DEVELOPMENTS IN RADIO RECEIVERS AND TAPE RECORDERS
1964–65

THE first all-transistor domestic stereo radiograms appeared on the U.K. market during this period. Higher power complementary pairs of transistors and the first silicon transistors for entertainment equipment were also introduced. Developments of interest to service engineers also took place in tape recorders and with pick-ups and tone arms. These and other developments are described in this section.

TRANSISTOR STEREOGRAMS

All-transistor stereo radiograms, record players and high-fidelity audio equipment for operation from A.C. mains and providing sufficient output for normal domestic use were introduced on the U.K. market during the year under review.

Many of the designs make use of the wider range of complementary-symmetry (matched pairs of *n-p-n*/*p-n-p* types) transistors becoming available. Apart from the popular combination of AC127/OC81 and NKT753/NKT271, matched complementary symmetry pairs include the AC157 (*n-p-n*)/AC154 (*p-n-p*), the AC176 (*n-p-n*)/AC128 (*p-n-p*), the AC168 (*n-p-n*)/AC166 (*p-n-p*) and the AD161 (*n-p-n*)/AD162 (*p-n-p*) combination; the last pair is suitable for output powers of up to about 5 watts, or to about 15 watts by using two AD161 and two AD162 in a " bean-stalk " arrangement.

Where a complementary-symmetry pair of sufficient output power is not

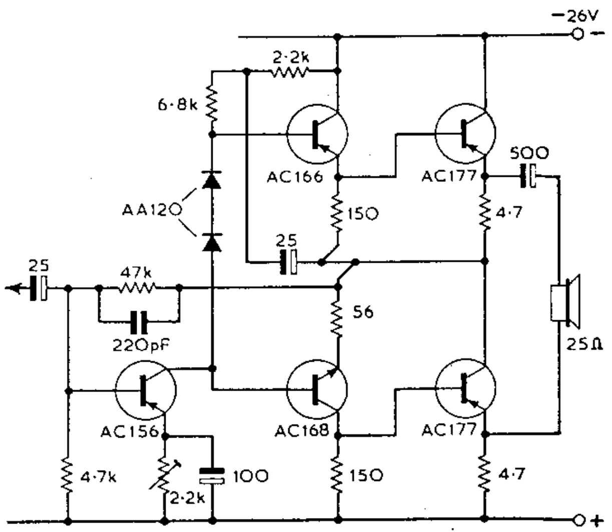

FIG. 1.—A.F. AMPLIFIER USING A COMPLEMENTARY-SYMMETRY DRIVER STAGE (AC166/AC168), FROM A THORN–A.E.I. DESIGN.

The complementary symmetry driver stage is followed by a pair of AC177 transistors in a transformerless output stage. The AA120 bias stabilising diodes are incorporated in the collector circuit of the first A.F. stage (AC156).

used, a D.C.-coupled transformerless circuit is still possible using a complementary-symmetry driver stage followed by two *p-n-p* power transistors as the actual output pair. This arrangement is used in a number of hi-fi amplifiers and radiograms; a representative 2-watt all-transistor amplifier using this technique is shown in Fig. 1.

This technique requires an audio driver stage to precede the complementary driver stage and the output pair, usually with all stages D.C. coupled. In effect the output and complementary transistors form what are termed " super alpha " pairs (Darlington compound). For domestic equipment this arrangement is likely to give way eventually to the complementary output stage as transistors of greater power rating and gain become available.

R.M.S. and " Music " Ratings

The standard practice in the U.K. in regard to the rating of audio output stages has been to rate the stage according to the maximum possible sustained R.M.S. output power for a specified degree of permissible distortion. This is measured by applying a sine-wave input to the stage and measuring the output.

Critics of this system have long pointed out that sine waveforms are seldom encountered in nature (a sustained whistle being the nearest approach) and that the maximum possible undistorted output on the spiky waveforms of normal speech and music is usually appreciably greater than the r.m.s. rating; this is because of deficiencies in the regulation of the supply voltages to the valve electrodes. Since, in practice, an output stage is called upon to deliver high output only for short periods of time before the drop in voltage makes itself felt, these deficiencies in regulation have much less effect upon normal signals than would be suggested from measurements with sine-wave signals.

This argument led to the general adoption in the United States some years ago of an alternative form of output stage rating, the so-called " music " rating which can roughly be regarded as the output which would be delivered with a sine-wave input were the stage being operated with perfectly regulated supplies. While this rating gives a more realistic idea of the maximum power handling capabilities of the stage, it is considerably more difficult to measure or check. One method is to measure the stage under sine-wave conditions using special supply sources equivalent to those normally used with the stage but with a high degree of voltage stabilisation.

This form of rating is considered by some engineers to be particularly suitable for the rating of transistor audio equipments which are often capable of handling appreciable " music power " but which provide only modest sine-wave output when operated from the associated power supplies without introducing distortion. For this reason, a number of British firms now tend to use " music ratings " in their performance specifications.

