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DESIGN OF TAPE RECORDERS, Part I

VOLUME 10
NUMBER 4
NOVEMBER
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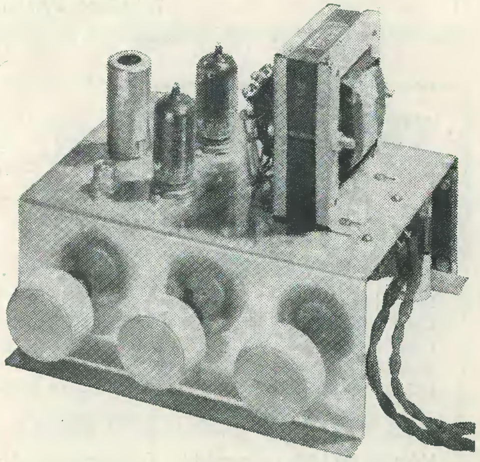

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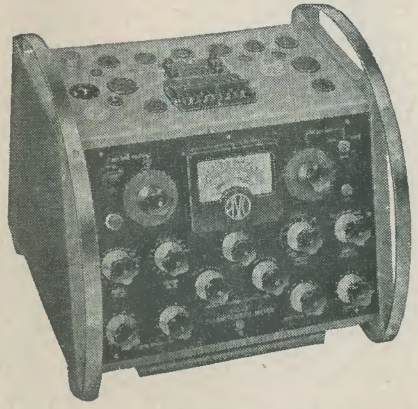

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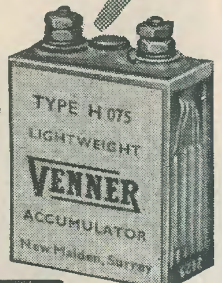

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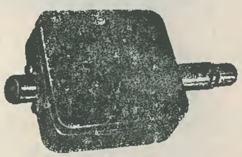

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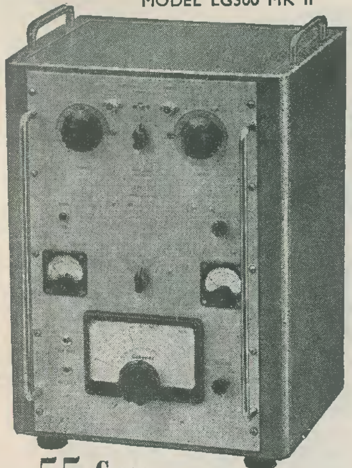

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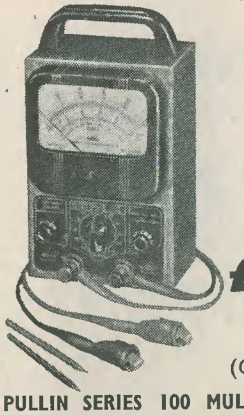

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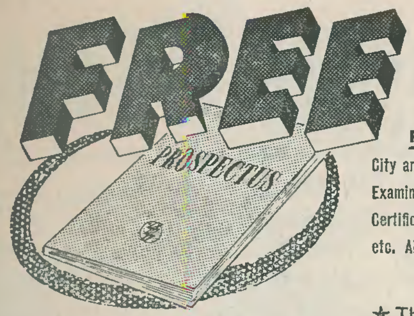

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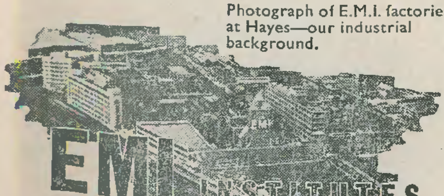

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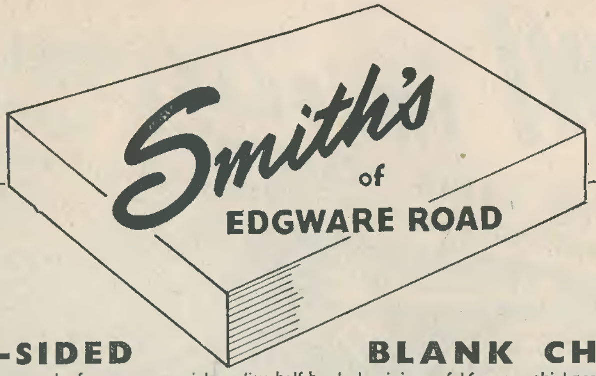

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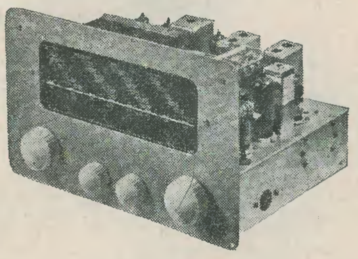

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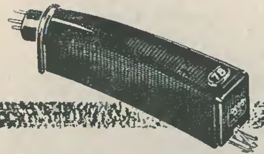

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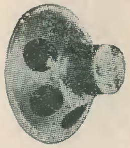

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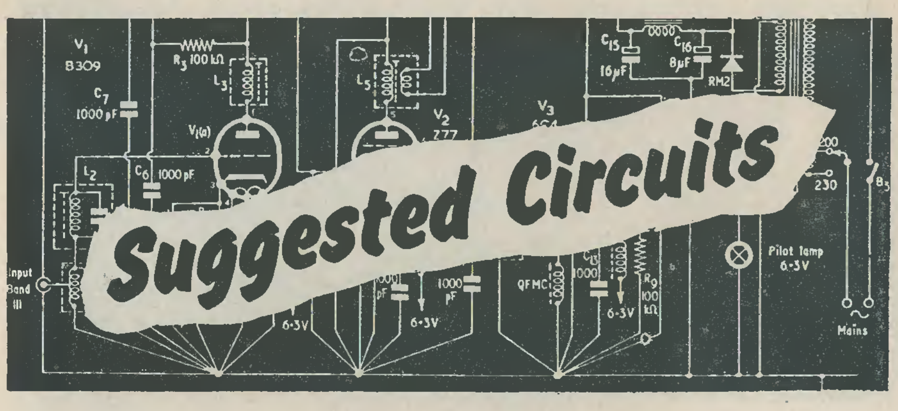

The circuits presented in this series have been designed by G. A. FRENCH, *specially for the enthusiast who needs only the circuit and essential relevant data*

No. 72. A PHOTOTRANSISTOR LIGHT-OPERATED SWITCHING CIRCUIT

A FASCINATING SIDELINE OF RADIO engineering is the use of photo-cells and similar devices to enable circuits to be controlled by the appearance or interruption of light rays. Typical instances appear in such widely varying devices as automatic garage doors (opened by a car's headlamps or by the breaking of a light beam), burglar alarms, and television remote controls (operated by beams of light from a torch).

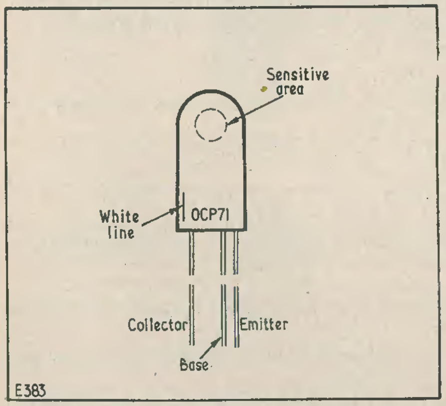

Fig. 1. Illustrating the connections and "sensitive area" of the OCP71

So far as the home constructor in this country is concerned, light-operated devices have hitherto been rather an unattractive proposition owing to the fact that the photo-cells normally needed require valve amplifiers before they can be made to operate relays. Such amplifiers incur, in their turn, the use of power supplies which are uneconomical in components as well as being wasteful from the point of view of current consumption when left continually switched on. In addition there is the further fact that some care has to be taken with continually-used equipment to ensure adequate ventilation and safety margins.

This situation has now been altered by the recent introduction of the Mullard phototransistor type OCP71. The OCP71 is a miniature component requiring only a low voltage supply source, and it will operate a relay directly. This month's article discusses the functioning and operation of the OCP71, whilst next month's contribution will outline the more versatile relay switching circuits which may be employed with this phototransistor.

Phototransistor Circuitry

The OCP71 is a p.n.p. phototransistor of miniature construction. As shown in Fig. 1, it has three lead-out wires, these connecting to the emitter, base and collector. Fig. 1 also shows the "sensitive area" of the phototransistor, this being the point at which greatest current change occurs for a given quantity of incident light.

