RADIOTRONICS

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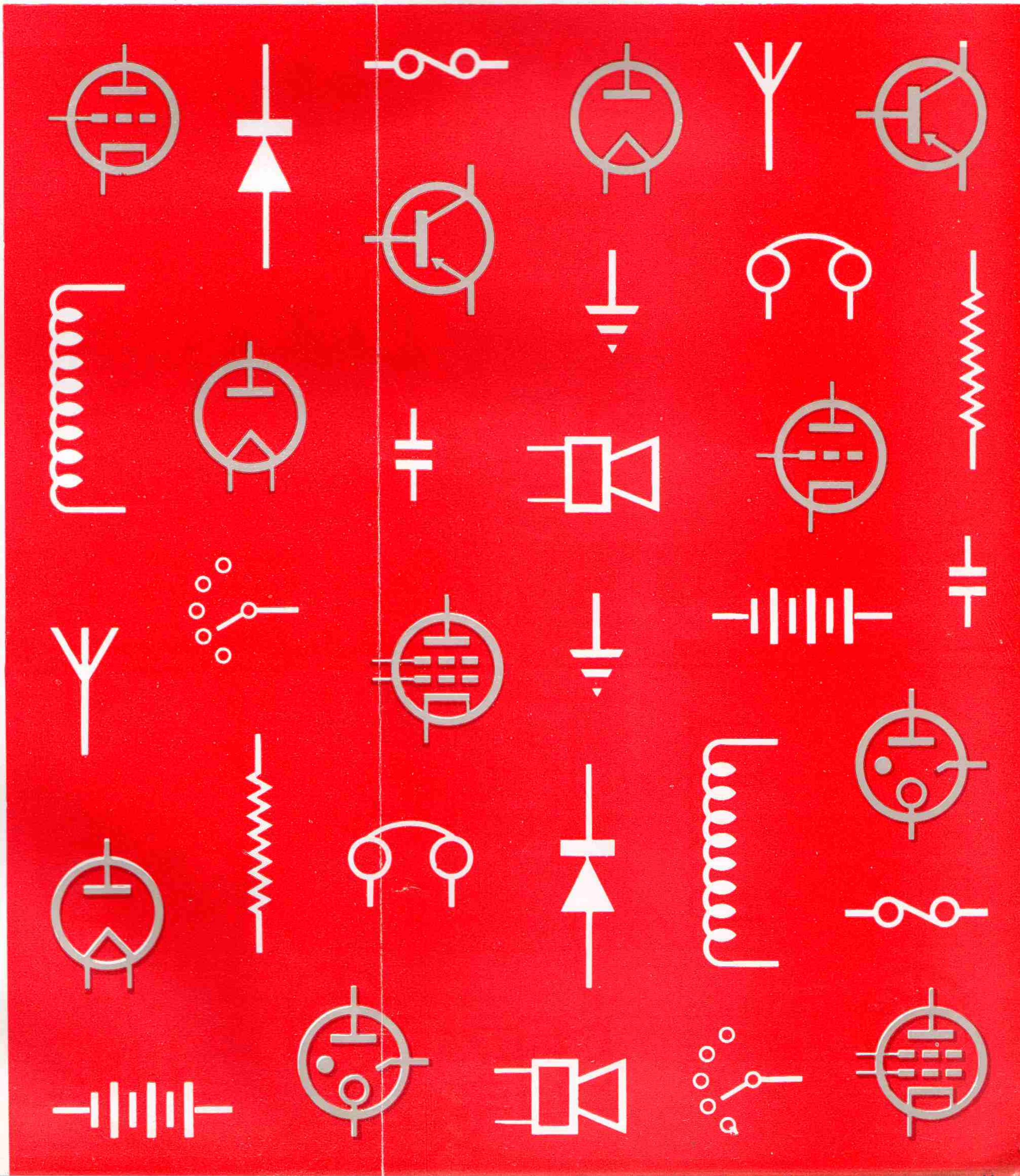

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Vol. 26, No. 9, 1961

Editor, Bernard J. Simpson

IN THIS ISSUE

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TOWARDS SIMPLER STEREO

Since stereo became an established fact, there has been considerable effort devoted to the search for a record playing setup which is simple and cheap to buy or construct. Faced with the provision of a second channel, designers and builders have devised many ingenious methods of producing acceptable (as opposed to theoretically perfect) stereo reproduction at low cost. Some of the methods used have already been discussed in these pages. This note describes a further method of providing acceptable stereo which has been the subject of a recent development by Telefunken.

Most radiogramophones available today are designed for single channel reproduction of broadcast transmissions, and two-channel reproduction of stereo records. Sometimes these units include mixing or other arrangements to use part of both channels to provide a "third" channel to fill the elusive "hole-in-the-middle".

For stereo reproduction in the type of radiogramophone mentioned, a loudspeaker for medium- and high-frequencies is arranged on one side of the receiver and fed from the output amplifier of one channel, and a similar loudspeaker is situated on the other side and fed from the output amplifier of the other channel. Where a middle or third channel is provided, the loudspeaker situated in the front or middle of the receiver is fed with only the low audio frequencies up to about 300 cycles per second from both channels via separating filters.

With such a receiver it is possible to make provision, e.g., by means of plugs and sockets, for the connection of additional external loudspeakers for the medium and high audio frequencies, one on each side of, and relatively remote from the receiver. Such an arrangement is well suited for high fidelity reproduction but is expensive.

Another known and cheaper arrangement employs a conventional broadcast receiver for one channel and a second channel limited to the reproduction of medium and high audio frequencies. With this arrangement good stereophonic reproduction cannot be obtained, as will be explained later.

