered that transistors are very robust, and for a transistor to fail of itself is probably rare. Failures can usually be attributed to an outside cause, such as heat, mishandling, or the incidence of incorrect circuit conditions. As far as the service bench is concerned, probably the best way to check a transistor is by substitution, but in view of the foregoing remarks, a few precautionary checks should be made before resorting to the substitution method of fault clearing. Having isolated the fault to a particular stage, it would be wise at least to check applied potentials before making a substitution. It will be seen then that whereas it is common in servicing sets using thermionic valves to pull the valves and check them early in the procedure, and then later check the circuit if necessary, the reverse is the case with transistorized equipment. In a transistor radio, every effort is made to check the circuit before suspecting or replacing transistors.

Dynamic testing procedures are familiar to servicemen, who have the choice of the signal tracing or the signal injection methods. In the following remarks it will be assumed that the latter method is used, as being perhaps the more popular of the two, and translation into terms of signal tracing should present no difficulty. The basic procedures are no different from those used in thermionic valve radios.

Reference to Fig 2 will show that certain test points have been indicated on the diagram, labelled alphabetically. These test points on this typical receiver are suggested as examples of check points which may be selected on receivers for the purpose of carrying out dynamic tests. Assuming that the set is completely non-operative, a good place to start is between the second detector and the first audio stage, shown at A. If an audio signal injected at this point produces an output, then the fault must lie in the preceeding stages. Thus by one simple test, half the set has been eliminated in the search for the fault. Additional check points on the audio section of the receiver would be B and C, assuming that signal at A produces no output. Points B and C then attempt to eliminate the audio stages one by one.

If signal output is heard with an injected audio signal at A, then steps must be taken to trace the faulty stage in the high frequency sections of the receiver. Injecting the intermediate frequency (455 Kc) modulated by an audio tone at D halves the remaining stages to be checked. If no output results, then test with the same frequency at point E. If output is obtained from D, then the fault must be in the converter stage. Checks may then be made at F using the intermediate frequency and at G using any frequency within the