SILICON TRANSISTORS

Until 1964, the transistors used for entertainment equipment in the U.K. were of germanium type, although the more expensive silicon transistors have been used for industrial purposes for a number of years. Improved manufacturing processes have reduced the price gap between the two types of transistors, and advantage is now being taken for some purposes of the improved characteristics of silicon types: typically for V.H.F./F.M. tuners; for car radios; for low-noise pre-amplifiers; and for some television receiver applications, etc. Silicon planar transistors, for example, have been used in the V.H.F. tuner units fitted to the all-transistor stereo radiograms marketed during 1964 by the Thorn group of companies.

As an example, the BF115 is an *n-p-n* silicon R.F. transistor which can be used in lieu of the AF117 *p-n-p* transistor for radio receivers. Compared with the AF117, the BF115 has lower feedback capacitance (about 0·7 pF. compared with 2·4 pF.) enabling greater stage gains to be achieved without affecting stability; the low knee voltage permits an improved A.G.C. characteristic to be obtained; it has better resistance to voltage surges; and considerably better operation at high temperatures. Noise performance is also satisfactory, permitting high sensitivity to be achieved. A proposed car radio design uses one BF115 as a permeability tuned R.F. amplifier, another BF115 as a self-oscillating mixer, and a third BF115 as an I.F. amplifier.

Another suggested application for the BF115 is to use four of these devices in the R.F./I.F. stages of a mains-operated A.M./F.M. receiver: two transistors are used for the V.H.F. tuner unit; one as an A.M. frequency changer or 10·7 Mc/s. I.F. stage; and the fourth as a dual-I.F. stage. Only a minimum of switching is needed to change from A.M. to F.M. operation.

The BC107 *n-p-n* silcon transistor is intended for low-noise, high-gain stages such as A.F. pre-amplifiers in much the same way as the earlier AC107 *p-n-p* germanium transistor. It can be expected that these transistors will be used for the first stage of tape recorders, etc.

Silicon transistors provide no new problems for the service engineer, since they are basically a more rugged development of the existing germanium transistors. However, it should be noted that many of the entertainment silicon types introduced during 1964 are *n-p-n* rather than *p-n-p* types. This again emphasises the need to check transistor types before undertaking servicing of transistorised equipment.

Another future possibility for the R.F. amplifier stage of car radio receivers and other consumer applications is the use of unipolar field-effect transistors (FET) or the basically similar metal-oxide semiconductor transistors (MOST). These devices are more closely akin to valves, in having very high input impedances compared with conventional transistors.

SEMICONDUCTOR CODE

A standard European code for semiconductor devices is coming into general use and helps to identify the general type of component from its type number.

Under this code, germanium devices such as transistors and diodes always begin with the letter *A* (AF117, etc.) whereas silicon devices begin with the letter *B* (BY100, BF115, etc.).

The second letter of the type number gives the general construction and application: *A*, diodes (except certain special types which have their own identification letter); *C*, A.F. transistors other than power types; *D*, A.F. power transistors; *E*, tunnel diodes; *F*, R.F. transistors other than power types; *L*, R.F. power transistor; *P*, photodiodes, photo-transistors, etc.; *R*, controlling and switching devices (not power types); *S*, power type transistors for switching applications; *T*, controlling and switching devices with specified breakdown characteristics; *U*, power transistors for switching applications; *Y*, power diodes or rectifiers; *Z*, reference diodes or zener diodes.

The remainder of the type number comprises a device serial number: entertainment devices have three figures; professional and industrial types have one letter (usually, *Z*, *Y* or *X*) followed by two figures.

Thus an AF117 can be immediately identified as an entertainment type of germanium small-signal R.F. transistor, while the BY100 would similarly be recognised as a silicon power diode for entertainment equipment.

Unfortunately this code does not provide any indication as to whether a transistor is an *n-p-n* or *p-n-p* type. It should also be noted that while this code is being used for recently introduced diodes and transistors, there are still many older type numbers not based on this standard code, for example OC81, etc.

MINIATURE RECEIVERS

During the year many of the smallest personal transistor receivers on sale in the U.K. originated overseas, mostly from Japan and Hong Kong; a number of British makers discontinued manufacture of these receivers owing to the difficulty of meeting price competition. In some cases, imported chassis were marketed under British brand names. Representative of the very compact dimensions now possible even for full specification transistor receivers are Japanese models about $2 \times 1\frac{3}{4} \times \frac{7}{8}$ in., with built-in loudspeakers.

A different approach has been adopted by one British kit supplier—Sinclair Radionics—for a miniature receiver only $1\frac{4}{5} \times 1\frac{3}{10} \times \frac{1}{2}$ in. for use with a separate earpiece. This receiver, see Fig. 2, uses a three-transistor reflex circuit and operates from two small mercury cells. Tr1 functions as an R.F. amplifier with regenerative feedback, followed by an untuned R.F. stage Tr2, and a diode integrator detector (D1/D2). The A.F. signal is fed back to the input circuit of Tr1, and Tr1, Tr2 and Tr3 then form a three-stage A.F. amplifier.