The arrangement described here is designed to solve the problem of providing a cheap and at the same time good radiogramophone with two-channel operation at least for record reproduction. As with the arrangement described in the previous paragraph, the radiogramophone in this system employs a broadcast receiver and an additional external loudspeaker (or several loudspeakers) for the reproduction of the medium and high audio frequencies of the second channel. The loudspeaker of the broadcast receiver (or its low frequency loudspeaker) however is fed with the low frequencies up to about 300 cps from both channels via suitable filters, whilst this loudspeaker (or the medium/high frequency loudspeaker of the receiver) is fed with the medium and high frequencies from the first channel only.

With this arrangement in accordance with Fig. 1, one side, the right-hand side, comprises the broadcast receiver apparatus, which radiates the medium and high frequencies of one channel and the low frequencies of both channels, whilst the other (left) side embodies the additional external loudspeaker, which radiates the medium and high frequencies of the other channel. The success of this arrangement is based on the knowledge that in spite of this unsymmetrical arrangement, practically the same effect is obtained as with the known symmetrical arrangement previously described. This is because the low frequencies up to about 300 cps have little or no directional effect and do not contribute anything to the stereophonic effect.

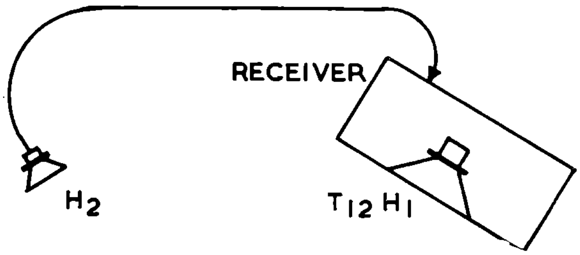


Fig. 1

Nevertheless musical instruments producing low frequencies are correctly located by the listener, because he assumes this location unconsciously, relying on the ever-present harmonics of the low frequencies.* One can support the placing of the broadcast receiver on the right because with the classic orchestra the lower-sounding instruments are generally arranged on the right, and the shrill-sounding instruments on the left. However it is possible, by changing over the pickup connections, to place the receiver on the left side.

In both cases a real stereophonic impression can only be obtained by the fact that the low frequencies of both channels are supplied to the low-frequency loudspeaker of the broadcast receiver. If on the other hand the method mentioned previously is used, using a second channel limited to the medium and high register, and with the low frequencies of the one channel only fed to the low-frequency loudspeaker of the broadcast receiver, a wrong impression is produced. This is because the sound of the low frequencies which reaches only or mainly the microphones of the other channel, is not reproduced, or is reproduced too weakly. The result is an unbalanced reproduction which many would find unacceptable.

A feature of the present arrangement is that the amplifier for the second channel (channel 2 in Fig. 2) requires a lower-power output stage than that of the first channel in the broadcast receiver, because the low frequencies of the second channel are branched off, via an R/C separating filter, from the input to the final stage of the second channel, and fed to the input of the final stage of the first channel.

This arrangement enables the use of a smaller output stage for the second channel. The chokes in the filters of the usual arrangement, when the branching is done from the output of the final valves, are not required. Such a simplification is also possible with a symmetrical arrangement of the loudspeakers as shown in Fig. 4a.

In a modification, the output of the additional channel is also used with single channel operation, as shown in Fig. 3. Examples of other arrangements are illustrated in Figs. 4b and 4c, in which unsymmetrical arrangements involving add-on loudspeakers are shown. There follows an amplified explanation of the various arrangements shown in the diagrams.

* See "Radiotronics" Vol. 24 No. 11, November 1959.