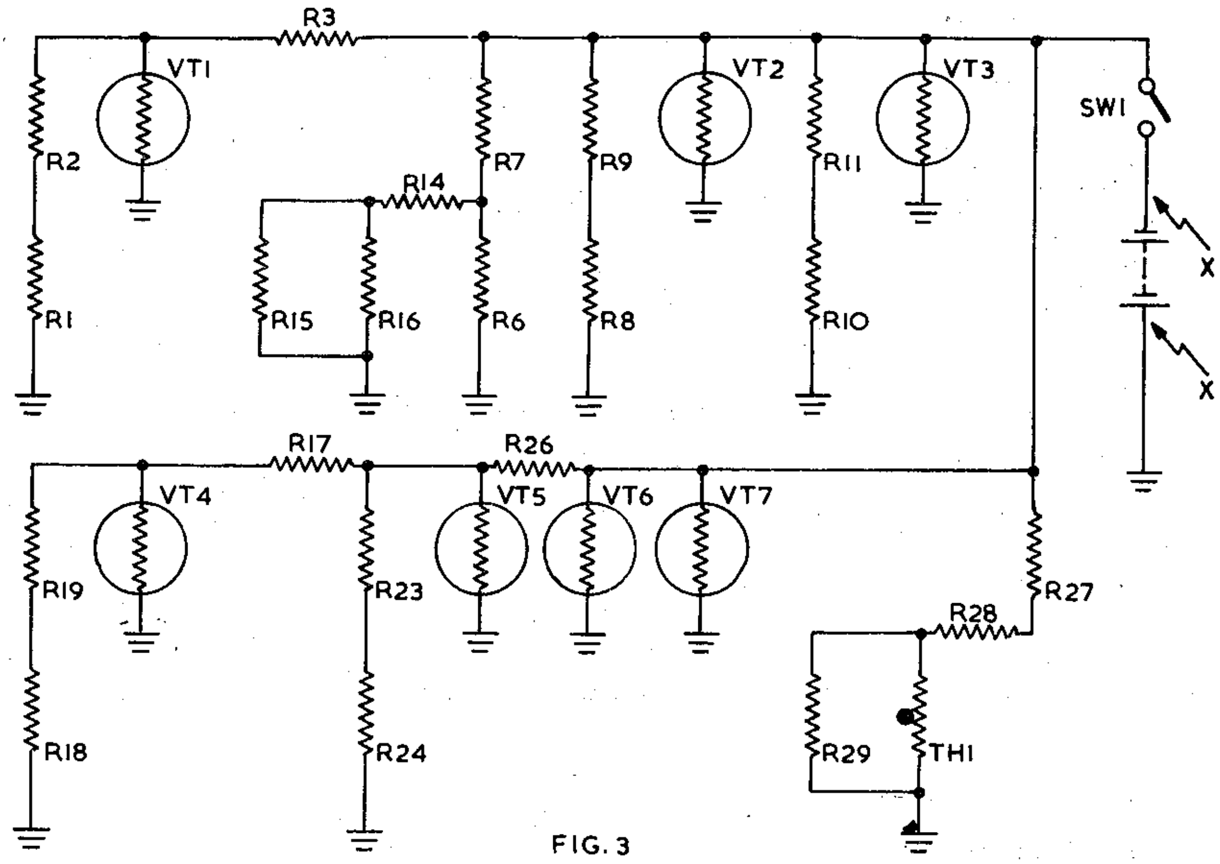


FIG. 3

range of the receiver; the receiver will, of course, have to be tuned to the same frequency. Failure of the local oscillator signal at the converter stage may be checked by tuning the receiver to a known active station and then injecting the calculated local oscillator frequency through a very small capacitor at point H. Slight adjustment of the signal generator may be necessary to secure the correct frequency, and the signal should of course, be unmodulated.

Whilst the foregoing remarks indicate one approach to the problem, any systematic method will produce the required results in fault location. One point to watch is that the input signals at the various test points are at a level which might reasonably be expected there. Too large a signal will lead to misleading results, either in masking low sensitivity or by direct capacitive coupling "jumping" a faulty stage. Too low a signal will, of course, tend to mark a stage as faulty in error. As a guide it may be assumed that levels are generally 20 to 30 db below those in a thermionic valve receiver with similar layout and number of stages, when measured on an input electrode.

It may be as well to stress again here the importance of avoiding a dc path between the generator output terminals. Such a dc path would alter the transistor bias conditions. This position can be avoided by the insertion of a suitable capacitance in one of the generator leads.

AUTOMATIC GAIN CONTROL

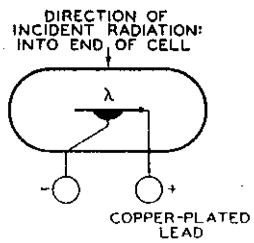
The automatic gain control characteristic can yield valuable information on set performance in transistorized radios as with other types of set. The purpose of the function is the same, to keep the carrier level at the second detector constant regardless of signal input level, but the manner in which the function operates may be different.

Where p-n-p transistors are used in the controlled stages, the agc voltage is positive. In a thermionic valve the positive input signal is superimposed on a negative bias which holds the valve in the correct operating condition, and the negative agc voltage increases the bias to reduce gain. In the case of the p-n-p transistor, the signal input electrode (base in the common emitter circuit) is negatively biased (emitter with respect to base). A stronger input signal produces a higher positive agc voltage, which drives the base of the controlled transistor less negative to reduce the stage gain.

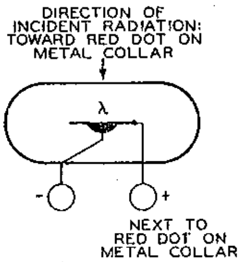
Where n-p-n transistors are used, the polarities of the respective voltages are reversed, and so is the polarity of the agc voltage, which now be-

(Continued on page 216)

7223 RADIOTRON 7224



PHOTOJUNCTION CELLS



Two Radiotron photojunction cells (photodiodes) have just been announced. They are the Radiotron 7223 and 7224, both of which employ a germanium p-n alloy junction. These cells will provide useable output current with polarizing voltages from a few volts up to as high 50 volts. Their spectral response covers the range from approximately 3500 to nearly 19000 angstroms, with maximum reponse at about 15000 angstroms. They therefore have high sensitivity to red and infrared radiation, as well as good response over the visible region of the spectrum.

RADIOTRON 7223

Radiotron 7223 is a very tiny, photojunction cell of the head-on type, especially intended for computer, punched-tape, punched-card, and sound pickup-from-film applications. The 7223 has fast rise and decay characteristics and a signal output which is approximately proportional to the intensity of incident radiation.

DATA

General:

Spectral Response	S-14
Wavelength of Maximum Response	15000 angstroms
Window	Glass
Operating Position	Any
Weight (Approx., avoirdupois)	3 grains

Maximum Ratings, Absolute Values:

POLARIZING VOLTAGE	50 max. volts
POWER DISSIPATION	0.025 max. watt
AMBIENT TEMPERATURE	50 max. °C

Characteristics:

Under conditions with polarizing voltage of 2.5 volts and ambient temperature of 25°C, unless otherwise noted.

Sensitivity:	Min.	Median	Max.	
Radiant intensity, at 15000 angstroms	—	0.68	—	μa/w/metre^2
Illumination § *	0.1	0.2	0.5	μa/ft-c
Dark Current:				
At polarizing voltage of 2.5 volts	—	—	14	μa
At polarizing voltage of 50 volts	—	—	35	μa

§ For conditions where the light source is a tungsten-filament lamp operated at a colour temperature of 2870°K.