Another development in this field is the introduction of standard transistor circuit modules by transistor manufacturers for assembly by set makers. For example, Mullard produce pre-aligned R.F./I.F. modules which can be assembled with an associated A.F. circuit module to form a complete receiver

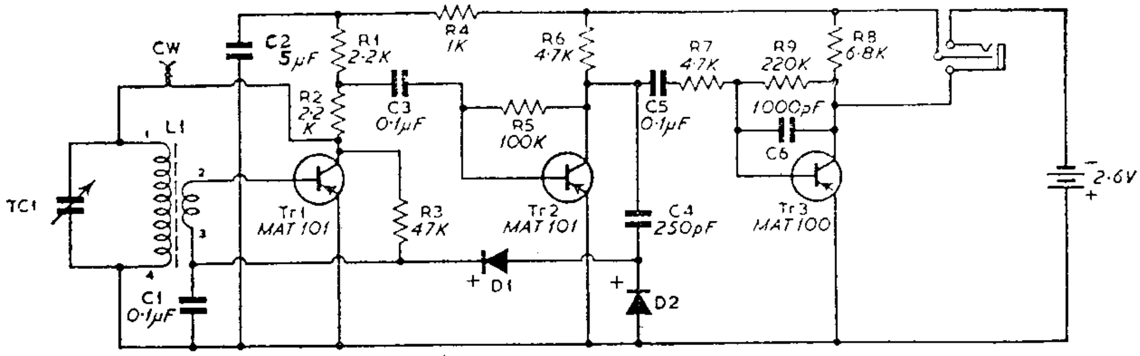

FIG. 2.—CIRCUIT DIAGRAM OF THE SINCLAIR " MICRO-6 " MINIATURE TRANSISTOR RECEIVER, AVAILABLE IN KIT FORM.

with the addition of only an aerial rod, tuning capacitor, volume control, wavechange switch, loudspeaker and battery. The circuit modules use small printed circuit boards: 2·44 × 1·19 × 0·64 in. for the R.F./I.F. modules; and 2·01 × 1·27 × 1·08 in. for the A.F. module. A.F. circuit modules are also made by Newmarket Transistors.

A subminiature version of the OA79 point-contact diode has been introduced under the type number AA119 easily small enough to be built into a miniature I.F. transformer.

A further major reduction in size of circuits is possible in the future with the development of various micro-miniaturisation techniques (" microelectronics "). During 1964 the Zenith company introduced the first hearing-aid to make use of an integrated solid-state circuit in which the A.F. amplifier, including six transistors and sixteen resistors, is fabricated together in a single tiny slice of silicon. The complete amplifier is thus only about one-tenth of the size of a safety match head. There are signs that the widespread use of such techniques for consumer goods may not be far distant. Eventually miniature receivers may be a solid encased block intended as a disposable item to be thrown away when a fault occurs—but meanwhile there remains a lively demand for the servicing of small receivers of more conventional type.

TRANSISTOR SERVICING TIPS

Some additional hints and tips for the servicing of transistor receivers, suggested by manufacturers, should be noted.

Where receivers show any tendency towards mechanical rattles and resonances, an improvement can often be effected by: using a pair of pliers to put a kink or bend in each transistor lead to prevent sleeving rattle; similarly treating any other sleeved leads of appreciable length; bending capacitor wires so that the body of the component is pressed against the circuit board to prevent rattle; investigating for any other metal parts or lugs in which vibration could be set up.

A useful extension of the old technique of " tuning wands " is suggested by Sharp. A rod of reasonable length is fitted with a piece of dust-core or ferrite material at one end and a piece of brass rod at the other end. This can then be used on any receiver fitted with a ferrite rod aerial to check the alignment of the aerial coils without the need first to unseal them. The dust-core end is brought near to the aerial rod: if this causes the output to

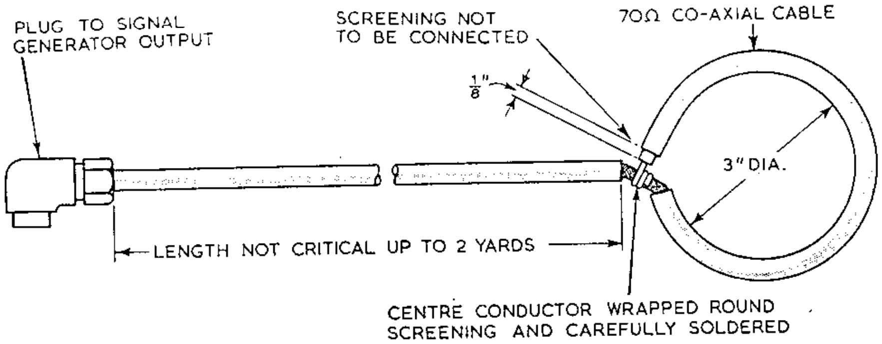

FIG. 3.—ELECTROSTATICALLY-SCREENED COUPLING LOOP RECOMMENDED FOR TRANSISTOR RECEIVER AERIAL CIRCUIT ALIGNMENT BY BAIRD. (RADIO RENTALS LTD.)

increase, it indicates that the circuit is out of alignment at that frequency and requires more inductance (aerial coil requires sliding towards centre of rod); on the other hand, if the brass rod causes an increase in output and the ferrite end a decrease, the circuit has too much inductance and the coil should be nearer the end of the rod. If alignment is correct, the approach of either end of the tuning wand should cause output to fall.