Unless it is intended for use at relatively high frequencies (up to 3 kc/s) the base of the OCP71 need not normally be connected into circuit. Thus for usual switching operations it is necessary to connect to the emitter and collector only, the base being left floating. In this mode of operation the phototransistor may be considered almost as a variable resistor. Under "dark" conditions it offers a high resistance to the flow of current, whilst, when illuminated, it offers a low resistance. The simplicity of the circuitry required around the phototransistor will at once become apparent.

A practical circuit is shown in Fig. 2. In this diagram the phototransistor is connected in series with a nominal 5,000 ohm relay with changeover contacts, the whole being powered by a 12 volt supply. In common with other transistors it is essential that the polarity of the power supply applied to the OCP71 is correct. Reverse polarity could irreparably damage the phototransistor.

The relay shown in Fig. 2 has a sensitivity such that it closes reliably with the 2mA current at which the circuit is intended to operate when the OCP71 is illuminated. The particular model employed by the writer when checking the circuit was obtained from H. L. Smith, Edgware Road (type RL5K/M). After reasonably careful adjustment of the spring tension and contact settings, this relay can be made to operate at approximately 1½mA. The changeover contacts fitted to the relay are adequate for low current switching, and can be coupled to a larger relay for controlling heavier currents. Some hints on adjusting the relay are given at the end of this article.

The phototransistor is employed under rather conservative conditions in this circuit. One of the reasons for this is that such conditions will help to obviate failures due to the phototransistor overheating when continually illuminated. In practice the dissipation in the phototransistor need be no greater than 4mW in the illuminated condition. (This assumes 2mA flowing through the relay coil.) The coil resistance of the relay is of some importance. If a relay having a resistance of less than 5,000 ohms is used, additional series resistance to make up this value may be advisable. Alternatively, the energising voltage may be lowered. Such changes are left to the discretion of the constructor, after he has studied the characteristics of the phototransistor and considered the points raised in the following paragraph.

Another, and extremely important, reason for using conservative current and voltage ratings in the circuit is that the limiting collector voltage quoted for the OCP71 is −25 volts. This at once introduces design difficulties owing to the fact that the coil of the relay has a relatively high value of inductance. When the phototransistor is illuminated, a steady current of some 2mA flows through the relay coil. As soon as the illumination ceases, this current drops to some 200 to 300μA. The drop in current in the relay coil results in the collapse of the magnetic field previously sustained, with the consequent formation of a momentary "back e.m.f." across the coil having opposite polarity to that previously applied. This momentary voltage will add to that provided by the power supply. Also since the phototransistor in the dark condition has a high resistance, the reduced damping in the circuit may allow the back e.m.f. across the relay coil to rise to values as high as 40 to 50 volts. The total voltage thus obtained could possibly damage the phototransistor.

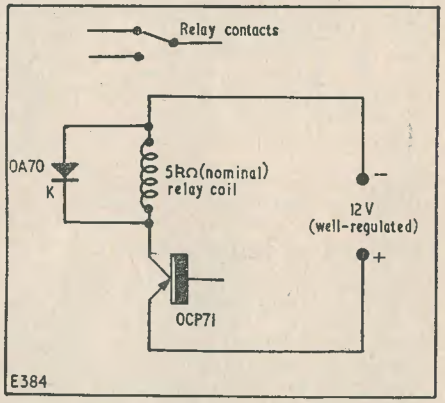

Fig. 2. The basic relay circuit in which the OCP71 may be used

To overcome this difficulty a crystal diode rectifier is connected across the relay coil in Fig. 2. When the relay is energised the voltage across the coil is such that the diode does not conduct. However, when the relay de-energises, the momentary back e.m.f. has opposite polarity to the energising voltage; with the result that the diode conducts during the existence of this voltage. A low-impedance diode, the Mullard OA70, is recommended here, and it is probable that most of the back e.m.f. is dropped across the internal resistance of the relay coil, only a small fraction appearing in the external circuit across the diode.

It is important to ensure that the diode is connected the correct way round in Fig. 2. If connected incorrectly the OCP71 may pass excessive current. If desired, the polarity of the diode can be checked by inserting a 2kΩ resistor in place of the phototransistor during initial tests. If the resistor causes the relay to operate (or causes 2mA to flow in the circuit), it can then be replaced by the phototransistor. "Surplus," or otherwise unreliable, crystal diodes are not recommended for this application, incidentally.

The fact that a back e.m.f. appears across the relay coil tends to limit the supply voltage which may safely be applied to the whole circuit. The writer decided to employ caution in this particular arrangement, and the conservative voltage and current ratings mentioned above are the result.

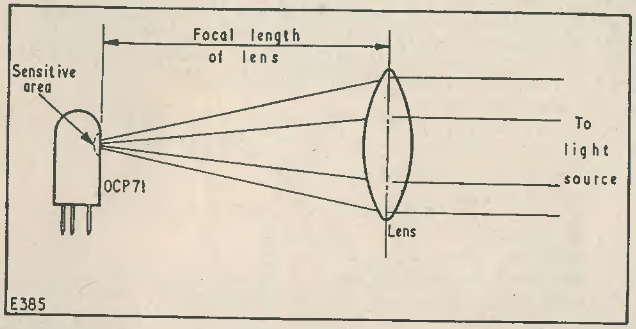

Fig. 3. The method by means of which the OCP71 is employed with a convex lens

Illuminating the Phototransistor

For normal operation the phototransistor requires an illumination of approximately 75 foot-candles. This is a high degree of illumination if the light is not concentrated on the small sensitive area of the phototransistor. However, by the use of a simple lens assembly, such concentration may easily be obtained.

All that is required for this purpose is an inexpensive convex lens of the "magnifying glass" variety, this having a diameter of one to two inches. Such lenses may normally be obtained for one or two shillings. It next becomes necessary to find the focal length of this lens. This may be discovered quite easily by holding the lens between a sheet of paper and an electric lamp. When a sharply focused image of the lamp appears on the paper, the distance from the centre of the lens to the surface of the paper is the focal length.

The phototransistor and lens are then mounted as shown in Fig. 3. As will be seen, the light falling on the lens is then focused on the sensitive area of the OCP71. The result is a considerable increase in sensitivity of the phototransistor, together with marked directional properties. The writer found that he could operate his phototransistor switching circuits with complete reliability when using the lens assembly some 8 feet away from a 40-watt lamp. If the lamp had been fitted with a reflector a much lower wattage would probably have sufficed. It should be mentioned that it would be inadvisable to direct the assembly shown in Fig. 3 at any source of very high light intensity, such as the sun, in case the phototransistor became damaged.

It is recommended that the phototransistor and lens be mounted in a separate assembly away from the power unit and relay, two-way cable coupling the two. This has the advantage of keeping the phototransistor removed from sources of heat such as may be given by the power supply components. Other sources of heat are also best avoided. It should be pointed out that there is little point in illuminating the phototransistor excessively. When the illuminating lamp and phototransistor assemblies are fixed, the power of the former could be adjusted such that the phototransistor passes some 2 to 2½mA (measured by a meter in series with the negative power lead of Fig. 2) when illuminated. Alternatively, sensitivity may be reduced by "stopping down" the lens: i.e. by masking part of its area.

Adjusting the Relay

The 5,000Ω relay recommended above for this circuit may be adjusted in the following manner. The "make" contact should be adjusted such that, when the armature contact is held against it a line of light can just be seen between the armature and core. (If the armature touches the core when energised, it may not fall-off immediately when the energising current ceases.) The "break" contact is then brought up until the relay energises reliably with approximately 1½mA coil current. If this cannot be achieved, the spring tension should be reduced by carefully

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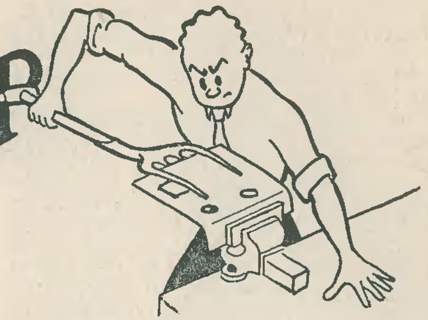
IN YOUR WORKSHOP



In response to requests from readers, Smithy the Serviceman continues to conduct this feature

When Smithy the Serviceman drove up to his workshop on the first morning after his holidays, he found that Dick was already waiting for him.

"Well, you're early," he grunted in reply to Dick's greeting. He took a small portable receiver from his car, opened up the workshop and entered. Dick grinned as he followed and watched Smithy fussing around with the tools on the bench.

"Did you have a good holiday?"

"Yes, thanks," replied Smithy. "What I'm trying to do now is make up my mind whether I'm glad to be back or not! I suppose I am, really."

Holiday Troubles

He placed the portable he had taken from the car on to the bench, and proceeded to remove its chassis from the cabinet.