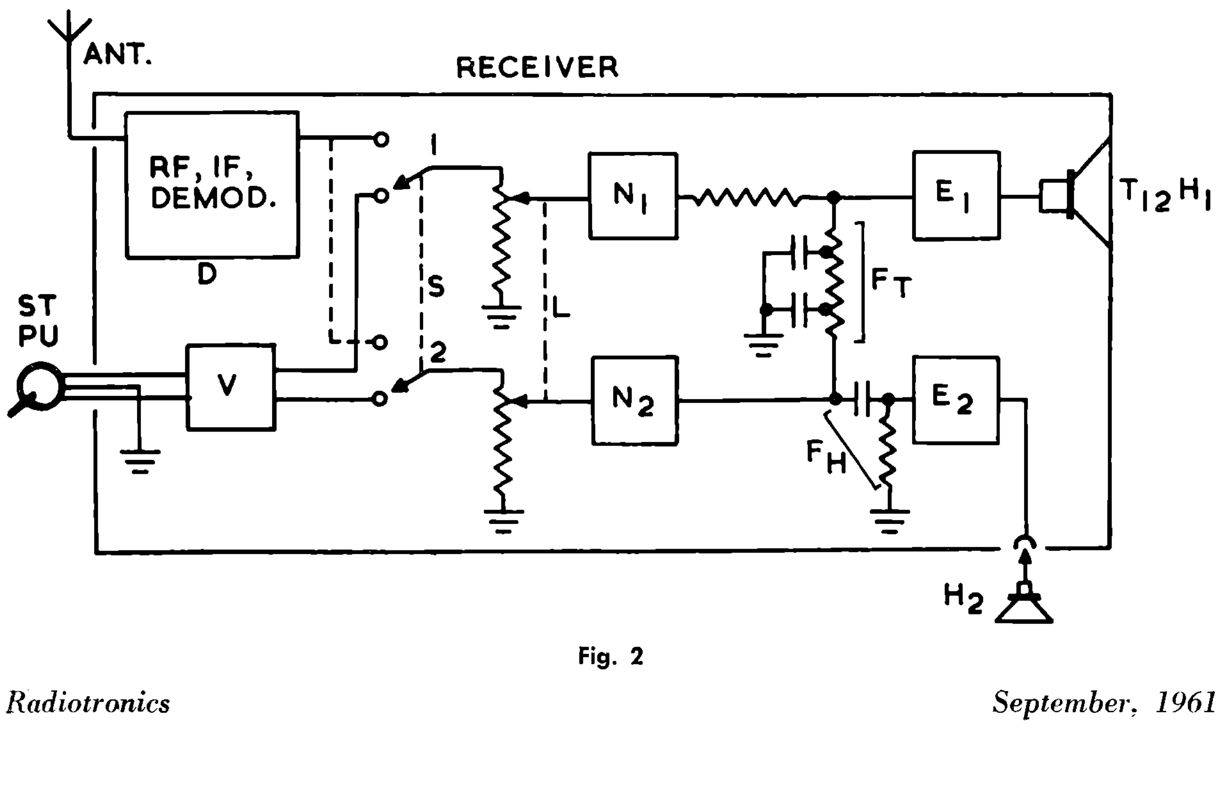


Fig. 2

In this description, for the sake of simplicity, the medium and high audio frequencies are indicated as high frequencies, so that there is only the difference between the low frequencies up to about 300 cps, and the high frequencies over about 300 cps. The low-frequency loudspeakers are indicated with reference T. Reference T_{12} indicates that the low-frequency loudspeaker is fed by both channels 1 and 2. The high-frequency loudspeakers are indicated with reference H. Reference H_1 indicates a high-frequency loudspeaker fed by channel 1, and H_2 a high-frequency loudspeaker fed by channel 2. A loudspeaker designated $T_{12}H_1$ is one which handles the low frequencies of both channels 1 and 2 and the high frequencies of channel 1.

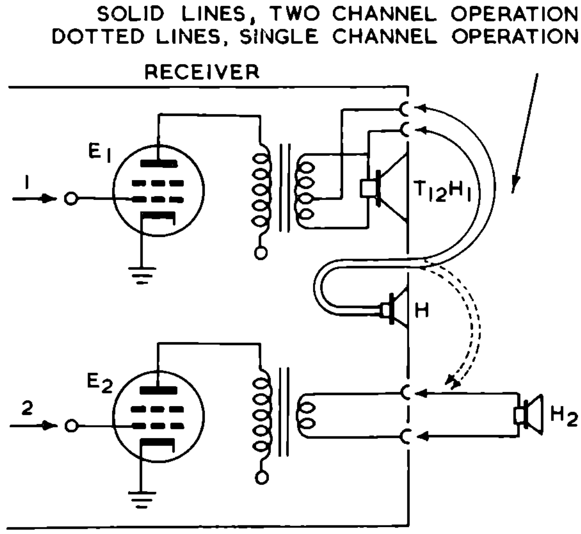


Fig. 3

In Fig. 1, the receiver is shown on the right, and in this example it contains only a single loudspeaker designated $T_{12}H_1$. The high-frequency loudspeaker H_2 positioned on the left is connected by a line and plug connection with the receiver. As already described above, such an unsymmetrical arrangement has pactically the same effect as a symmetrical arrangement, because the low frequencies have no directional effect. The advantage of this arrangement is not only its low cost, but the fact that less space is required.

Fig. 2 shows the circuit for carrying out the arrangement shown in Fig. 1. The radio receiver contains a mixer stage, if section and demodulator. At the lower left hand side the stereo pickup ST is connected to a preamplifier. A switch S follows which in the illustrated position is switched for stereophonic record reproduction. In the other position of the switch, at least channel 1 is connected to radio receiver D. Both channels are controlled in the usual way by a double volume control L. In each channel there is a low-frequency input stage N_1 and N_2, followed by an output stage, E_1 and E_2.

The low frequencies of channel 2 are supplied to the output stage E_1, so that they may be radiated from the loudspeaker $T_{12}H_1$ of the receiver. The filter F_H on the other hand passes only the high frequencies to the output stage E_2 and loudspeaker H_2. In the output stage E_2 a valve of small power is provided because it has to handle only the high frequencies above 300 cps.

The arrangement of Fig. 3 differs from Fig. 2 only in that a high frequency loudspeaker H is provided in the receiver itself, on the front of the cabinet. When only single-channel operation is desired, the additional external loudspeaker H_2 is disconnected; this however means that the channel 2 output valve E_2 is not used. To make use of this valve with single-channel operation, the additional loudspeaker H is built into the receiver; the leads to this loudspeaker can be connected to the upper sockets for two-channel operation or to the lower sockets for single-channel operation.

If the additional loudspeaker H_2 is disconnected, the audio power of the output valve E_2 is used to energise loudspeaker H. If the loud-

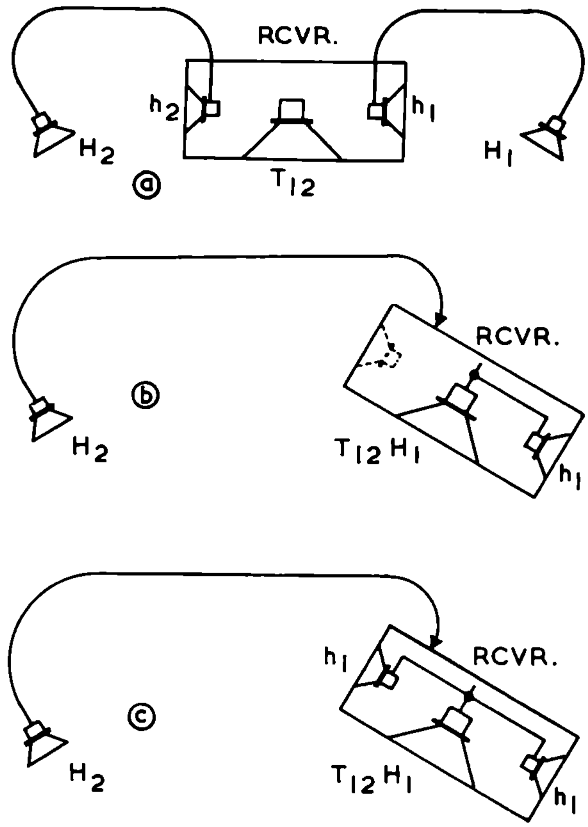


Fig. 4

speaker H_2 is used, the leads to loudspeaker H are changed over to the upper sockets for two channel operation.