* The value of illumination incident on the window is 73 foot-candles.

RADIOTRON 7224

Radiotron 7224 is a very small photojunction cell of the side-on type, especially intended for sound pickup from film and for computer applications. The photocurrent of the 7224 has fast rise and decay characteristics. Signal output is approximately proportional to the intensity of the incident radiation.

DATA

General:

Spectral Response	S-14
Wavelength of Maximum Response	15000 angstroms
Envelope	Glass
Operating Position	Any
Weight (Approx.)	1 gramme

Maximum Ratings Absolute Values:

POLARIZING VOLTAGE	50 max. volts
POWER DISSIPATION	0.030 max. watt
AMBIENT TEMPERATURE:	
Operating	-40 to +50°C
Storage	-65 to +75°C

Characteristics:

Under conditions with polarizing voltage of 45 volts and ambient temperature of 25°C.

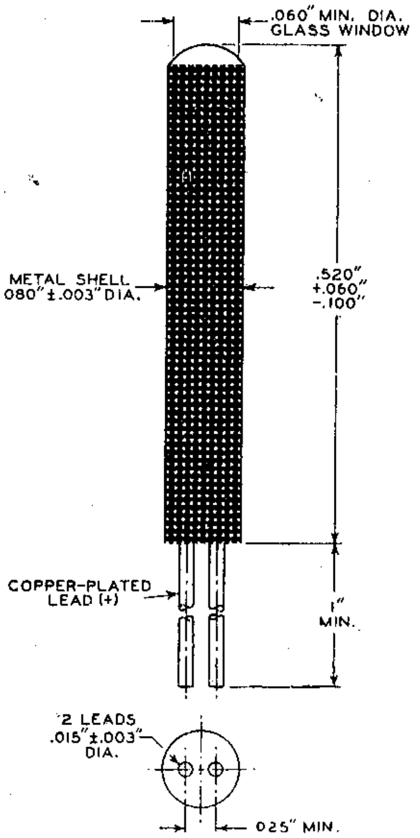
	Min.	Median	Max.	
Sensitivity:				
Radiant, at 15000 angstroms	—	0.52	—	μa/μw
Luminous ‡	—	14	—	ma/lumen
Illumination ‡ *	0.5	0.7	—	μa/ft-c
Dark Current:	—	—	35	μa

‡ For conditions where the light source is a tungsten-filament lamp operated at a colour temperature of 2870°K.

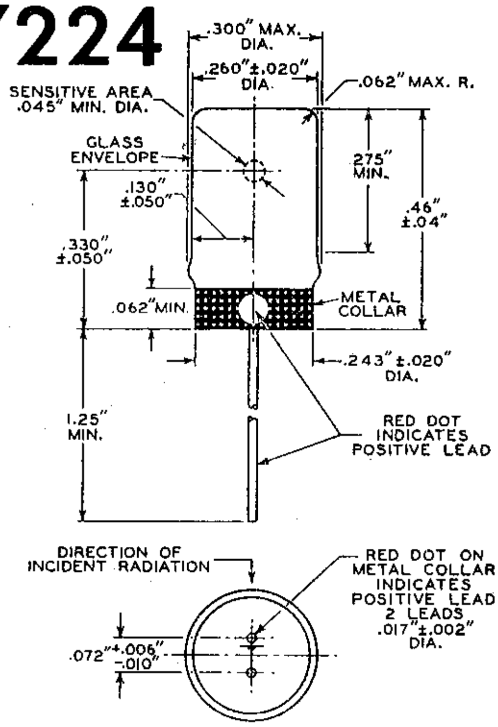
* The value of illumination incident on the sensitive area is 73 footcandles.

DIMENSIONAL OUTLINES

7223



7224



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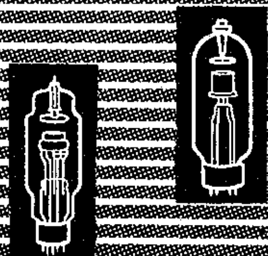
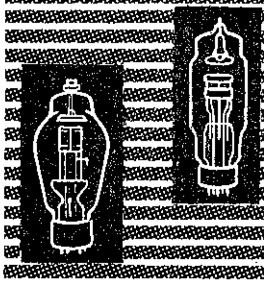


Pulse Emission Testing of Gas Valves



Because of the particular voltage-current characteristics of gas-filled valves, a single pulse test can be used in the field to detect both complete failures and "marginal" valves. This article describes a basic circuit for making such a test.