"You'd think," he remarked, as he removed the chassis-securing bolts, "that if I went on holiday I might have a chance to get away from radio, if only for just a little while."

"Why, what happened?"

"Well," continued Smithy, "my wife and I went out into the country for a drive one day. The only possible snag I could see was that she had made up her mind that she was not going to miss a particular programme on the radio on any account, and so we took the portable. And then, of course, the tarnation thing had to pack up just an hour before the programme started.

"Now, this is the sort of thing that always puts me in a spot. If you're a serviceman and get into a situation like this you're always expected to at least make an attempt to fix the fault. To make things worse I only had a screwdriver and a pair of nippers with me in the car, plus some odds and ends of wire and things. Anyway, I decided to have a look at the chassis just in case it was something simple."

"Was there anything seriously wrong?"

"Well, what had happened was that the 0.01μF coupling condenser between the diode-pentode and the output valve had gone open-circuit. Normally, of course, I could have fitted another in a matter of seconds. However, out in the country 0.01's don't grow on trees!"

"What did you do to get over it, then?" asked Dick.

"I'm afraid I cheated a little," replied Smithy. "There was a 0.1μF condenser decoupling the a.v.c. line, and I pinched that! What I actually did was to nip it out of the a.v.c. circuit and then fold and press the wires around those of the faulty coupling condenser. Fortunately, its body was a little larger than that of the coupling condenser, and its lead-out wires were long enough to enable me to do this. I then short-circuited

SUGGESTED CIRCUITS—*continued from previous page*

bending the spring-holding lug on the yoke a small amount towards the armature pivot. When finally adjusted the relay contact should be able to travel over some 0.010in between the fixed contacts.

Next Month

Next month the provision of heavier relay switching circuits, operated from the same 12-volt power supply which feeds the OCP71, will be discussed.

the a.v.c. line to chassis and the set was ready for use."

"Sounds O.K.," remarked Dick, dubiously, "but I'd like to ask a few questions about it, if you don't mind. First of all, wouldn't short-circuiting the a.v.c. line to chassis upset any bias voltages in the set?"

"It depends mainly on the set," said Smithy. "For instance, if it is one of the type which is intended purely for battery operation and which has a single 1.4 volt cell for the filaments you're pretty safe. The reason for this is that all the filaments in a set of this type are almost certain to have one leg taken to chassis. However, if it is an a.c./d.c. battery job where the filaments are run in series, then you have to be careful.. This is because the filament of the detector in such a set may not be at chassis potential. In this case you would need to locate the a.v.c. diode load resistor and short the a.v.c. line to the filament leg to which it connects. Usually, in battery sets, the a.v.c. diode load is also the signal diode load, and is often the volume control itself. Shorting the a.v.c. line will not prevent audio being obtained, due to the presence of the series a.v.c. decoupling resistor. Perhaps these sketches will make things clearer to you."

He scribbled a pair of circuits on a piece of paper (Figs. 1 and 2) and passed it over to Dick. As Dick studied the diagrams he pointed out the circuit changes he had made.

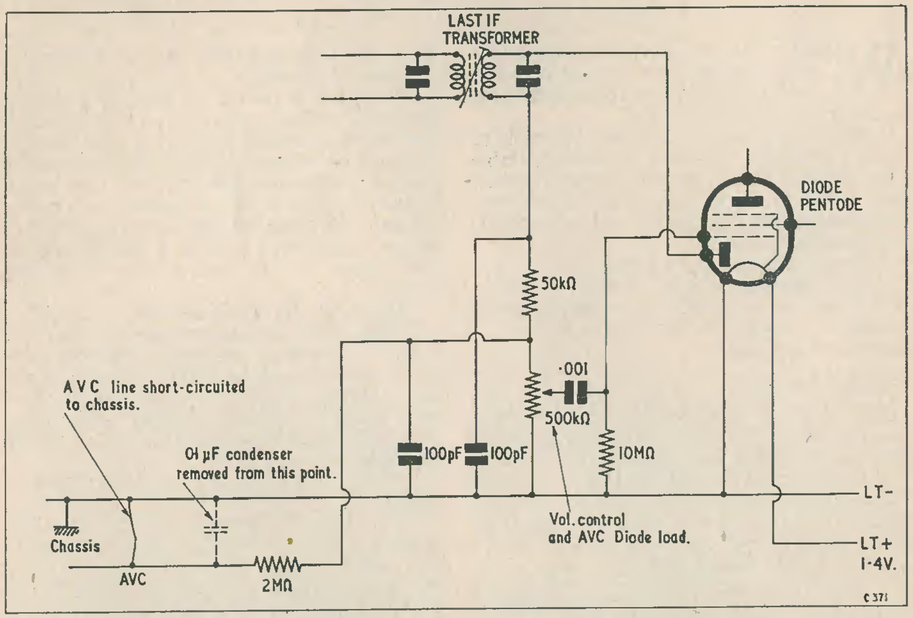


Fig. 1. Illustrating how Smithy carried out his emergency repair. The component values shown here are typical of most battery set second detector circuits. The 2MΩ resistor prevents loss of audio when the a.v.c. line is short-circuited to chassis

"Another question I feel certain you will ask me is whether the lack of a.v.c would cause the set to overload. The answer to that is that you can prevent overloading by reducing the signal strength. As this set was a portable I was able to turn it until the signal strength was as low as I required it to be."

"I suppose," commented Dick, "that you located the faulty condenser by touching the output grid and the previous anode and seeing which of these points caused hum in the speaker?"

Smithy chuckled.

"I have been waiting for you to fall into that little trap. What you forget is that, when you get out into the country, there just ain't no hum! If you touch a sensitive a.f. point with a screwdriver, keeping your finger on the metal, you will hear a click or the set may go unstable. But you won't hear any hum. It's only when sets are tested in localities which have mains wiring that we get the hum effect."

"Well, that's interesting," commented Dick. "I'd never thought of it like that before."

"Which reminds me," continued Smithy, "of a little effect which has caused quite a few arguments between engineers before now."

He leaned over and switched on the bench oscilloscope.

"While the 'scope is warming up," he said, "I'll connect its input to a source of mains voltage. Ah, there's a 6.3 volt point here. This will do."

Whereupon, Smithy clipped the oscilloscope input leads across the pilot lamp of a chassis which was lying on the bench, and set the oscilloscope gain and timebase frequency to give a trace of three or four cycles.

"There you are," he remarked, "here we have the waveshape of the mains which is fed into the workshop. As you can see, it is quite reasonably sinusoidal. Now I'll unhitch the test leads from the 6.3 volt supply and catch hold of the hot lead with my hand. "I'll turn the 'scope gain up a little, and here we have the trace again. Only just look how distorted it has become this time."

The 50 cycle trace had, indeed, reappeared; but it was anything but sinusoidal.

"I should imagine," said Smithy, "that there's something approaching 50% distortion here. Yet the 'scope amplifier is not overloaded and the distortion is not caused by noise, because each cycle has the same shape. Also, all I'm doing is picking up hum capacitively with my body, whereas previously I had a direct connection to the heater winding of a transformer. Why, therefore, do we now get the heavy distortion?"

"That sounds to me like the 64,000 question." replied Dick, scratching his head. "At this moment, quite frankly I just haven't a clue."

"Well, I'll leave you to think about it," grinned Smithy. "Perhaps one or two others might be interested in offering a solution as well." *

Corona

Smithy proceeded with his portable receiver and started work on returning it to its original state.

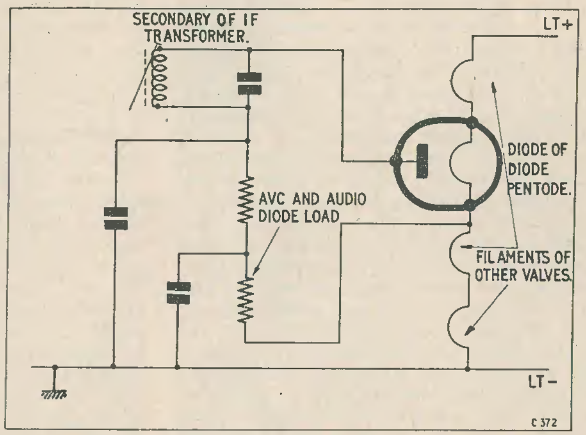
Dick settled down to watch him.

"By the way," he remarked after a while, "do you remember what we were discussing before you went on holiday?"

Smithy thought for a moment. "Could it have been corona?" he asked. "I seem to remember that we finished up with a television set that had very bad corona."

"Yes, that's right," said Dick. Only we were so busy then that you didn't have time to answer any queries. For instance, what I don't quite understand about corona is why it seems to be so bad with some sets and not with others."