In Fig. 4a the previously-described known symmetrical arrangement is shown. The loudspeaker T_{12} is fed with the low frequencies from both channels, whilst the external separate loudspeakers H_1 and H_2, and the built-in loudspeakers h_1 and h_2, are fed with the high frequencies. The receiver may be provided with a switch or other change-over arrangement to allow selection of conditions of use in the unsymmetrical arrangement. when for example, space is insufficient, or only a single additional loudspeaker H_2 is desired. The switch may be connected in such a way that it permits three types of loudspeaker connections.

Firstly, the broadcast receiver may be situated in the centre, as shown in Fig. 4a. As an alternative the receiver may be placed on the right side, and a stereo additional external loudspeaker is placed on the left. In this case the high-frequency loudspeaker mounted on the left side of the receiver, and radiating to the left, must be either switched off (as shown dotted in Fig. 4b) or switched over to channel 1, as shown in Fig. 4c.

Also with the arrangement shown in Figs. 4b and 4c the high frequencies of channel 1 must be radiated towards the front by the low-frequency loudspeaker, as shown by the loudspeaker connections. For this purpose the low pass filter belonging to channel 1 is switched off or shorted out.

As a further alternative, reversing the sides of the receiver and satellite speaker(s) is possible. The receiver of Fig. 4a may be provided in the usual way with two equally-powerful output valves and with separating filters after the output valves. It is however possible, as previously mentioned, to provide only a weak output valve for channel 2 in accordance with the connections shown in Fig. 2. Then the built-in high-frequency loudspeaker h_1 (Fig. 4) and the external loudspeaker H_1 must be connected to the output of the valve E_1 via a high-pass filter. Further, the built-in loudspeaker h_2 must be connected to the output stage E_2.

(With acknowledgements to Telefunken)

PREMIER AMERICAN AWARD TO BRITISH COMPANY

The American National Academy of Television Arts and Sciences has awarded an "Emmy" for the year 1960-61 for outstanding engineering technique to the English Electric Valve Co. Ltd., Marconi's Wireless Telegraph Co. Ltd. and RCA for the independent development of the 4½" image orthicon television camera and pick-up tube.

An "Emmy" is the television equivalent of a motion picture "Oscar" and the engineering technique award is one of twenty-four categories, including best actress, actor and supporting players, etc. Mr. W. E. Turk, manager of the Photo-electric Tubes Division, received the award, which is one of the premier honours which America can bestow in the field of electronics, on behalf of the English Electric Valve Co. Ltd. The awards, which have immense prestige value, were made on an NBC-TV programme and it is estimated by one American writer that 100,000,000 viewers will have watched the show.

An early version of the 4½" image orthicon was developed by RCA but did not proceed beyond the laboratory stage. Further work was undertaken by the English Electric Valve Co. Ltd. and Marconi's Wireless Telegraph Co. Ltd., who pioneered the commercial development of the tube and the camera respectively. The success of the Mark III 4½" orthicon camera led to the development of the Marconi Mark IV camera also using English Electric pick-up tubes. This latter combination consolidated the 4½" image orthicon, which is widely used in studio and outside broadcast channels throughout the world and has proved very successful in Videotape equipments.

CAUSE OF THE MINORITY CARRIER STORAGE EFFECT IN SEMICONDUCTOR DIODES

When a semiconductor diode is operated in the forward direction, a certain current flow is established, corresponding to the applied voltage. That is, a charge distribution will occur inside the diode as illustrated in Fig. 1.

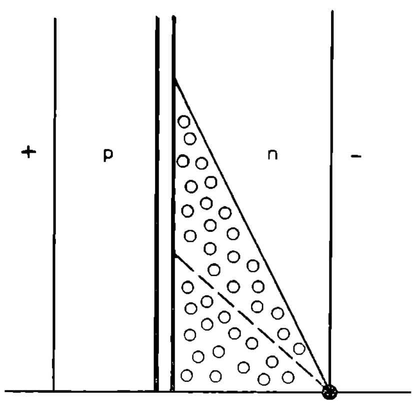


Fig. 1—Diffusion triangles for different values of forward current.

A reduction of the external applied voltage results in a change to the diffusion triangle. This is shown by the dotted line in Fig. 1, and indicates a change in the value of the current flowing through the diode.

It will be seen from this that a reduction of the externally applied voltage flattens the diffusion triangle. This implies that, at the moment of voltage change, an excess charge inside the diode must be transported away before the diffusion gradient can adjust itself to the value corresponding to the new voltage. The current flow therefore lags somewhat behind the voltage.

Applying a voltage to a diode so that it is operated once in a forward direction and once in a reverse direction will influence the carrier storage present in the diode through its current in such a way that in the reverse direction a current pulse appears instead of the expected very low reverse current. This current pulse is a multiple of the normal static reverse current.