During transistor receiver alignment of the aerial circuits the signals must usually be inductively injected to the rod aerial via a " transmitting loop ", which should preferably be electrostatically screened. The usual form of loop consists of a number of turns of wire on a large diameter former with a wire mesh electrostatic screen, as described in earlier volumes. An alternative form of transmitting coil which can be constructed very simply consists of a single turn loop which can be connected directly to the 70-ohm output socket of a signal generator. This form of construction, shown in Fig. 3, is recommended by Baird (Radio Rentals Ltd). The loop is made from a length of standard co-ax bent into a circle, with the end of the inner core connected to the outer screening braid at the other end of the loop. The braid then forms an electrostatic screen. For ease of connection a co-ax plug should be fitted to the other end of the co-ax.

BIAS COMPENSATING DIODES

The use of germanium junction diodes such as the AA120 or AA129 to provide compensation for changes of battery voltage and temperature is widespread, although the alternative technique of using thermistors to provide temperature compensation is still found. Junction diode stabilisers are of particular value in improving the thermal stability of complementary-symmetry output stages.

Without compensation, class B transistor output stages are prone to severe cross-over distortion when the battery voltage falls. If the bias conditions of the stage are chosen to provide low cross-over distortion throughout the lifetime of the battery, then the no-signal current through the transistors at full battery voltage is likely to be so high that thermal runaway may occur. On the other hand, if the bias is set so as to give good thermal stability with a reasonable standing current at full supply voltage, then objectionable cross-over distortion is liable to occur well before the most economical end-point of the battery has been reached. Also, unless the circuit provides temperature compensation, cross-over distortion will be accentuated at low ambient temperatures.

The inclusion of a junction diode minimises such troubles—in two ways. First, the non-linear voltage/current relationship of the diode means that the voltage across it falls very much more slowly than the current flowing through it (current will be roughly dependent upon battery voltage); secondly, voltage across it decreases with a rising temperature. These characteristics match those of the base-emitter voltage/base current characteristic of the output transistors, allowing an output stage to operate satisfactorily down to a much lower supply voltage than an uncompensated stage, without the need for high initial no-signal currents.

With a direct-coupled complementary-symmetry output stage, a further advantage is obtained by putting the diode into the collector circuit of the driver transistor. Because of the low A.C. resistance of the diode at the operating point it also reduces the effects of the changes of current in the Class B output stage on the driver stage. An example of this technique can be seen in Fig. 1.

In a typical application, it can be shown that the use of stabilising bias diodes enables a Class B output stage to function satisfactorily from 9 volts

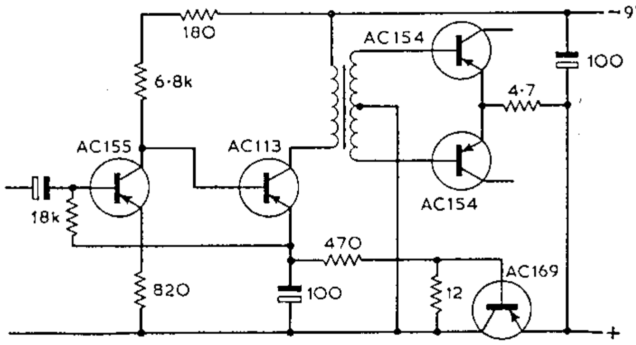

FIG. 4.—TRANSISTOR BIAS STABILISING CIRCUIT WHICH HAS BEEN USED IN MARCONIPHONE AND ULTRA TRANSISTOR RADIO RECEIVERS.

The bias applied to the AC154 push–pull transistor output stage is determined by the collector–emitter voltage of the AC169.

to 4 volts, for a degree of cross-over distortion which would otherwise set in at about 7·3 volts. It can also reduce the effect of changes of ambient temperature on the bias conditions of a complementary-symmetry circuit to roughly 40 per cent. of that of circuits not using compensation.

An alternative form of bias stabilisation is shown in Fig. 4. In this case the bias applied to the push–pull output transistors is determined by the collector-emitter voltage of the AC169 which is in turn dependent upon the base-emitter voltage. This is derived from the voltage across the 12-ohm resistor which with the 470-ohm resistor forms part of a potentiometer in the emitter circuit of the audio driver stage. Thus a voltage change in the emitter circuit of the driver stage will produce a corresponding change in the control voltage applied to the base of the stabilising transistor. Temperature variations are compensated by a change occurring in the base emitter voltage of the stabilising transistor and any supply voltage variations are compensated by the change caused by the variation in the emitter current of the driver stage.

TRANSISTOR A.G.C. CIRCUITS

The problem of obtaining a good A.G.C. characteristic with transistor receivers is described in the 1963–64 volume. The techniques generally adopted (including the use of variable damping of an I.F. transformer by means of a crystal diode; the use of separate mixer and local oscillator transistors; and the use of a D.C. amplifier stage in the A.G.C. line) can all be found in the models covered in the Servicing Data sections. As mentioned earlier, the introduction of silicon transistors will help to solve this problem, although, for some time, the use of these devices in battery-operated transistor portable receivers is not likely to be common.