Fig. 2. In most a.c./d.c./battery sets the filaments are connected in series. In such receivers the filament of the second detector valve need not necessarily be at chassis potential. An example is shown here. It may be noted that the diode load is still returned to the diode filament



"Well," remarked Smithy, "the trouble with corona snags is that complications creep in. To begin with, hardly any viewer will ever bother about corona pure and simple unless it actually interferes with his reception. Also, one particular set, on installation, may show up corona in the form of interference far more noticeably than another.

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* Letters from readers who are interested in this problem will be welcomed by the author. Some of these may be published in future series.

"Anyway, the first thing to examine, really, is the *nature* of corona. Without becoming too pedantic, the best explanation would probably be that corona occurs when the air around an electrode carrying a high potential becomes ionised. This ionisation then shows up as a fluorescent blue haze around the electrode. Sometimes the corona is very slight, whereupon it can only be seen in dark surroundings. You will have noticed, now and again, that when I'm trying to locate a case of corona I find that I have to pull down the blinds and switch off the lights in order to see it properly. Occasionally, corona appears as a thin, continuous, hazy line between two conductors. When that happens, there is a fair chance that an actual spark will occur if the potential difference between the two conductors were slightly increased. Sometimes, too, you get what looks like a thin film of corona spread all over the surface of an insulator carrying high voltage electrodes. Some insulators appear to be worse than others in this respect. Perhaps they are more hygroscopic."

"More hygro-what-ic?" exclaimed Dick.

"More hygroscopic," repeated Smithy. "That is to say, they have a greater tendency to absorb moisture from the atmosphere.

"Now, in television sets," he resumed, "corona can appear around the components and wiring which are fitted to the line output stage. Any electrode carrying a voltage greater than 4kV or so above chassis is capable of causing corona. Because of this, corona can occur not only on the e.h.t. wiring to the tube final anode, but also around the wiring to the line output valve anode or the booster diode cathode. These days, both these valves are usually top-cap types, the booster *cathode* being taken to the top cap; and most manufacturers fit connectors to these caps which are designed to prevent corona. Another point to remember is that corona gets worse as voltage increases. Around 15kV it becomes quite difficult to prevent corona. And it gets worse again as you go above this potential."

"Corona forms on spikes in the wiring, doesn't it?"

"Yes, that's right. Corona forms around any spiky connection because, due to its shape, there is only a small amount of air in its vicinity to take up a charge. If an electrode is given a rounded shape the charge is distributed more equally through the surrounding air, and the amount of ionisation becomes lower. It should be remembered, also, that the charge in the electrode concentrates at its edges and, where a spike occurs, is liable to become very concentrated at the end of the spike.

"A point which is sometimes overlooked is that corona may often become worse if an earthed metal object, such as a screen, approaches high-voltage electrodes. I've cured quite a few cases of corona merely by dressing high-voltage leads away from nearby screens.

"Of course, the best cure for corona is to avoid spiky connections altogether. However, even smooth rounded connections sometimes cause mild corona now and again, whereupon you have to fall back on another plan of attack. A good method, which is usually worth trying, consists of physically displacing air away from the surface of the electrode by covering it with insulating material. As there is then no air immediately around the electrode the corona reduces. The thicker the insulant, the less the corona. Anti-corona dope works in this fashion. This dope often consists of a high grade insulant, such as polystyrene, dissolved in a solvent. After the dope has been applied the solvent evaporates, whereupon a film of insulant is left on the electrode; thereby displacing the air in the immediate vicinity. In some cases, mild attacks of corona can be cleared by covering the electrode with good quality paraffin wax. This isn't a perfect solution, but it serves at a pinch. For an emergency repair you can always melt a little wax off a condenser with a soldering iron.

"When the corona seems to be appearing between two electrodes with a high potential difference between them, a successful cure is often given by inserting one or more sheets of polythene between the two. This is a very good idea for such things as deflector yokes when corona appears, say, between line and frame coils. A small piece of polythene wedged between the two often clears it up altogether."

"Just a minute," interrupted Dick. "Isn't polythene in sheet form difficult to get hold of?"

"Well, it's becoming more and more common these days," replied Smithy, "becuase a number of manufacturers are using it for packaging, Polythene is one of those plastics which seem to be of use in almost any application. It's cheap, quite strong mechanically, and, from the electrical point of view, has exceptionally high qualities of insulation. Indeed, its dielectric strength is 1kV per thou—that's an easy figure to remember!—and it is used very extensively for e.h.t. insulation. So far as the packaging is concerned, you will find it used for packing quite a number of things: from vacuum cleaners to cough sweets. So don't throw away your old sweet wrappers as they may come in useful! You can usually recognise polythene because it has a waxy feel and, in its "colourless" form, has a slightly milky appearance. Also, you can set light to it, whereupon it burns rather slowly. This, incidentally, is an easy way of selecting polythene from p.v.c., which is not so good as an insulator. P.V.C. will char, but it won't burn."

Corona Indication

"You said just now," Dick reminded him, "that some sets show up corona worse than others."

"Oh, yes, so I did," remarked Smithy. "And the reason for that is that corona causes a small amount of radio interference to be radiated. This can be picked up by any receiver with sufficiently high gain. A television receiver usually provides sufficient gain, whereupon the corona becomes apparent as white flashes on the screen. If the r.f. or early i.f. stages of a television set are badly screened, these may pick up corona interference inside the cabinet. Normally, however, corona is picked up by the aerial. If the aerial is an indoor job mounted close to the set it may pick up any corona that exists, but if it is fixed some distance away, say on the roof, it will do so only rarely. The downlead *might* pick up corona interference if it were badly matched, but I have not encountered this myself. Also you *could*, of course, have the case where a viewer with an outside aerial has a perfect picture whilst his next-door neighbour, who has an indoor aerial on the other side of a party wall, suffers with the corona!"

Dick chuckled. "That sounds a bit far-fetched to me," he remarked.

"I don't know so much," replied Smithy. "To take the argument a little further, it is quite possible for corona to occur on a line output anode or booster cathode connection without showing up on the screen at all. This is because the corona would only occur during the line flyback pulse when the screen is blanked out and the resultant interference would not be visible. If, however, the interfering set were switched to the B.B.C. and a neighbouring set was receiving the I.T.A., or vice versa, the neighbouring set might exhibit the interference because the two line frequencies would not be synchronised with each other. What the neighbouring viewer would see would be a thin vertical line made up of white flashes moving horizontally back and forth across his screen. Since the I.T.A. came on the air such cases have actually occurred. It's possible that the interference might be caused not by corona in the interfering set, but by an internal spark in a cold joint, or even by Barkhausen oscillations. Nevertheless, the trouble *does* occur and could quite easily be caused by corona."

"Well, that's something I didn't know," remarked Dick. "By the way, what are Barkhausen oscillations?"

"That," said Smithy, looking at his watch with a start, "is very much another question, my lad. I haven't even started work this morning yet; so I think we will have to consider that particular query as 'being continued in our next'."

Technical Forum

continued from page 261

Fig. 2. It will be noticed that there is a non-linear portion on either side of the zero point, and unless correct biasing is employed this discontinuity can cause audio distortion. This biasing voltage is at a frequency some five times above the top of the audio range, and it is modulated by the signal being recorded. This brings the modulation on to the straight part of the curve as shown in Fig. 2. As the bias frequency is of too high a value to appear directly on the tape, only the average value is retained. This is shown by the heavy line on the output side of the diagram. This average value accurately follows the audio signal which is being recorded.

The same biasing signal is also employed to erase or clean the tape of any past recordings before a new one is attempted. The very rapid oscillations about the zero point ensure that all traces of the previous signal are removed and that the tape is left with zero magnetisation. The erase head usually requires about 2 watts to be fully effective, which means that a reasonably substantial oscillator has to be employed. It is important that the oscillator has a good waveform free of harmonics and that it is symmetrical about the zero line. The erase head precedes the record head on the tape so that when a recording is being made the erase head cleans the tape immediately beforehand. This obviates the possibility of making a double recording.

Level Indicator

If the level at which a recording is made is too low, the signal-to-noise ratio will be raised, and also there may not be sufficient audio gain in the playback amplifier to provide a good signal. On the other hand, reference to Fig. 2 shows that if the level is too high the tape will be working on the curved part of the magnetising curve, giving a noticeable increase in distortion. Thus to enable the correct recording level to be maintained, an indicator is required. In the equipment to be described a tuning indicator is employed and is arranged so that the "petals" just close when the level is correct.