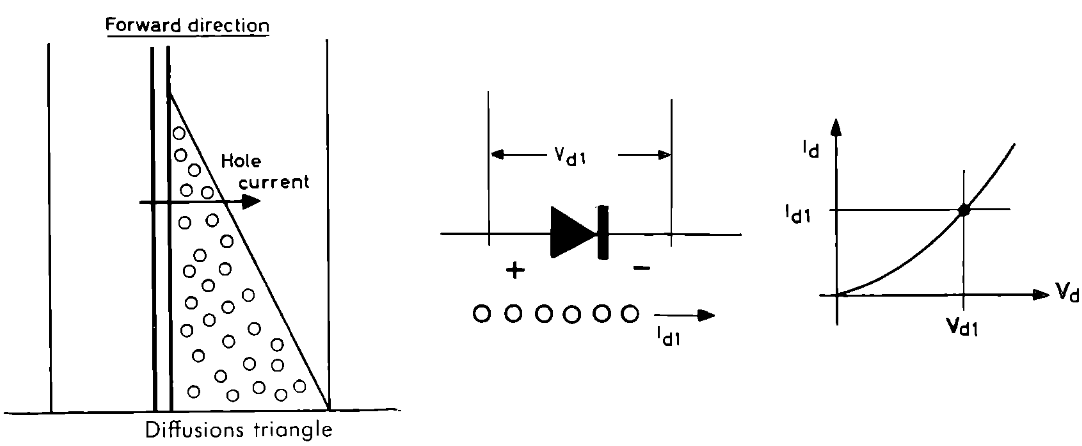


Fig. 2—Forward conduction through a diode.

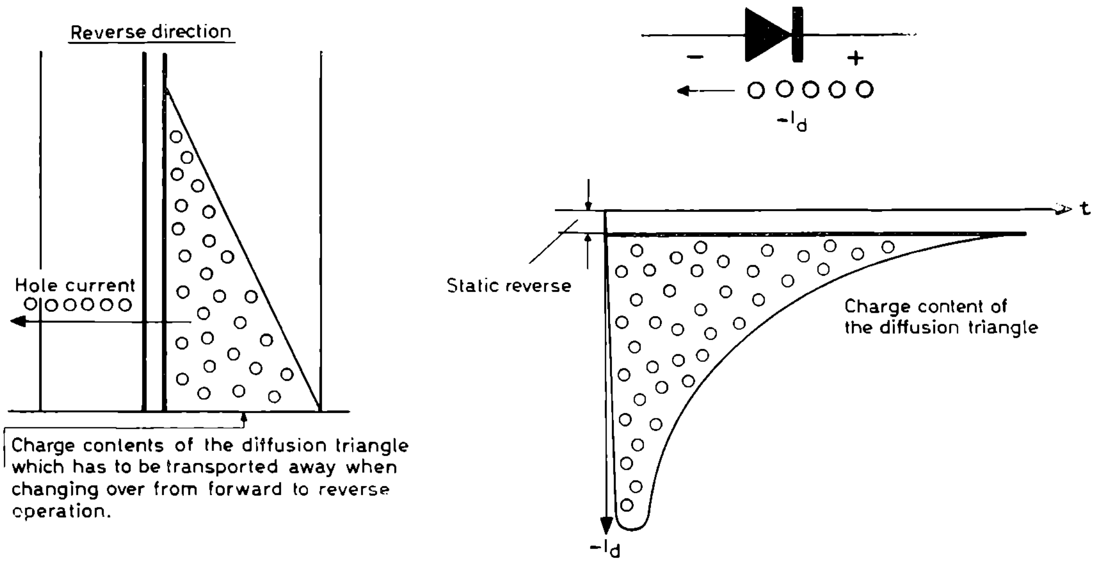


Fig. 3—Reverse current through a diode following forward current flow.

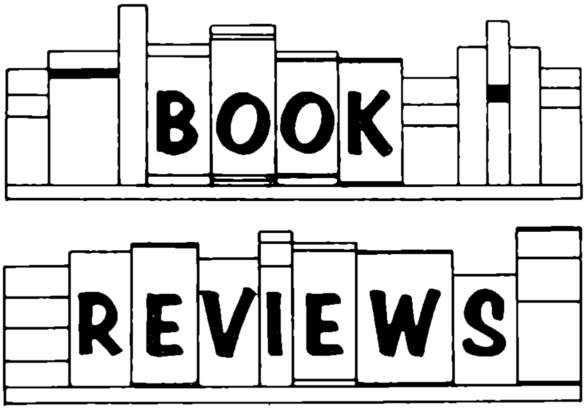
The current pulse decays exponentially, and only reaches the static value of reverse current after some time. This is quite understandable in view of what has already been said, because the charge carriers caused by the current have first to be transported away. (See Figs. 2 and 3.)

The time required for this purpose depends in the first instance on the characteristics of the material. They influence the life of the charge carriers, which is much larger in the usual junction diodes than in point-contact diodes. Further, the comparative quantity of charge carriers is much larger in junction diodes than in point-contact diodes.

(With acknowledgments to Telefunken.)

NEXT MONTH

Next month we hope to publish the first of a series of constructional articles now under preparation for the pages of this magazine. The first to appear will meet the demand for a low-cost stereo music system to provide acceptable reproduction from records. It is proposed to detail the complete system including amplifier, record player and pickup, loudspeakers and their enclosures. It is intended that future articles will deal with amplifier systems of greater quality, complexity and cost, and also with other types of apparatus, including test equipment.



Books reviewed in these pages (except AWV publications) are complimentary copies received direct from the publishers. All enquiries for these books should be directed to your local technical booksellers, and not to AWV.

"HOW TO FIX TRANSISTOR RADIOS AND PRINTED CIRCUITS," L. Lane. Gernsback Library Inc. Two volumes, each 160 pages. Size 5½" x 8½". Copiously illustrated.

The basic plan of this two-volume production is that theory is covered in the first volume and the practical applications and servicing techniques in the second volume. The book is a revised version of a transistor radio repair course offered by a famous American set manufacturer. The text is specifically aimed at the serviceman and technician. Where possible mathematics have been omitted to make for easier reading. The text is eminently readable, the techniques and circuits described are up to date and the coverage of the subject good. Even such later developments as the transistorised car radio are covered, both in the hybrid form and in the more recent all-transistor form. It would be interesting to know, today, what percentage of radio service jobs in this country (excluding TV) are concerned with transistor radios. The figures could be surprising.