Voltage-Current Characteristic of Gas Valves

Hot-cathode gas valves, like vacuum valves, utilize oxide-coated cathodes which emit electrons copiously. In a vacuum valve, however, some of the emitted electrons are driven back into the cathode by a field of previously emitted electrons; the emission, therefore, is said to be space-charge limited. In a gas valve, on the other hand, electrons emitted from the cathode strike gas atoms and ionize them. The ions then neutralize the space charge around the cathode and thus remove the deterrent effect of the space charge on the current. As a result, most of the emitted electrons can reach the anode under the influence of a modest voltage.

Fig. 1 shows a typical voltage-current characteristic curve for a gas-filled valve. The maximum voltage which can be applied to a gas valve before appreciable current flows is known as the starting or breakdown voltage, indicated in Fig. 1 as Eb. After breakdown occurs, a gas valve needs only sufficient anode voltage to produce ionization of the gas, so long as the current drawn is within the emissive capabilities of the cathode. This voltage is about 9 volts for xenon-filled valves, and about 12 volts for mercury-filled valves. Because the current after breakdown increases rapidly without further increase in voltage, a series resistance is necessary to limit the current. In the typical rectifier circuit, this resistance is represented by the useful load. The operating point, A, is determined by drawing through the supply voltage, Ebb, a line with a slope equal to the reciprocal of the load resistance. The anode voltage across the valve, Ea, at a given current, Ia, is known as the valve drop.

Causes of Failure in Gas Valves

Failure, or incipient failure, of gas valves is usually evidenced by a decrease in the emissive capabilities of the cathode. The reduced emission, however, may be attributed to any one of several causes. The presence of a foreign gas such as oxygen or air in the valve may poison the cathode coating and reduce its emissive capabilities. This foreign gas, which may be introduced as a result of a leak in the glass envelope or through evolution of gas from parts within the valve, may also cause breakdown of the valves on the inverse cycle of voltage if the ionization point of the foreign gas is lower than that of the original gas filling used in the valve.

Poor emission may also be caused by gas clean-up, which results when the cathode coating material in the valve sputters under the bombardment of ions. The material thrown off from the cathode collects some of the gas atoms and is deposited on the valve walls. The decrease in emission results from both the damage to the cathode coating and the scarcity of ions.

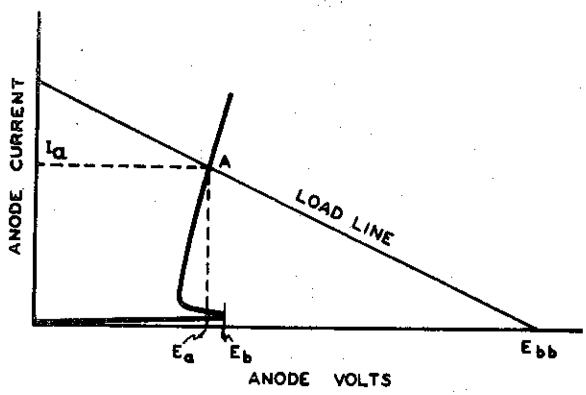


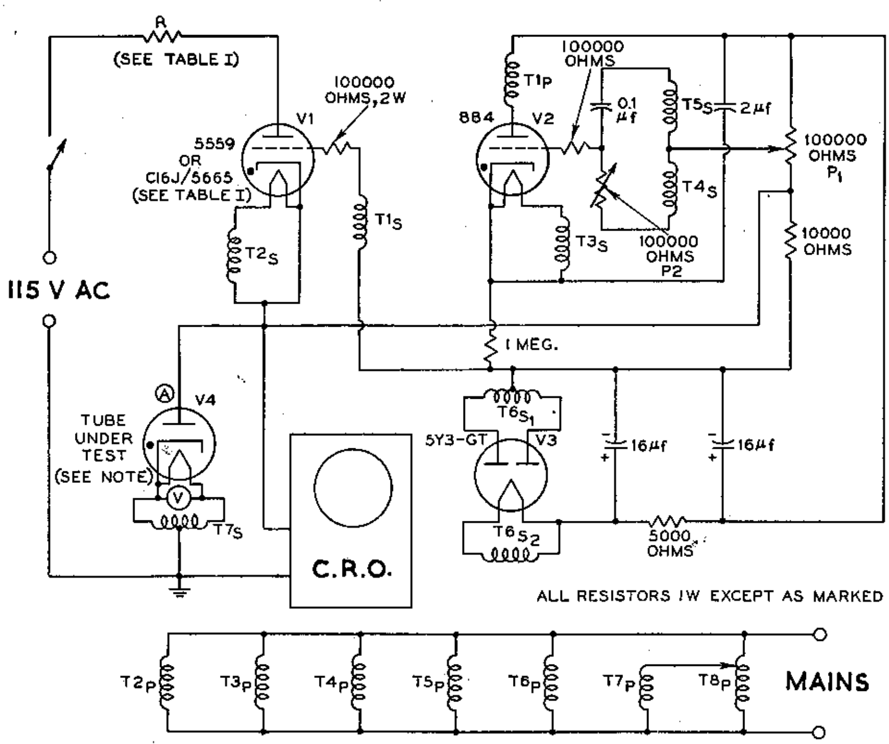
Fig. 1 — Typical Voltage-Current Characteristic for a Gas-filled Electron Valve.