Another technique providing an extended A.G.C. range has been described by Mr. R. E. Brown of Mullard as having particular application to domestic receivers designed primarily for use with external aerials which give rise to a wider range of first-stage signal voltages. In this system the A.G.C. is applied in two stages. The first I.F. amplifier is controlled in the conventional manner, using rectified A.G.C. currents. But, in addition, a second aerial A.G.C. system is used to decrease the input signal to the mixer transistor on strong signals, depending upon a control current obtained from the

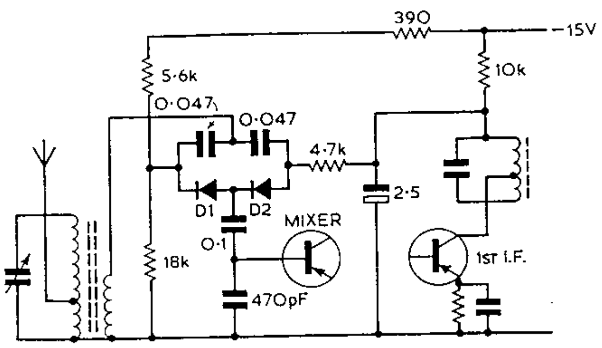

FIG. 5.—AERIAL A.G.C. CIRCUIT SUGGESTED BY R. E. BROWN FOR DOMESTIC TRANSISTOR RADIO RECEIVERS.

Two OA70 crystal diodes (D1, D2) are used in the aerial A.G.C. circuit, which reduces the input to the mixer stage on strong signals. The potentiometer (5·6k, 18k in series) determines the point at which the A.G.C. circuit comes into effect.

first I.F. stage. Each of the two A.G.C. loops can be delayed independently.

It will be seen from Fig. 5 that the aerial A.G.C. circuit consists basically of two OA70 crystal diodes arranged so that the signal from the aerial to the mixer must pass along a path comprising the two diodes. When these are reverse-biased they present a high impedance to the signal and only a small proportion of the aerial signal voltage is passed to the mixer. On the other hand, when the diodes are forward-biased they offer relatively little impedance to the signal voltage.

To change the bias applied to the diodes in the required manner, a diode control bias is obtained on one side from a potentiometer across the D.C. supply, and on the other side from the collector circuit of the first I.F. stage. Under no-signal conditions, the diodes are forward-biased, but as the signal increases the conventional A.G.C. loop tends to reduce the collector current of the I.F. stage so that additional negative voltage is applied to the " anodes " of the crystal diodes, until they eventually become reverse-biased. The actual signal voltage at which this aerial A.G.C. system comes into effect can be controlled by the design of the bias potentiometer across the D.C. supply.

TAPE RECORDER DEVELOPMENTS

Several developments in tape recorders have taken place during 1964. One innovation was the introduction of a compact Philips portable recorder fitted with a quick-change tape cassette using $\frac{1}{8}$-in. wide tape instead of the conventional $\frac{1}{4}$-in. tape. The cassette can be snapped into position without regard to the position of the tape on the cassette. The sealed tape cartridge measures $4 \times 2\frac{1}{2} \times \frac{7}{16}$ in. and contains 300 ft. of triple-play tape. With a

Table 1.—Playing time for various tapes and spools

Type	*Spool Diameter (inches)*	*Tape Length (feet)*	*Approximate Playing Time Per Track*		
			$1\frac{7}{8}$ in./sec.	*$3\frac{3}{4}$ in./sec.*	*$7\frac{1}{2}$ in./sec.*
			hr. min.	hr. min.	hr. min.
Standard Play	$3\frac{1}{4}$	200	21	10	5
	5	600	1 4	32	16
	$5\frac{3}{4}$	900	1 36	48	24
	7	1200	2 8	1 4	32
	$10\frac{1}{2}$	2400	4 16	2 8	1 4
Long Play	$3\frac{1}{4}$	300	32	16	8
	5	900	1 36	48	24
	$5\frac{3}{4}$	1200	2 8	1 4	32
	7	1800	3 12	1 36	48
	$8\frac{1}{4}$	2400	4 16	2 8	1 4
Double Play	$3\frac{1}{4}$	400	42	21	10
	5	1200	2 8	1 4	32
	$5\frac{3}{4}$	1800	2 50	1 25	42
	7	2400	4 16	2 8	1 4
Triple Play	3	450	48	24	12
	$3\frac{1}{4}$	600	1 4	32	16
	5	1800	3 12	1 36	48
	$5\frac{3}{4}$	2400	4 16	2 8	1 4
	7	3600	6 24	3 12	1 36
Quadruple Play	3	600	1 4	32	16
	$3\frac{1}{4}$	800	1 24	42	20

tape speed of $1\frac{7}{8}$ in./sec. the recorder provides some 30 minutes playing time on each of the two tracks. Another development has been the introduction of quadruple-play tape, allowing some 800 ft. of tape to be wound on a single $3\frac{1}{4}$-in. diameter spool. A quadruple-play tape thus provides nearly three hours playing time on a four-track recorder playing at $3\frac{3}{4}$ in./sec. Despite the thinness of the tape it is claimed to be of high mechanical strength and to be free from print-through problems.