In next month's issue the complete circuit diagrams and methods of connection for these three units will be given.

TELEVISION for the HOME CONSTRUCTOR

PART 5.

by **S. WELBURN**

This month S. Welburn devotes his space to a discussion of remote control circuits suitable for application to standard television receivers

A NEW AND INTERESTING TREND IS NOW becoming apparent in the domestic television sphere. This new trend is the increasing popularity of devices designed to control television receivers from a distance. The idea behind such devices is that they enable certain circuits in the television receiver—volume, brightness, contrast, etc.—to be adjusted without the viewer having to leave his chair. Television remote controls have been employed quite extensively in the United States over the last year or so, and have been exhibited in this country (at the 1956 Radio Show) by Ekco and Philco.

The use of remote control is of especial interest to the home constructor as it enables him to carry out modifications to existing television receivers which greatly enhance their usefulness without incurring any heavy cost. Some of the remote control circuits used commercially in the States are complex, and they necessitate the use of quite large numbers of valves and relays plus, usually, a motor for operating the tuner. Complicated arrangements such as this are not, perhaps, quite so necessary in this country, where only two programmes, at most, are available. A considerable amount of practical usefulness may be obtained from much simpler devices, and it is proposed to discuss these in this article.

Remote Volume Control

Probably the most desirable feature of any television remote control system is that in which sound volume may be adjusted by the viewer. So far as their sound channels are concerned, television transmissions seem to be following the pattern set by sound broadcasting in this country, insofar that speech appears to be transmitted at a fairly low volume, to be followed by music at a disproportionately high level. This effect is irritating and can, indeed, be embarrassing to those who live in flats and apartments where consideration for neighbours is desirable.

It is a fairly simple matter to fit a remote volume control to an existing televisor without upsetting the internal wiring to too great an extent. Problems crop up when it becomes necessary to decide whether the remote volume control will be fitted to the audio or to the i.f. stages of the receiver.

Fig. 1A shows a typical a.f. volume control circuit as employed in a television receiver. At first sight it would appear that a simple way of fitting remote volume control would consist of modifying this circuit so that it took up the appearance shown in Fig. 1B. In Fig. 1B the switch transfers the control of volume from the internal to the remote potentiometer. This circuit represents a perfectly good method of remote volume control and can be recommended on the condition that certain factors are taken into account.

The first of these is that, to prevent pick-up of noise and hum, the wiring to the remote volume control must employ screened cable. However, the screened cable normally encountered for a.f. use has a rather high capacity between the centre wire and the screening, and it is quite possible that the internal capacity of the lengths of cable required for remote control purposes would be at least as high as several hundred pF. Most volume control circuits of the type shown in Fig. 1A work at high impedance, the volume control being a 250kΩ to a 1MΩ component. When it is considered that a capacity of 100pF presents a reactance of only 300kΩ (approx.) to 5,000 c/s, it will be seen that the circuit of Fig. 1B is liable to cause a quite noticeable degree of top-cut in the audio response of the receiver. A useful solution would consist of employing low-capacity screened cable for the remote leads, a good choice being provided by co-axial cable. The only disadvantage with this cable would be its slightly extra bulkiness and non-flexibility.

A second snag to the circuit of Fig. 1B appears when the internal volume control is

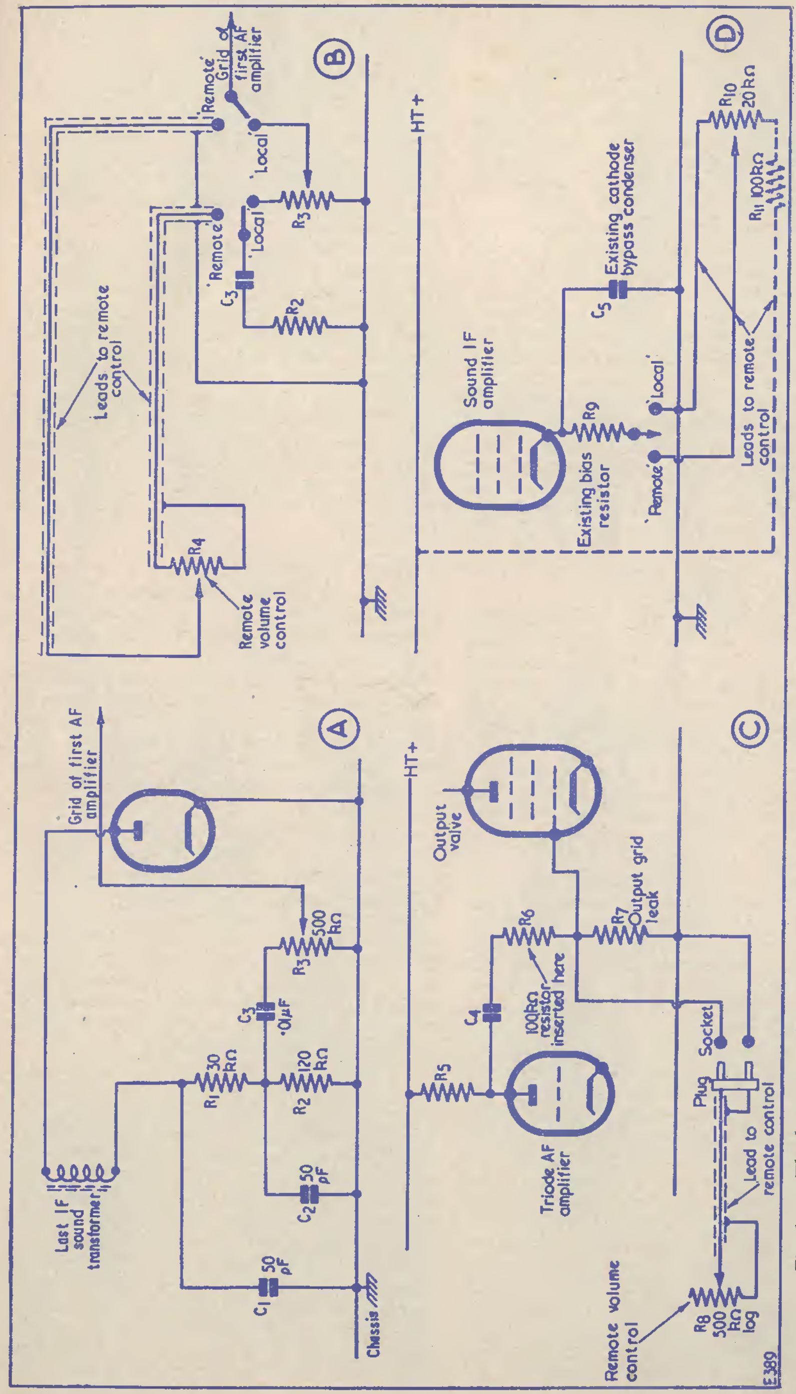

Fig. 1A. The basic sound detector and volume control circuit fitted to many receivers. The circuit values shown are fairly typical. B. How remote control facilities may be fitted to the circuit of A. The disadvantages of this arrangement are discussed in the text. C. An alternative type of remote volume control which has several useful advantages. D. Volume may be controlled in some receivers by varying the cathode bias of a sound i.f. valve, as shown here. R_{11} may be needed if it is found difficult to obtain sufficient attenuation.

placed in the circuit immediately after the sound detector (as is usually the case), and is followed by a two-stage (say, triode plus pentode) a.f. amplifier. The difficulty is caused by the fact that the considerable amount of a.f. gain provided after the volume control is liable to make the remote leads rather susceptible to hum and noise pick-up. In some cases care would be needed to prevent undue trouble from this source.

An alternative scheme, and one which, the writer confesses, is rather a "pet" idea of his, is shown in Fig. 1C. This circuit is applied to the grid of the output valve and it presumes that a triode amplifier precedes this grid. The receiver volume control, not shown in the diagram, would be in the grid circuit of the triode.

Most television receivers have ample a.f. gain, and this point is taken advantage of in Fig.1C by inserting a 100kΩ resister, R_6, between the triode anode and the output grid. The a.f. applied to this grid then becomes equal to a large fraction of the a.f. at the triode anode, the fraction being determined by the ratio of R_7 to R_7 plus R_6. In most cases the loss in gain incurred by inserting R_6 can be sustained quite comfortably.

Using the circuit of Fig. 1C the remote volume control can be plugged in, when desired, in the manner shown in the diagram, i.e., between output grid and chassis. As will be realised, the amount of a.f. applied to the grid will then be controlled by the resistance inserted by R_8, the remote control.