Poor emission or a complete lack of emission may also be caused by such defects as open filaments, improperly coated cathodes, and shorts. A suitable test of emissive capability, therefore, detects these defects as well as those mentioned above.

Methods of Test

A conventional method of testing gas valves in the field is the measurement of breakdown voltage. This test is a fairly accurate indication of the emissive capabilities of the cathode in valves in which the anode directly faces the cathode. In most gaseous rectifiers, however, a cathode shield employed to improve thermal efficiency breaks up the direct path between cathode and anode. This shield also acts as a grid which is made positive or negative with respect to the cathode by the action of the ac heater voltage and, therefore, affects the breakdown voltage of the valve. If the shield is negative with respect to the cathode when the anode swings positive, the breakdown voltage of the valve is considerably higher than if the shield and anode voltages are in phase. In such valves, therefore, the starting voltage should not be taken as a measure of the emission.

Measurement of dc valve drop at rated average current is also used quite often in the field to determine the performance level of gas valves. A gas discharge is somewhat self-compensating, however, and, therefore, an increase of a volt or two in valve drop can compensate for a considerable decrease in emission. If the cathode emits insufficient electrons to provide the current which would normally flow through the given load resistance, the valve drop increases. Because of this increased voltage drop, the positive ions strike the cathode with higher velocity, raising the cathode temperature and also increas-



T_1 = Audio transformer-turns ratio 1:1

T_2 = Filament transformer suitable for V_1

T_3, T_4, T_5 = Filament transformer - 6.3 volts, 1 ampere

T_6 = Power transformer - 500 volts, 60 milliamperes; 5 volts, 2 amperes

T_7 = Filament transformer suitable for V_4

T_8 = Variac

NOTE: When a thyratron is being tested, the connection at A is made to grid No.1 of the thyratron; no connection is made to the thyratron anode or grid No.2.

Fig. 2 — Basic Circuit for Making Pulse Emission Tests on Gas Valves.

ing the secondary-emission yield, and, as a result, bringing the emission back to normal. Because of this compensation, little is learned about the condition of the cathode by measurement of the voltage drop with a dc anode supply and with average current flowing.

If, however, a gas valve under test delivers a peak current several times its rated current, the rise in peak voltage drop is appreciable and is indicative of the quantity of electrons emitted by the cathode.

Such a high current cannot be drawn continuously because the anode-dissipation rating of the valve would be exceeded. The desired information can be obtained, however, when the current is drawn in short pulses and with a relatively long inter-pulse period (low duty cycle).

TABLE 1

Valve Under Test	Auxiliary Thyratron	Peak Test Current amperes	Resistor (R) ohms,	Resistor (R) watts	Valve Drop at End of Life volts, approx.
Rectifiers:					
816	5559	2	70	3	25
866-A	"	5	28	10	25
3B25	"	5	28	10	25
3B28	"	5	28	10	25
5558	"	5	28	10	25
872-A	C16J/5665	20	7	25	25
8008	"	20	7	25	25
575-A	"	30	4.7	35	25
673	"	30	4.7	35	25
5561	"	30	4.7	35	25
6894	"	30	4.7	35	25
6895	"	30	4.7	35	25
869-B	"	40	3.5	50	25
857-B	"	80	1.7	100	25
Thyratrons:					
5696	5559	0.2	700	0.5	25
884	"	1.0	140	2	25
885	"	1.0	140	2	25
2D21	"	2	70	3	25
502-A	"	2	70	3	25
2050	"	2	70	3	25
629	"	1	140	2	25
5557	"	5	28	10	25
627	"	5	28	10	25
3D22-A	"	10	14	15	25
6012	"	10	14	15	25
3C23	"	10	14	15	25
5559	"	15	9.4	20	25
5720/FG33	"	15	9.4	20	25
5728/FG67	"	15	9.4	20	25
5560	C16J/5665	30	4.7	35	25
632-B	"	40	3.5	50	25
672-A	"	40	3.5	50	25
5563-A	"	30	4.7	35	25
105	"	80	1.7	100	25
172	"	80	1.7	100	25
677	"	30	4.7	35	25
676	"	80	1.7	100	25
C1K/6014	"	8	17.5	20	50
C3J/5632	"	30	4.7	75	50
C3J-A/5684	"	30	4.7	75	50
C6J/5C21	"	77	1.8	200	50
C6J-A/5685	"	77	1.8	200	50
C16J/5665	"	160	0.87	250	50

Pulse Test Circuit

A basic circuit suitable for making pulse emission tests on gas valves in the field is shown in Fig. 2. This circuit causes the valve under test, V_4, to conduct about once a second, each conduction period lasting for only one half-cycle of the voltage from the 50-cycle supply. Such a low duty cycle permits high peak currents to be drawn without the dissipation limits of the valve being exceeded. The repetition rate is fast enough to permit observation of the valve drop on an oscilloscope.