"ABC's OF RADAR," Alan Andrews. Howard W. Sams and Co. Inc. Size 8½" x 5½". 112 pages. Well illustrated.

There are many students and others who have had no opportunity to familiarise themselves with the techniques grouped together, today, under the general heading of "radar." This book assumes little prior knowledge on the part of the reader and sets out to explain the fundamentals of radar in simple and understandable terms. In a book of this size, of course, it is possible only to cover the fundamentals, leaving the detailed study and analysis to others. It is amazing, however, to note how even the simplest basic knowledge of some of the techniques used widen the reader's outlook. Further, radar, today, is reaching into many fields other than defence, typical applications being in speed timing, traffic control and weather detection.

"HI-FI STEREO HANDBOOK," W. F. Boyce. Howard W. Sams and Co. Inc. Second Edition. Size 8½" x 5½". 288 pages. Well illustrated.

This is a revised and enlarged edition, brought up to date on the latest equipment and techniques. The book is intended as a reference and guide for those interested in high-quality sound reproduction. The subject is covered from the idea of fidelity through the various processes and equipment to the final reproduction. A useful chapter is included on the selection and installation of systems. This book would be particularly valuable to the newcomer to high fidelity, presenting as it does a very complete picture of the entire field of endeavour.

"TRANSISTORS," various authors. Gernsback Library Inc. Size 8½" x 5½". 96 pages, 65 diagrams and illustrations.

Constructors and experimenters will find this book interesting. It is a collection of selected and edited articles from the U.S. magazine "Radio-Electronics." The articles chosen for inclusion fall into two categories, those on building transistor testing equipment and those on constructing various useful and interesting units of transistorised test equipment.

The sub-title of the book sums up its objects, "How to test them, how to build all-transistor test equipment." The units covered in the book include a power transistor checker, a direct-reading transistor tester, a laboratory-type transistor tester, noise squirter, TV bar generator, scope calibrator and several others.

"PRINCIPLES OF SEMICONDUCTORS," M. G. Scroggie. Iliffe Books Ltd. Size 8½" x 5½". 156 pages. Well illustrated.

A book by the famous Mr. Scroggie must always invite attention. This book is intended to provide sufficient basic theory to form an

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Important Notes on Handling Transistors and Diodes

When using transistors and diodes a number of precautionary measures must be taken to prevent damage to the devices during assembly in equipments, setting in operation and circuit testing.

Mechanical

Under no circumstances may the terminal wires be bent immediately in front of the glass seal because the glass may easily crack due to the mechanical strain (Fig. 1.a) and thus cause early, in some cases immediate, destruction of the diode or transistor. If bending near the glass seal is absolutely unavoidable then the wire must be gripped with a pair of pliers near, but not touching, the glass seal (Fig. 1b) and bent on the side away from the glass.

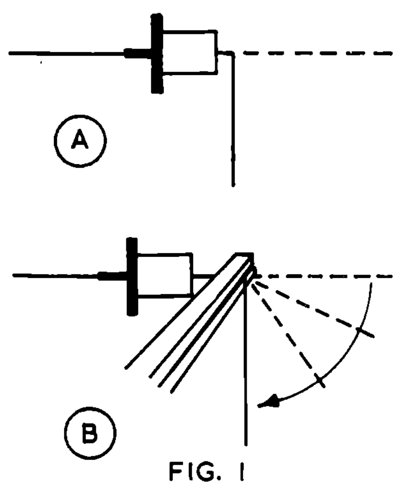

FIG. 1

Thermal

During operation the temperature on the barrier layer of germanium devices must not exceed about 75°C if value is attached to long life. This temperature dependence means that germanium semiconductors should not be fitted near parts radiating heat, mains transformers, valves, highload resistances and the like.

When semiconductors are not connected such as during storage, assembly etc., the maximum admissible temperature to which they may be exposed is of the order of 90°C. This temperature must never be exceeded. Maximum operating and storage temperatures are specified by makers.

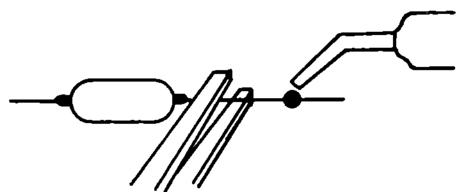
FIG. 2

In order to prevent over heating of the semiconductor when soldering a connection, it is highly recommended that the device be soldered as near the wire end as possible. Otherwise, and it is most important the nearer the soldering point is to the seal, the connecting wires must be held between the soldering point and glass bulb with a pair of pliers, preferably with a copper nose (Fig. 2), to ensure adequate heat dissipation.

In general it is advisable to use a medium size, well heated soldering iron. Due to the higher heat capacity of this soldering iron soldering should be far quicker than when a small, relatively warm iron is used. Hence, the amount of heat arising at the soldering point is less and thus less dangerous. The amount of heat transferred to the semiconductor is however still dependent on the skill of the operator.

It has been repeatedly observed that too little attention is paid to the dissipation of heat generated on the barrier layer, particularly in respect of power transistors and diodes. The dissipation ratings shown on manufacturers' data sheets apply in the event of a thermal short-circuit between the cooling area of the device and the surrounding medium (air as a rule). In practice this can never be completely achieved. It can be approached as far as possible by fitting a metal heat sink in so far as permitted by design considerations. Therefore, at a given dissipation rating, the size, thermal conductivity and cooling property of this surface must exceed certain minimum values which can easily be ascertained for all cases from the customary leaflets published by companies manufacturing semiconductors. For the same reason, during assembly care must be taken to ensure optimum thermal contact between the semiconductor and the cooling area and, finally, that temperature-stabilizing components such as thermistors are mounted near the heat-generating semiconductor.