Two operational devices have also appeared on some recorders and tape dictaphones: one is the use of automatic level circuits (termed by Grundig " Magic Ear " and found also on a number of other brands); the other is the use of voice-operated switches to start and stop units automatically when speech begins and ends.

A representative automatic level circuit will be found in the Grundig Model TK18 covered in the Servicing Data section. Basically the device provides an automatic gain control circuit on the A.F. amplifier so that the audio output fed to the record head remains substantially constant for a wide range of signal levels from the microphone: a sufficiently long time constant is included to prevent the amplifier from responding to the normal variations of the speech waveform. The circuit, when correctly adjusted, eliminates the need for the conventional type of magic-eye level indicator.

A combined A.F. output stage and H.F. bias oscillator using transistors, described by Mullard Ltd., has a number of interesting features. The circuit (Fig. 6) uses a pair of complementary transistors AD161 (*p-n-p*)

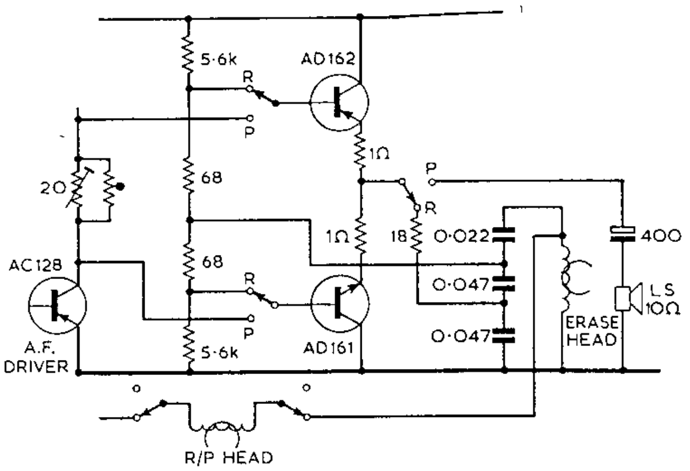

FIG. 6.—SIMPLIFIED CIRCUIT OF COMBINED 4-WATT OUTPUT AND PUSH–PULL OSCILLATOR.

The AD161/AD162 complementary-symmetry pair act as audio output stage on playback, but are switched on record to form a push–pull H.F. bias oscillator, the erase head forming the inductance in the oscillator tank circuit.

and AD162 (*n-p-n*) to form a 3-watt complementary-symmetry audio output stage which can be simply switched to form a push–pull H.F. bias oscillator during recording, the inductance of the erase head being used as the inductance of the oscillator tank circuit with capacitive tapping to establish the correct oscillator conditions and voltage across the erase head. Since the oscillator is of the push–pull type, very little even-harmonic distortion of the bias waveform occurs.

BATTERY DEVELOPMENTS

The development of mercury, alkaline-manganese cells and sealed nickel-cadmium re-chargeable cells has been described in earlier volumes. During 1964 a further category of primary cell has been marketed in the U.K. to provide an economical supply for heavy duty operation (calling for currents of the order of several hundred milliamperes) but where the situation does not call for the more expensive alkaline-manganese and mercury cells.

This is the "heavy duty" Leclanché cell which shows a marked superiority for some applications over the conventional dry Leclanché cell, due to constructional improvements and to a change in the chemical formula. The heavy duty cell has a paper separator which is much thinner than the electrolyte wall in the usual paste type cell, and a high grade manganese dioxide depolariser with improved properties.

For example, whereas a standard U2 1·5-volt cell will supply a continuous 500-mA. current for only about 18 minutes (assuming an end-point voltage of 1 volt), the heavy duty Every Ready HP2 cell will provide this current for about 3¼ hours. On the other hand, for smaller discharge currents the improvement would be considerably less marked.

Compared with a standard U2 cell, the cost of the equivalent "heavy duty" cell is about three times as great; this compares with roughly nine times for alkaline-manganese cells, and over twenty times for a mercury cell of equivalent size.

STEREO DEVELOPMENTS

During 1964, sales of stereo radiograms were at a higher level, and there were other signs of an increased public interest in stereo reproduction; this was in line with a noticeable rise in interest in sound radio and record reproduction generally as compared with television viewing. The year saw the marketing of the first fully transistorised stereo radiograms, using the type of audio circuits described earlier. A novel design was the Pye "Achoic" unit in which the side-facing loudspeakers in a 22 × 17 in. cabinet were designed to allow the stereo effect to be obtained by reflecting the sound waves from the walls of the room.

The first battery-operated portable stereo record player was also introduced by S. G. Brown; this uses a twelve-transistor, two-channel amplifier for use with loudspeakers or with stereo earphones fitted with a new type of ceramic transducer.

A noticeable feature, particularly with Continental and Canadian-built radiograms marketed recently in the U.K., has been the gradual breaking down of the former distinctions between "domestic" and "high-fidelity" equipment. Many of the higher-priced domestic units use techniques and provide a standard of performance formerly found only in the specialised high-fidelity units.