In the circuit of Fig. 2, thyratron V_1 serves as an electronic switch to pass the test current pulse through V_4. The value of the resistor R determines the amplitude of the current pulse. Suitable values of resistance for various types of gas valves are given in Table 1. Thyratron V_2 and its associated circuit comprise a relaxation oscillator which determines the repetition rate. The output of this circuit is coupled through transformer T_1 to the grid of thyratron V_1. The repetition rate is not critical; if desired, it can be adjusted with potentiometer P_1. The low-voltage windings of transformers T_4 and T_5 are connected in series aiding so that there is 12.6 volts across the outside leads. The trigger pulse applied to the grid of V_1 should occur at the beginning of a positive half-cycle of anode voltage on V_1. Potentiometer P_2 permits adjustment of the pulse phase over 180 degrees; it may also be necessary to reverse the transformer leads of both T_4 and T_5 to obtain the desired phasing. Rectifier V_3 supplies dc voltage for the relaxation oscillator and for the bias of thyratron V_1. The choice of thyratron V_1 depends upon the test current to be drawn; suggested thyratrons for use with various valve types under test are given in Table 1. When the valve under test, V_4, is a thyratron, the connection at A is made to the grid No. 1 of the thyratron; no connection is made to the thyratron anode or grid No. 2.

Use of Pulse Test

The conditions of valve operation during test should be controlled in order to assure reproducible results. The correct cathode temperature is obtained if rated heater voltage is applied for rated heating time; five minutes is adequate for all standard types. (This time should be doubled if heater transformers having poor regulation are used). The heater voltage should be measured at the socket with a good meter; the socket and top-cap contacts should be clean and snug-fitting.

The valve drop of mercury-vapour valves, in addition to being sensitive to heater temperature, is sensitive to changes of envelope temperature. The mercury-vapour pressure is determined by the temperature of a portion of the glass envelope half an inch long just above the base. The temperature of this portion of the envelope, sometimes called the condensed-mercury temperature, rises above the ambient temperature as the valve is operated. The rate of rise of the envelope temperature, as well as the operating temperature of the envelope, depends upon valve construction and upon the power dissipated in the heater and anode. When the condensed-mercury temperature is below 20°C, the mercury pressure is less than one micron and the valve drop is so high that the cathode coating may be damaged. When the condensed-mercury temperature is 25°C or higher, each additional increase of five degrees results in a decrease in valve drop of approximately two volts. Although the time required for a mercury-vapour valve to reach "equilibrium" temperature may be from 10 to 30 minutes, a warm-up time of five minutes should be sufficient to heat the cathode and to stabilize the mercury pressure before measurement of pulse emission and peak valve drop.

The oscilloscope used to measure the valve drop must be equipped to amplify dc signals so that the instrument may be calibrated with dc voltage and a convenient and stable zero voltage axis may be established. If conventional ac oscilloscopes are to be used in this application, they must be converted for dc amplification. In ac oscilloscopes having one stage of amplification, the input coupling capacitor should be shorted and the output coupling capacitor replaced with a 180-volt bias battery (isolated from ground) and a 0.5-megohm potentiometer for vertical-centreing control. If there is no common connection between any two of the four deflecting electrodes, the centreing may be accomplished without the internal battery by applying a suitable dc voltage from a tap on the internal supply to the vertical deflecting electrode opposite the signal electrode.

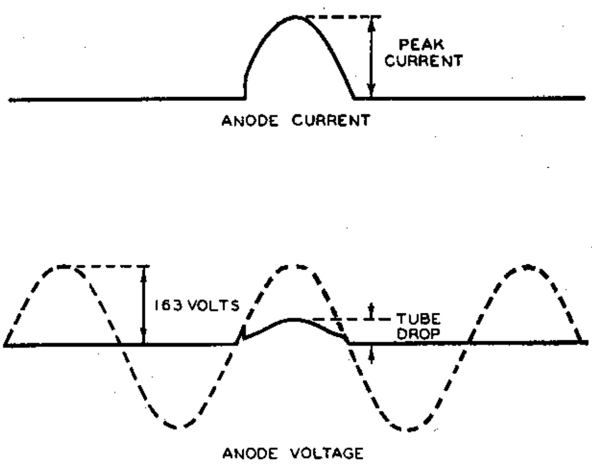


Fig. 3 — Waveform produced on Oscilloscope by a Gas Valve under test in the Circuit of Fig. 2.