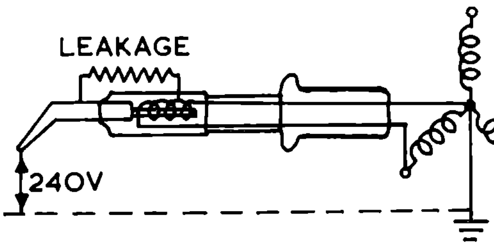

FIG. 3

Electrical

Since in most cases diodes and transistors are designed for low voltages, care must be exercised when employing them that these values are not accidentally exceeded. This is most likely to happen during soldering with an iron short-circuited between heater and tip (Fig. 3).

If the unit with which the defective iron is being used is connected to ground, then a strong current flows from the mains line into the chassis through part of the circuit via the leak in the soldering iron.

It is even possible that elements not situated in the direct path of the current will be destroyed or damaged as shown in Figs. 4a and 4b.

Grounding the soldering iron is the best precautionary measure but if this is impossible the transistor or diode can be insulated.

A very reliable method of preventing electrical destruction is to short-circuit the diodes or transistors during soldering by means of a wire with clips or a similar expedient as shown in Figs. 5a and 5b.

Testing

Similar precautions must be taken when testing semiconductors or circuits containing such devices. If, for example, a transistor or diode is being tested in respect of diode conductivity, no test units may be utilized that supply voltages and currents higher than the specified ratings of the devices being tested. In circuits where the test set, signal generator or similar unit is grounded, the device being tested must be insulated or other suitable means must be employed to ensure that the semiconductor concerned is not subject to excessive voltages or currents.

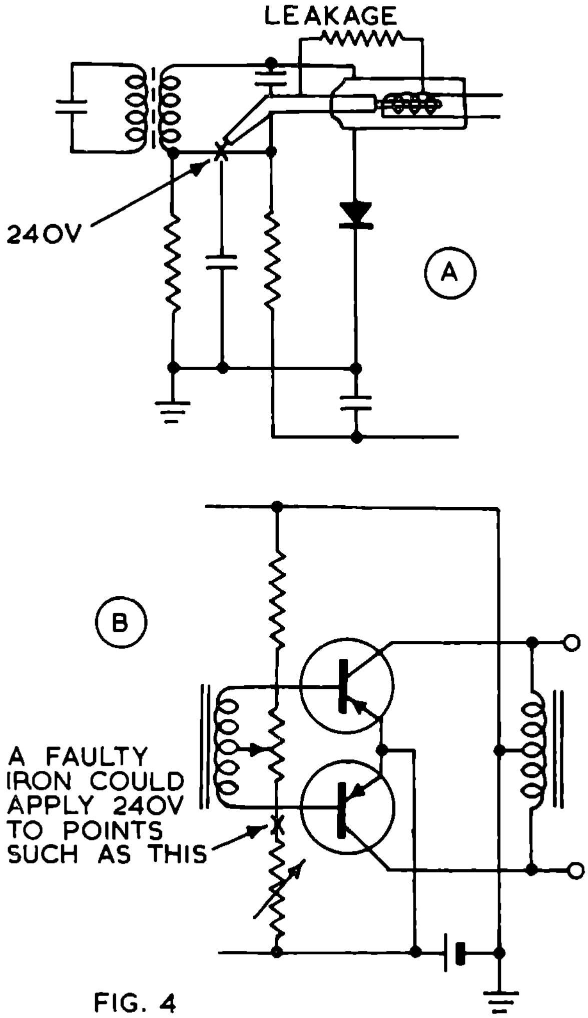

FIG. 4

A fact often overlooked during such tests, and which may easily cause damage to the transistor, is the "open base-emitter". In the relevant data sheets a maximum admissible collector-emitter voltage is stated which, as a rule, does not apply for the open base but represents a minimum conductance between base and emitter. If this conductance is too low or the resistance between base and emitter is higher than stated, then the maximum permissible voltage between collector and emitter is lower than specified and the transistor can be destroyed if the test voltage is not reduced accordingly. Under certain circumstances, as with an open-circuit base connection, the base-to-emitter resistance will be very high indeed.

An "open base" condition may also occur the moment the apparatus is switched on or at the peak value of a pulse if an inductance of a certain minimum value has been inserted between base and emitter. If a correspondingly high voltage is required between collector and emitter, the inductance must be by-passed by a resistance.

A further factor must be taken into consideration in the adjustment of no-signal currents in push-pull B output stages. If the milliammeter, having a measuring range suitable for the relatively-low no-signal currents, is connected in the emitter line (in accordance with the usual procedure when measuring no-signal currents in the cathode line of valve stages) then a voltage drop ΔV_{BE} occurs in the measuring instrument, whose internal resistance is not negligible, and reduces the effective base bias (Fig. 6). In this way an incorrect (too low) emitter current is indicated. When the instrument is removed the base bias returns to its original value and a far higher emitter no-signal current results. However, this error can be obviated in every case by coupling the instrument to the collector line when checking the emitter no-signal currents.