Several combined radiogram/television models were produced in the early 'fifties, but later virtually disappeared from the U.K. market until 1964 when several firms re-introduced this type of unit. One firm was Grundig, using a German-built radio chassis combined with a dual-standard television chassis built to their specification by Plessey. Philips combined a 23-in. television chassis with a five-band stereo radiogram, pointing out the improved sound quality possible by using larger loudspeakers for television sound reproduction.

Pick-up Developments

Stereo pick-up cartridges and tone arms have continued to show improvement. The year saw the introduction of low mass pick-up arms (e.g. Garrard 3000LM) and the floating pick-up cartridge (Pye " Butterfly "). The low mass pick-up arm is designed to permit optimum performance of a pick-up cartridge to be obtained unimpaired by mass or resonance of the arm, and to reduce record wear. Provision is made for fine stylus pressure adjustment. The " Butterfly " pick-up and tone arm was developed by Pye in conjunction with the American C.B.S. Laboratories; it allows an inexpensive stereo ceramic cartridge to be used with a playing weight of 2 grammes. The pick-up cartridge floats on a light spring within the tone arm. It is claimed that no audible damage results to the record when the pick-up is dropped on to a record or skated across the grooves. The unit will also track in the presence of vibration, or when the turntable is out of the horizontal, or with warped records.

Stereo Broadcasting

Although the B.B.C. continued during 1964 experimental V.H.F. stereo transmissions by means of the pilot-tone (Zenith/G.E.) system, the Corporation announced during the year that no definite plans could be made to introduce a regular service until an agreed system for Europe had been decided upon; this was unlikely before the C.C.I.R. meetings in 1965 or 1966. This cautionary view was not reflected by overseas broadcasting organisations: during the year there was rapid extension of both experimental and regular stereo broadcasting in European countries, including Austria, Germany, France, Italy and Holland, all using the pilot-tone system.

As a result of this, a number of imported stereo receivers fit stereo multiplex decoders, and such units have also been fitted to receivers by H.M.V., Ultra and Pye. An Ultra radiogram incorporating a multiplex decoder unit is described in the Servicing Data section of this volume.

REPLACING POTENTIOMETERS

Most service engineers appreciate that when replacing a noisy or otherwise faulty potentiometer it is necessary to use a component which is not only of the correct resistance value but also with the appropriate track law (taper) for

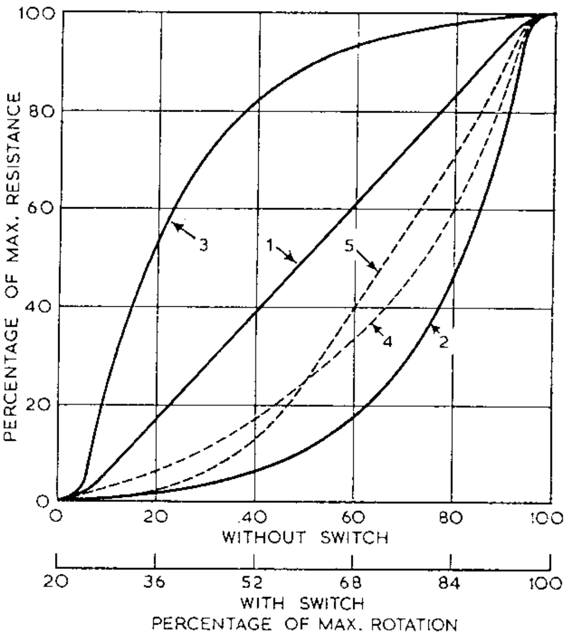

FIG. 7.—APPROXIMATE POTENTIOMETER TAPERS. 1 LINEAR; 2 LOG; 3 ANTI-LOG; 4 SEMI-LOG; 5 LINEAR-TAPERED.

Considerable tolerances in the case of carbon-track potentiometers should be expected.

For volume controls a log law potentiometer is required. For tone and most television receiver controls, where straight division of voltages is required, the linear taper is used. The anti-log taper is useful for applications such as cathode gain controls.

the particular circuit concerned. However, there is still some confusion on this matter and the following notes should clarify this subject.

The resistance law or taper is the manner in which the resistance changes with rotation of the shaft. There are now a considerable number of different tapers in common use, including linear, logarithmic (sometimes called " audio taper "), anti-logarithmic (" reverse taper "), and various intermediate types such as semi-log and linear-tapered.

Fig. 7 shows the three basic laws as found in the vast majority of radio applications. It should be noted, however, that when a carbon-track potentiometer includes a switch the first 20 per cent. of the rotary movement of the shaft is concerned with the switch function; the resistance variation is then condensed into the remaining 80 per cent. rotation.

Curve 1 shows the straightforward *linear* taper where the resistance change is proportional to shaft rotation. This type of resistance law is commonly used on tone controls and other applications requiring straight division of voltages.

With Curve 2, or *log law*, the resistance increases only gradually during the early clockwise movement of the shaft, squeezing almost 80 per cent. of the resistance variation into the final 20 per cent. rotation. This type of taper is roughly in accordance with natural sensation of loudness (our ears follow a logarithmic law in their sensitivity to sound), and such components are necessary for the conventional type of volume control in order to provide an apparent linear increase in sound output with shaft rotation. Use of a linear potentiometer for this application results in almost all appreciable variation in sound levels being squeezed into the first few degrees of shaft rotation.