The waveforms produced on a suitable oscilloscope by the circuit of Fig. 2 are shown in Fig. 3. A single half-cycle of voltage appears across resistor R when V_1 fires. The peak current can be calculated after the peak voltage across R is measured. The peak current is determined by the peak voltage, the circuit used, and the resistor specified. Because the valve drop is not sensitive to small variations in current, a fixed value of R may be used for any given valve type (see Table I). The valve drop is indicated on the oscilloscope by the perpendicular distance from the zero voltage axis to the point of the voltage waveform corresponding to maximum current flow. The value of the valve drop may be determined by substituting a dc voltage which produces the same amount of deflection on the oscilloscope.

When valves having directly heated cathodes are tested errors due to inclusion of the filament voltage in the reading can be eliminated by making all circuit returns to the centre tap of the filament transformer. When valves having indirectly-heated cathodes are tested, the return should be made to the cathode.

Evaluation of Test Results

A major advantage of a pulse test for gas valves in the field is the ease of locating "marginal" valves before failure. The operational "danger zone" of valve operation, when failure may occur at any moment, can be avoided if the emission test described in this article is utilized. The valve drop of an average gas valve at the beginning of its life ranges from 8 to 16 volts depending upon the valve type and test current. Valve drop may decrease slightly early in the service life, but it soon settles down to a nearly constant value for the major portion of the valve life. Toward the end of life, the valve drop rises, slowly at first but then at an increasing rate. When the valve drop at normal current approaches the end-of-life value, the valve may fail at any moment. In equipment in which continuity of service is important, valves having a drop approaching the end-of-life value under the test conditions shown in Table I should be taken out of service.

The peak test currents given in Table I are not critical; they may vary as much as ten per cent. or more for the purposes of this test. These current values, however, are in excess of the rated peak currents for the valves and are recommended only for pulse testing.

A suggested schedule of pulse tests in the field is at 100, 500, and 1000 hours, and at 1000-hour intervals thereafter. In general, this schedule will be sufficient to prevent excessive failure in operation; a modified schedule sometimes may be necessary to suit particular requirements.

(With acknowledgements to RCA)

SERVICING TRANSISTORIZED RADIOS

(Continued from page 209)

comes negative. A stronger input signal produces a higher negative control voltage, which drives the base of the controlled transistor less positive to reduce gain.

Provided this is remembered, the automatic gain control characteristic may be used in the conventional manner in checking sets. Checking for the presence of a control voltage when tuning through a known strong active station is a ready means of testing whether the stages up to and including the second detector are operative.

CONCLUSION

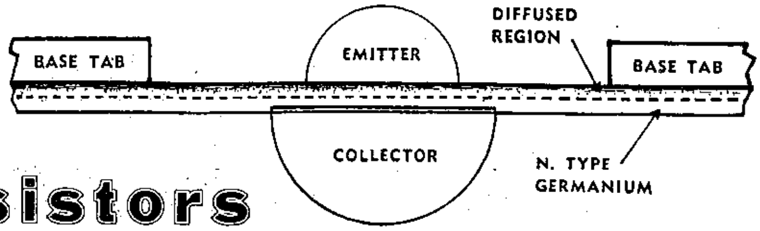
The servicing of transistorized radios raises no problems new to the serviceman, but a slight reorientation of outlook and adaption of well tried methods is required. Perhaps the small size of some of the "vest-pocket" type sets will give more trouble than the circuit and components. The use of smaller tools and soldering irons, and the use of a few precautions as outlined in this article, will make the repair of these sets no more difficult than any other type. In fact, the small size and weight of these units has already made them a popular job with many servicemen who have refused to be daunted by new ideas.

ACKNOWLEDGEMENT

The author wishes to acknowledge the kindness of various A.W.A. and A.W.V. engineers, who read and criticised this article.

HAVE YOU RENEWED YOUR SUBSCRIPTION FOR 1959?

Drift Transistors



A NEW CONCEPT IN DESIGN FOR HIGH-FREQUENCY APPLICATIONS

About the Name Drift

The word DRIFT is a well-known term in physics used to describe the motion of charged particles in ionized gases under the influence of an impressed electric field. Charged particles move much faster in a given direction by "drifting" in an electric field than they can by random diffusion in the absence of an electric field. Engineers, recognising the analogy between the drift phenomena in gaseous discharges and in semiconductors, applied the word Drift to transistors which incorporate a "built-in" accelerating field.