The main advantages of Fig. 1C are that only a single lead is needed to connect the remote volume control to the receiver, and that the whole device may be brought into circuit merely by plugging it in. When the remote control plug is removed from the receiver, the set reverts to normal functioning. Also the volume control wiring is inserted into the a.f. amplifier at a point where the risk of hum pick-up is not excessive. The disadvantages are that adjustment of the volume control varies the impedance presented to the triode anode; although the additional shunt impedance given by the circuit cannot be less than the 100kΩ provided by R_6. In practice, the varying anode load impedance causes no noticeable changes in quality of reproduction in the installations checked by the writer; indeed, there is no reason why the triode could not be working on a linear part of its I_a/V_g characteristic for any setting of R_8. The control given by R_8 may tend to be a little non-linear, insofar as db/spindle-rotation relationship is concerned, but the effect should not be at all excessive. As with the arrangement of Fig. 1B, low capacity screened wiring is advisable to prevent top-cut.

Alternative methods of remote control in the a.f. stages may consist of employing, say, a vari-mu pentode in the a.f. chain and obtaining control by varying its bias. Alternatively, control could be given by varying the screen-grid voltage of an a.f. pentode (*not* the output valve). Such arrangements are not very attractive, unfortunately, owing to the possibility of distortion. Attempting a potentiometer control in the speech coil circuit of the speaker is also not attractive, this being due to the difficulties of maintaining good matching.

Where the sound i.f. strip is not a.v.c. controlled, a useful method of obtaining remote volume control may be had by varying the control grid voltage of an i.f. amplifier (assuming a vari-mu valve). The simplest means of doing this is shown in Fig. 1D, wherein the cathode bias of the valve is controlled. The bleeder feed to h.t. positive provided by R_{11} in this circuit is desirable in cases when it is found difficult to reduce volume to sufficiently low levels. The circuit of Fig. 1D has the slight disadvantage that a local-remote switching arrangement is required.

Brillance Control

A remote control of brilliance is also a desirable feature and can usually be fitted as a plug-in device, similar to that shown in Fig. 1C, quite easily. The reason for this is that most brilliance control networks insert quite a large amount of resistance between the controlled tube electrode and chassis. Also the fact that frame blanking pulses are often fed to the controlled tube electrode results in set designers inserting even further resistance in the network.

A typical brilliance network is shown in Fig. 2A. In this diagram the tube is cathode modulated, and a potentiometer across the h.t. supply applies a varying bias to the grid, thereby giving a control of brilliance. The series resistor R_{15} provides further isolation for the grid, and frame blanking impulses are fed in via C_6 (usually 0.005 to 0.05μF). The source of frame blanking pulses to which C_6 connects usually has a fairly low impedance to chassis at video frequencies.

A remote control arrangement may easily be added to Fig. 2A by using the circuit shown in Fig. 2B. As in Fig. 1C, this device is of the "plug-in" variety; the set being automatically restored to normal functioning when the plug is removed. As will be seen, an additional resistor, R_{19}, is connected to the grid of the tube. This resistor should have a value four to five times larger than that of R_{15} in order to avoid upsetting to too great an extent the time constant of the frame blanking circuit. R_{19} has to be mounted at the *receiver* end of the remote control leads in order to isolate the tube grid from possible noise in such leads.

The remote control components consist, quite simply, of a potentiometer connected across the h.t. supply, in the manner shown in the diagram. The potentials available from the slider of the remote control R_{17} should cover approximately the same range as those given by R_{13} in the set. Indeed, the same component values could, in many cases, be employed for R_{16}, R_{17} and R_{18}, as are used for R_{12}, R_{13} and R_{14}.

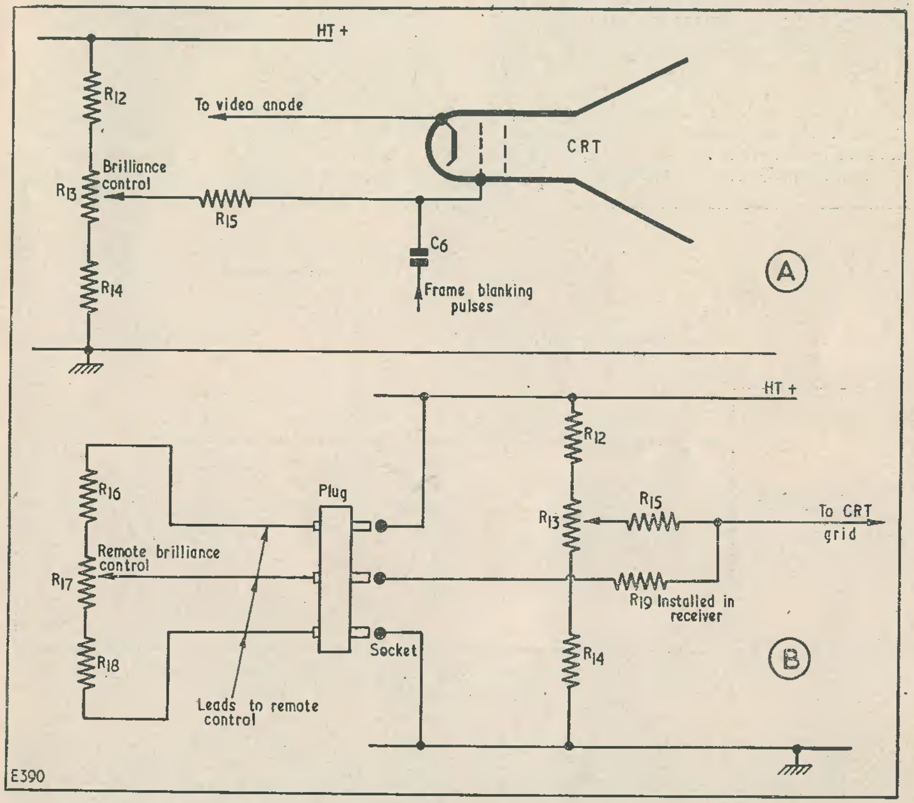

Fig. 2A. A typical brilliance control network. B. *How a remote brilliance control may be added to the circuit of* A

When used, all that is required is that the brilliance control in the receiver should be adjusted to the position in which normal brilliance is obtained. This setting may then be "trimmed" over quite a useful range by adjusting R_{17} in the remote control unit. If the range of control provided by R_{17} is lower than that desired it may be increased by reducing the value of R_{16} and R_{18} as applicable. The reason that it has a lower range of control is, of course, due to the fact that R_{19} is higher in value than R_{15}.

The circuit of Fig. 2B is applicable to grid modulated tubes as well as to cathode modulated tubes. In some receivers R_{14} or R_{12} may not be fitted, R_{13} connecting directly to chassis or to the h.t. positive rail. In such events R_{18} or R_{16} at the remote control unit may be similarly dispensed with. Also, the series resistor R_{15} may not be used in some sets, the tube electrode connecting directly into the potentiometer across the h.t. supply. In such a case it would probably be advisable to give R_{19} a value of some 250kΩ or so.

Contrast Control

A remote control of contrast is not as simple to obtain as are those of volume and brilliance, owing to the various different methods employed in receivers to achieve this control. This is especially true when a.v.c. is applied back along the vision i.f. strip, a contrast control being coupled into the a.v.c. line. An attempt to control contrast by varying the bias on the video amplifier valve cannot normally be recommended as this valve is usually working in the optimum part of its curve under the conditions imposed by the set designer.

In sets with a.v.c. lines, and in which contrast is controlled by applying a varying d.c. potential to the a.v.c. circuit, the experienced experimenter *may* obtain fruitful results by remotely varying this d.c. voltage. In such cases a "trimming" technique, such as was employed for brilliance control in Fig. 2B, would probably give good results. A point to watch is that hum and noise picked up by the wiring to the remote control may be fed into the a.v.c. circuits if precautions are not taken. In an arrangement such as that shown in Fig. 2B this snag can be obviated, if really troublesome, by decoupling the slider of the remote potentiometer to chassis by a condenser of some $8\mu F$ or so, this condenser being fitted at the receiver end of the wiring. However, the writer would like to reiterate that this is a job which is best tackled by the more experienced enthusiast, and only then after a careful study of the circuit of the particular receiver concerned has been made.

For receivers without a.v.c. in the video i.f. strip, the question of controlling contrast becomes merely that of controlling the gain of an r.f. valve in the manner shown in Fig. 1D. A control of gain of an i.f. valve may also be successful, but with some strips such a control may cause alterations in the i.f. response curve.

It is possible that other methods of remote control of contrast may be quite workable also. Unfortunately, the contrast circuits employed in modern television receivers are rather diverse, and it is difficult to attempt to discuss them collectively in the space of a single article.