Anti-log law tracks, as shown in Curve 3, are the opposite of the log law taper, providing a big change of resistance in the first half of the clockwise motion, and only about 20 per cent. of the total variation in the remaining half.

These tracks are useful in such applications as cathode gain controls (for example some contrast controls in television receivers) etc., and for biasing networks.

With the more elaborate form of tone controls now fitted on some receivers, it is important that the replacement should have identical taper to the original or operation of the control will be seriously affected.

Where the resistance law of a potentiometer is unknown it can be readily checked with the aid of an ohmmeter. First measure the full resistance value; then the resistance with the shaft half turned along the resistance track. If the second resistance value is about half the total, the track is almost certainly linear; if only 10–20 per cent. of total, then it is a log law component; and if about 80 per cent. of total, then it is anti-log. Semi-log and linear-tapered tracks would have values roughly mid-way between linear and log; to decide exactly which of the two it will usually be necessary to draw a rough graph, plotting resistance values against shaft rotation. In practice, linear-tapered tracks are only rarely encountered in domestic equipment.

SERVICING AIDS

A new type of aspirated soldering iron designed to assist in removing defective multi-tag components from printed wiring circuit panels has been introduced by Amalgamated Electric Services. The problem in dealing with such components arises mainly from the difficulty in removing completely, cleanly and quickly all solder from the tags.

In this tool the bit of the iron is hollow. It is applied to the solder on the tag in the conventional manner, but as soon as the solder melts the service engineer exerts slight pressure on a foot pump. As a result, the molten solder is sucked up through the hollow bit and into a receiving chamber. Provision is also made for the handle to be clamped directly on to the stand to allow work to be brought up to the hot bit.

Another servicing aid introduced by this firm is a printed panel service jig consisting of a base plate with 24 flexible and detachable plastic spikes. The printed panel is placed on the spikes and pushed gently downwards; the deflected spikes grip the sides of the components, holding the panel firmly while servicing.

MISCELLANEOUS DEVELOPMENTS

Apart from the ten-pin decal base used for television valves (PFL200), another recent valve base introduced to the U.K. market is the B9E (novar) nine-pin base used for high dissipation valves previously requiring an octal base. The novar base is used on all-glass type valves, but has a pin circle diameter of 0·687 in. Representative of the novar base for entertainment valves is the 7868 power pentode (Thorn–A.E.I.) with a maximum anode dissipation of 18 watts and primarily intended for use in the output stages of high-fidelity audio amplifiers.

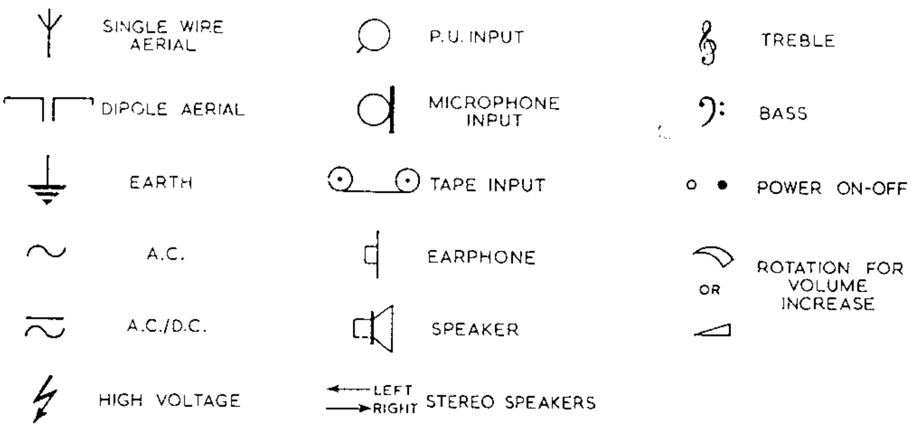

FIG. 8.—SOME COMMON SYMBOLS USED ON CONTINENTAL EQUIPMENT TO INDICATE THE PURPOSES OF KNOBS, SOCKETS, ETC.

Several small valve receivers (for example the Stella ST113U) use a high-impedance speech coil loudspeaker (800 ohms), thus eliminating the need for an output transformer. Care should be taken when servicing these receivers since the speech coil is at H.T. potential and the chassis is mains-connected.

An unusual feature of this firm's Model ST430 A.M./F.M. portable receiver is the use of 6·75 Mc/s. I.F. in place of the more usual 10·7 Mc/s.

Automatic frequency control circuits are used on several A.M./F.M. portable receivers covered in this volume; for example the Cossor Model CR7225T and Sharp Model BX326.

Continental Knob and Socket Symbols

In the 1961–62 volume a number of the circuit diagram symbols used by European companies were given, where these differ from standard British practice. Many of the imported Continental models also make use of pictorial symbols to indicate the purpose of the various sockets, knobs, etc.

Many of these are self-evident, but a selection of some of the more common symbols is given in Fig. 8.

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