The electric field in "Drift" transistors, which literally propels the charge carriers from emitter to the collector, is achieved by the graded distribution of an impurity in the germanium base region. This "built-in" accelerating field, a feature not available in conventional transistor designs, results in greatly decreased transit time and therefore a much higher upper frequency limit.

The Drift Principle

The successful use of the drift field principle lies in the critically accurate control of impurity distribution in the base region during manufacture. The density of the impurity distribution in the base decreases exponentially from very high values at the emitter to low values at the collector. The impurity distribution introduces a constant electric "drift" field which accelerates (propels) the charge carriers through the base region. Compared with the performance of conventional transistors in which the charge carriers move by means of diffusion — a comparatively slow process because of its random nature — the acceleration of charge carriers by the "drift" field represents a major improvement. Because of the accelerating field in the drift transistor, the transit time of the charge carriers is substantially less than the transit time of the carriers in a conventional transistor. This results in greatly increased high frequency performance.

Drift Transistors Provide Superior Performance

The high impurity density in the base near the emitter results in a low base resistance, while the low impurity density near the collector contributes to low collector capacitance and results in a high collector breakdown voltage. The extremely low value of collector capacitance makes neutralization unnecessary in most applications and permits the design of simple and economical circuits.

The combination of low base resistance, high collector breakdown voltage, low collector capacitance, and short transit time, makes possible the design of high power gain, high-frequency circuits with excellent operating stability and good automatic gain control capabilities over a wide range of input signal levels.

Shielding Minimizes Interlead Capacitance

Drift transistors generally have four flexible leads and are hermetically sealed in metal cases. The fourth lead is connected to the case internally to minimize interlead capacitance and reduce coupling to adjacent circuit components. These important design features contribute to the usefulness of drift transistors in high-frequency circuits, particularly in those military and commercial applications where low feedback capacitance is an important design consideration.

High Frequency Applications

The use of drift transistors in high frequency applications offers the following advantages:

- Low base resistance.
- High output resistance for increased gain.
- Low feedback capacitance.
- High alpha cutoff frequency.
- Controlled input and output characteristics.
- Controlled power gain characteristics to insure unit-to-unit interchangeability.
- Rugged mechanical construction.
- Excellent stability.
- Exceptional uniformity of characteristics.

Design Benefits

Design benefits obtained by the use of drift transistors include high input-circuit efficiency, excellent high-frequency operating stability, good signal-to-noise ratio, and good automatic-gain-control capabilities over a wide range of input-signal levels.

FIELD MESH IMAGE ORTHICONS

The reputation enjoyed by EEV* 3" image orthicons P-807 and P-809 for producing TV pictures of high photographic quality is due in no small measure to the incorporation in the design of an electrode which corrects the decelerating field on the scanned side of the target. This electrode, in the form of a fine copper mesh, ensures that the decelerating field is strictly linear as distinct from the somewhat curved field in other versions of the tube. The mesh is necessarily of very high uniform transmission since the scanning beam passes through it twice, and any non-uniformities impress themselves on the beam and appear as spurious picture signals. Considerable efforts have resulted in a mesh of extremely high perfection.

The function of this so called 'field-mesh', which is located at a point of least beam interference, is to correct the approach of the scanning beam to the target by ensuring more accurate alignment of the electric and magnetic fields.

In this condition the mechanism of discharge has increased efficiency because the beam approach and deflection return path is constant over the whole scanned area. Furthermore, the displacement of the return beam from the forward path is reduced, so limiting the amount of geometrical distortion produced in the scanning section of the tube. In addition the field mesh hides the inevitable faint blemishes on the first multiplier stage which otherwise would appear on the picture.

The improved picture producing ability of the tube was recognised very quickly when the image orthicon was applied to the problem of colour television, and the success of the recent experiments in England owe much to the field mesh tube. However, the exacting registration requirements of the three tubes in a colour camera indicated a need for even better geometry and the tube was redesigned to incorporate the conventional cylindrical electrode necessary to remove the remaining slight amount of S distortion, so considerably improving the geometry.

One further feature of the new series of tubes is the re-shaping of the main electrostatic focusing field in the scanning section, so that secondary electrons from the mesh are prevented from lowering the beam modulation and upsetting the sharpness of the return beam. The tubes have in consequence a lower dc output current, so ensuring better freedom from dynode saturation, and giving a signal current of greater purity and much better resolution.

At present, two versions of the field mesh image orthicon are available, the P-807, used for all normal monochrome work, and the P-809, which has found successful applications in colour cameras. These tubes carry the provisional Jetec registration numbers 7293 and 7294 respectively.

* With acknowledgements to English Electric Valve Co. Ltd.

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As a service to our readers we publish below a list of subscribers whose "Radiotronics" are being returned "addressee unknown". These readers have apparently not advised us of changes of address. Can anyone help please?

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