Remote Fine Tuning

An interesting little problem is presented by the arrangement needed to obtain remote control of fine tuning. The method usually suggested for this particular circuit consists of employing a crystal diode in the receiver oscillator circuit. When a crystal diode is connected to a source of potential in the non-conducting mode, its capacity varies over quite large amounts according to the voltage applied to it. This varying capacity may then control the oscillator frequency of a television receiver, it being controlled in its turn by a varying voltage at the remote control unit. The change in capacity is rather like that given between grid and cathode of a valve whose space charge varies, although with the crystal diode, the "space charge" is given by the free electrons and holes adjacent to the surface barrier. Although the crystal diode is very promising as a means of fine tuning control in commercial receivers, it raises problems for the home constructor. This is due mainly to the fact that it has rather a low r.f. impedance. However, good results might be given if it were connected across the oscillator in series with a condenser of some 5 to 15pF.

An interesting alternative arrangement is shown in Fig 3.*

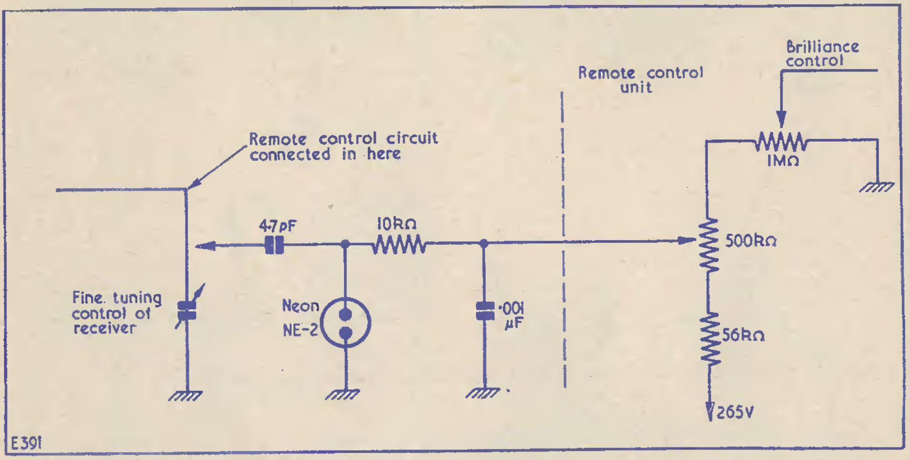

Fig. 3. The remote fine tuning control arrangement employed in the R.C.A. KCS. 96 chassis

This circuit is that employed in the R.C.A. chassis, type KCS.96. The device is said to function by reason of the fact that the resistance of the neon varies according to the potential applied by the $500k\Omega$ remote control potentiometer. This varying resistance alters the effect of the 4.7pF condenser on the oscillator tuned circuit and thus varies the oscillator frequency. The writer has not had a chance to try out this arrangement in practice but offers it (with aplogies to G. A. French!) as an interesting suggested circuit for the experimenter.

The NE-2 neon appears to be a frequently employed unit in the States. The writer does not know of a British equivalent, but feels that most miniature neons would work fairly effectively in the circuit, so long as the requisite voltage control range is found.

Safety Precautions

Before concluding, the writer must point out that the remote control devices described above involve connections to the receiver chassis. As most television receiver chassis are connected directly to one side of the mains, the remote control unit and wiring are liable to become live. In consequence, the usual safety precautions must be taken.

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* "Remote Controls for T.V." Henry O. Maxwell, *Radio-Electronics*, Sept. 1956.

Can Anyone Help?

Requests for information are inserted in this section free of charge; subject to space being available

P. D. ROBERTS, 28 Mumbles Road, Blackpill, Swansea, wishes to buy or borrow the circuit of the RT-34/APS-13 Tail Warning Unit (420 Mc/s); and also the circuit and bias details of the B2 Receiver.

* * *

CAPT. G. A. DARE, R.A.S.C., Command Supply Depot R.A.S.C., Sudbrooke Park Camp, near Lincoln, is willing to pay for any information on the circuit of a Beaver Radio a.c. mains radiogram. The chassis employs a coil pack on the front panel, 3-waveband, and the valve line-up is 6K8, 6K7, 6Q7, KT61 and 5Z4.

* * *

R. TURTON, 6 Shortwood Crescent, Hucknall, near Nottingham, has failed to obtain circuit details of the R.D.F.1 Unit No. 1, ZC.13312. Any reader who would lend, sell, or even write about it would secure his grateful thanks.

* * *

P. DUTE, The Radio Shop, Mercantile Buildings, Calcutta 1, India, wishes to obtain a copy of the August 1954 issue of this magazine, or of Suggested Circuits therein. Please reply by airmail; reimbursement will follow immediately.

* * *

G. M. SIFFERD, c/o "Franklin House," Upper Frog Street, Tenby, Pembrokeshire, S. Wales, requires information on the R.C.A. manufactured transmitter model A.T.B. Aircraft Radio Equipment, type CRV/52233.

* * *

E. G. LAMBERT, 4 Edward Street, Hull Road, Hessle, E. Yorks, wishes to buy or borrow the circuit details of a leaky grid r.f. pentode detector, using a separate valve for reaction, as believed to have been used in the ST800.

S.A.C. PAYNE, Hut 343, 3 Wing, R.A.F. Compton Bassett, near Calne, Wilts, is willing to buy any data on the transmitter that goes with the Army Receiver type 107.

* * *

G. POTTER, 4 Shakespeare Way, Hanworth, Middlesex, wishes to buy or borrow circuit and alignment details of the Murphy V.200A television receiver.

* * *

K. E. SUTTON, 45 Tournament Road, Salisbury, Wilts, requests information on, or the service sheets for, the 15-valve Murphy A.40 console; and will gladly pay for any assistance given.

* * *

J. B. RYAN, 98 Raphoe Road, Crumlin, Dublin, Eire, wishes to obtain the circuit diagram and service data of the Crossley 728-A receiver.

* * *

R. C. READER, 14 Motton Road, Woolton, Liverpool, wishes to hire, buy or borrow the circuit and servicing data for the Pullman radio No. 60443, and also the circuit, or if possible, the manual for the Taylor Valve Tester 45C.

* * *

23285027 SIGMN. PURDY, L.8 "D" Troop, 2 Squadron, 1st Training Regt. Royal Signals, Catterick Camp, Yorks, wishes to obtain the circuit and/or details of the R-26/ARC-5 receiver (Valve line-up 12K8, 12SK7 (2), 12SR7, 12A6 and 12SF7; range 3–6 Mc/s).

* * *

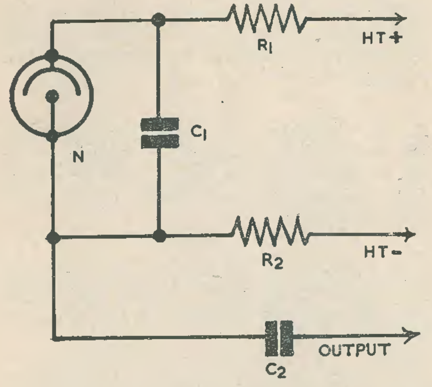
H. A. FORRESTER, 58 Bede Avenue, Durham, wishes to obtain on sale or loan the circuit and data of the American Pelican IV receiver.

(continued on page 251)

A MINIATURE AUDIO OSCILLATOR

by G3XT

THERE IS, FRANKLY, NOTHING NEW ABOUT the use of a small neon bulb as the "heart" of a miniature audio oscillator. The circuit will probably be familiar to a good many readers. But this handy device does not seem to be as widely known and used as it deserves to be, in view of its low cost, small size, light weight and general usefulness in tracing faults, especially in audio amplifying stages, modulators, etc.



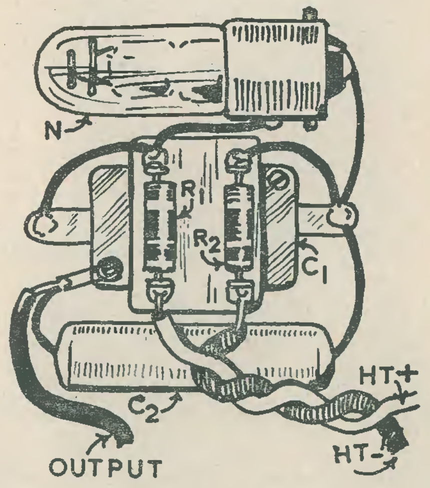
NEON AUDIO OSCILLATOR 01

Although admittedly a poor substitute for a proper signal-generator, this little oscillator has some special merits of its own. Whereas the full-size generator is a comparatively heavy and bulky piece of equipment to carry around, the neon oscillator is so small and light that it can be slipped into one's pocket (and is too cheap to make much of a "hole" in it!)