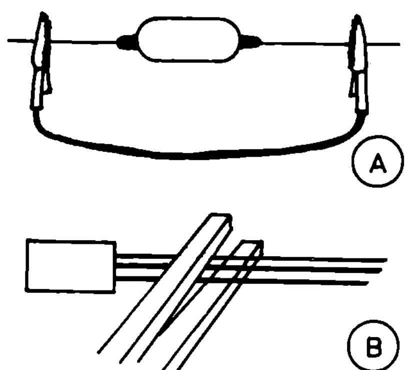

FIG. 5

Insulation

When mounting semiconductors with a metal case it must be ascertained whether the system and case of the type concerned are connected electrically. As a rule the electrodes of pre-amplifier stage and small power-stage transistors with up to about 400 milliwatts power dissipation and diodes predominantly used for demodulation purposes are insulated from the case. In the interests of better heat dissipation the case of larger-power transistors and diodes is generally connected to the collector or cathode. In this event care must be taken that the metal semi-conductor case cannot make contact with the chassis, suspended wires, shielded cables etc. where they are not connected to the same potential. Such contact would

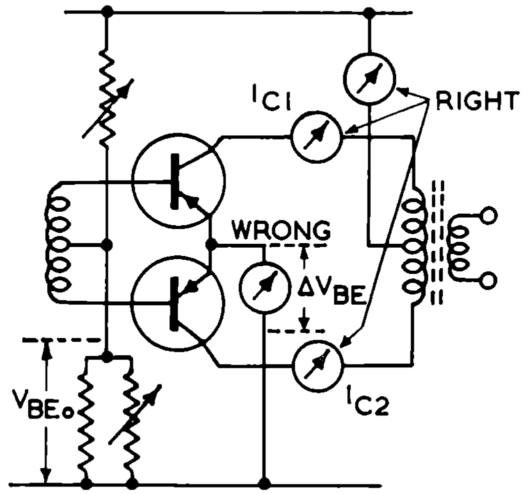

FIG. 6

result in destruction of the semiconductor or short-circuits in the wiring, since as a rule the case coating is not sufficiently resistant to frequent contact, and cannot be relied upon for insulation. Some power types of transistors are fitted with a base plate insulated from the case. These transistors can be fitted directly on the metal chassis.

Photo-electric sensitivity

In consequence of the photo-electric effect on the barrier layers of transistors and diodes, exposure to light causes the operation point to shift. When the barrier layer is exposed to a light source fed by direct current—and daylight too—the gain varies, whereas exposure to alternating light—lamps fed with ac—will cause modulation of the signal to be amplified. Care must be taken therefore that the opaque coating of semiconductors in glass capsules is not scratched since, for example, amplifiers whose sensitive input transistors are fitted near a scale lamp, may easily pick up hum. This does not of course apply with metal-cased units.

Dip soldering of printed circuits

The thermal stress to which semiconductors are subjected during dip soldering is determined by the thermal capacity of the chassis and the adjacent metal parts, above all the wiring. After removal of the printed plate from the solder bath, considerable heat flows from these parts into the transistors and diodes and the temperature of the barrier layer rises even after the actual soldering operation has been completed. The following recommendations are based on thorough measurements:

The distance between the surface of the solder bath and the stem-press (lead entry) of the transistor must not be less than 5 mm.

Normally a dip of three seconds is sufficient to ensure satisfactory connection provided the solder point has been properly prepared beforehand. The dip may last a maximum of five seconds, assuming a solder bath temperature between 230 and 250°C.

After removal from the bath the entire unit must be cooled in a stream of cold air in such a manner that it reaches normal ambient temperature again after about ten seconds.

Repeated dipping with insertion of prints is unsuitable because, as described above, the temperature on the barrier layer rises to maximum a short time after completion of the soldering operation and it would rise even further by dipping again shortly afterwards.

These recommendations should always be checked against manufacturer's data, and considerations such as very high ambient temperatures may require modifications of the procedure.

(With acknowledgements to Telefunken)

BOOK REVIEWS

(Continued from page 164)

introduction to the more advanced literature on semiconductors and is aimed at the newcomer to semiconductors. Not only does the book present sufficient basic theory for the purpose, but also explains the special properties of semiconductors and how they are applied to many kinds of device.

It is worth mention that this book has also appeared in the U.S.A. under the title of "Fundamentals of Semiconductors," Gernsback Library Inc.

HIGH VACUUM VARIABLE CAPACITORS

One of the first applications of the new EEV U200/10 vacuum capacitor is in the grid circuit of the penultimate rf stage in one of the B.B.C.'s high frequency transmitters at Daventry. The vacuum capacitor, which has a capacitance of 5.5 to 206 pf and overall dimensions of 9.5″ x 3.5″, replaced a conventional 5 to 37.5 pf air dielectric capacitor which was 12″ long x 4″ square. The extra available capacitance has meant that only one coil change is required to tune the transmitter from 21 Mc to 6 Mc. Beside the circuit advantages of a high maximum peak rf voltage (10 Kv) and a high maximum rf current (20 amps rms) the vacuum capacitor has the practical advantage of not being affected by atmospheric dust.

The accumulation of dust on the plates of an air dielectric capacitor can cause flashover, but as the vacuum capacitor is completely sealed, internal flashover from this cause cannot occur. The capacitor plates are in the form of two sets of concentric cylinders and their relative axial positions are controlled by the rotation of a shaft at one end of the capacitor. Accurately machined screw threads are employed to obtain an axial movement for expanding or contracting metal bellows which transmit the motion directly to one set of cylinders. The inner surface of the bellows is at atmospheric pressure and the outer surface at a very high vacuum.

The nature of the construction ensures that an approximately linear capacitance law is obtained over the specified range which can be extended slightly in both directions, although fringe effects do result in a slight deviation from linearity in the latter regions. The compactness permitted by the use of a vacuum dielectric does however keep the fringe effects and self inductance to a lower level than could be obtained with an air dielectric type of comparable capacitance. U200/10 vacuum capacitors have also been ordered for use in six high frequency 100 Kw transmitters at the B.B.C. transmitting station at Skelton.

At present the EEV series comprises five types covering the capacitance ranges 5 to 30 pf, 16 to 80 pf and 5.5 to 206 pf; this will be extended to meet future demands for other capacitance or voltage ratings.

AWV