Alternatively, it can be built into a spare corner of a home-made multi-purpose test-meter, thus extending the usefulness of the latter. The neon needs no separate power supply as it derives the necessary striking voltage from the h.t. in the receiver or amplifier under test.

With a suitable h.t. voltage applied, the neon glows steadily and generates an audio note that can be heard from the loudspeaker when the oscillator output test-prod is applied to the signal grids of the audio stages in the set. Although chiefly useful for audio stages, the oscillator will also provide a check, of sorts, on preceding stages as well.

The portability of this small gadget makes it a handy thing to take with you, if you are called upon to trace a fault in a receiver at a friend's house.



SUGGESTED LAYOUT 02

Component values in the writer's version are as follows, *but these should be taken only as a rough guide*, actual values for a given neon being best found by experiment:

R_1, 1 MΩ, ½ watt; R_2, 100 kΩ, ½ watt; C_1, 0.002 μF, mica; C_2, 0.01 μF, tubular paper.

A different choice of capacity for C_1 will after the c.p.s. pitch of the audio note.)

Three flex leads (or a length of 3-core flex), terminating in miniature crocodile clips for the h.t. positive and negative leads and in a test prod (or another croc. clip, if preferred) for the output lead, are also required. A suitable layout is suggested in the sketch, but the components have been spread out to show the wiring clearly, and in practice they can be more compactly assembled, making the whole thing remarkably small. The writer fitted one version into a safety-razor case with transparent plastic lid, and another into a home-built testmeter, as already mentioned. But any small box of insulating material will do.

The writer used three-core flex for the test-meter leads, the cores being colour-coded red, black and green. The green one is permanently connected to the neon oscillator output only and is used for that exclusively. The red and black pair are so arranged that they can be switched (a) to the h.t. positive and negative tags on the oscillator for set testing, or (b) to the meter and its associated resistances or shunts for checking volts, milliamps and ohms. A two-wafer multi-way switch serves the dual purpose of either selecting the required meter range or feeding the h.t. from receiver to neon.

CLUB NEWS

Details for insertion in this section should reach us not later than 7th of the month of publication. Insertions are subject to space being available.

LIVERPOOL AND DISTRICT AMATEUR RADIO CLUB

Programme for November: 6th, G2AMV—Complete requipment for sensitive detection of TVI and for aligning filters for its attenuation; 13th—Inter-Club Quiz, versus West Lancs; 20th—Construction Contest; 27th—Rummage Sale (radio). Meetings are held every Tuesday at the Wavertree Community Centre, Penny Lane, Liverpool, 18. Further details are obtainable from the Hon. Sec., A. D. H. Looney, 81 Alstonfield Road, Knotty Ash, Liverpool, 14.

ROMFORD RADIO SOCIETY

The Society's autumn programme includes talks on audio equipment (Nov. 27th) and test equipment (Nov. 13th); two film evenings (Nov. 20th and Dec. 11th); fixed and mobile operation on 28 Mc/s (Nov. 6th) and operation of the 150W club Tx as conditions allow.

Meetings are held every Tuesday at 8.15 p.m. at RAFA House, Carlton Road, Romford, where visitors will be welcome. Further information can be obtained from the Hon. Sec., N. Miller, 55 Kingston Road, Romford.

THE SLADE RADIO SOCIETY

The Club Station at the Church House, High Street, Erdington, Birmingham, 23, is available every day of the week for the use of members. Instructional and constructional classes are held every Tuesday and Wednesday evening. Nov. 2nd—Whist Drive; 9th—Microwave Techniques, by Mr. T. J. Hayward, G3HHD, of the R.A.F. School of Radio; 23rd—Annual General Meeting. Further particulars from the Hon. Sec., C. N. Smart, 110 Woolmore Road, Erdington, Birmingham, 23.

CRAY VALLEY RADIO CLUB

At the November meeting to be held at Station Hotel, Sidcup, Kent, on Tuesday 27th at 8 p.m. Mr. L. Clinch will talk on "Natural Sound in the Home." There will be a demonstration of home-built equipment accompanying this talk. Visitors, particularly those interested in recent audio developments, are cordially invited to the meeting. Hon. Sec., S. W. Coursey, G3JJC, 49 Dulverton Road, New Eltham, S.E.9.

THE BRADFORD AMATEUR RADIO SOCIETY

November meetings: 6th—Town Hall Clock and Carillon, by W. Barton, F.B.H.I.; 20th—Visit to Burley Street Repeater Station, Leeds. Meetings are normally held at 7.30 p.m. on alternate Tuesdays at Cambridge House, 66 Little Horton Lane, Bradford; morse instruction preceding the meetings at 7 p.m. Further particulars, and a copy of the Syllabus 1956–57, from the Hon. Sec., F. J. Davies, 39 Pullan Avenue, Eccleshill, Bradford, 2.

CRYSTAL PALACE AND DISTRICT RADIO CLUB

Meetings are held at Windermere House, Westow Street, Crystal Palace, S.E.19 on Fridays at 7.30 p.m. Hon. Sec., A. J. Worrall, 169 Kent House Road, Beckenham, Kent.

CLIFTON AMATEUR RADIO SOCIETY

November Diary: 2nd, 9th and 23rd—Constructional and Ragchews; 16th—Progress of the Avometer, by Mr. J. A. Thomas; 30th—Junk Sale.

Meetings are held every Friday at 7.30 p.m. at the clubrooms, 225 New Cross Road, S.E.14. Details of membership from the Hon. Sec., C. H. Bullivant, G3DIC, 25 St. Fillans Road, S.E.6.

A TRANSISTOR SUPERHET
WITH CLASS B OUTPUT

by **H. A. JENNERS**

A description of the new superhet receiver available, in kit form, from Henry's Radio, Ltd.

THE INTEREST SHOWN BY HOME-CONSTRUCTORS in transistor receivers has been very evident over the last two years. During this time *The Radio Constructor* has devoted a considerable amount of space to this new trend and has published articles describing transistor receivers. To date, these receivers have been of the t.r.f. type. A transistor *superhet* for the home-constructor is now readily available and this article, which is devoted to its description, takes on some consequent importance.

The kit for the receiver is available from Henry's Radio Ltd. Two versions of the receiver are available, the only difference between these being the audio output stages. The basic design of the receiver employs a number of modern features not previously encountered in amateur transistor receivers. Typical of these is the fact that the set employs inductors especially made for transistor operation. Thus, the oscillator coil is designed for use with transistor r.f. oscillators, whilst the i.f. transformers are similarly wound with transistor requirements in mind. The inductors are made by the Teletron Co. Other features of similar interest and value will be recognised in the circuit description which follows.

The Circuit

The circuit of the receiver is given in Fig. 1. This circuit is that of the version which employs a transformer-coupled Class B output stage. The version with the alternative output stage will be described later in this article. As has just been mentioned, the circuit of the receiver incorporates several interesting departures from the t.r.f. techniques at present familiar to home-constructors. A typical example is provided by the frequency-changer circuit. In this, the first transistor TR_1 functions both as oscillator and mixer.

With many of the transistors at present available on the home-constructor market it is difficult to design a transistor oscillator capable of functioning reliably over a range of frequencies higher than the medium-wave band, whilst still retaining a reliably high amplitude of oscillation voltage at all frequencies covered. However, this has been achieved here by the use of a special r.f. transistor (blue coding) plus carefully planned circuitry.

As an oscillator, the transistor TR_1 may be considered as operating in the earthed base mode, the oscillator tuned circuit connecting to its emitter, and the feedback coil to its collector. The emitter is tapped down the tuned coil to obtain optimum matching with least damping of the tuned circuit, whilst the resistor R_2 serves to take up the slight differences in characteristics which are liable to appear from individual transistor to transistor. The oscillator tuning is provided by one section of the two-gang condenser C_{1B}; C_7 being a trimmer. The circuit is padded by C_6.

As a mixer, transistor TR_1 functions largely in the earthed emitter mode. The particular transistor employed in this receiver is capable of appreciable gain at r.f., and especially at the intermediate frequency of 315 kc/s used here, with the result that the earthed emitter connection assists noticeably in providing a useful conversion conductance. The signal input is applied to the base of the transistor by means of a matching winding on the ferrite frame. The main coil of the ferrite frame is tuned by the remaining section of the gang, C_{1A}, and is trimmed in conventional fashion by C_2. The resistor R_1 maintains a condition of non-linear amplification in TR_1, thereby enabling frequency changing to take place. The condenser C_4 serves as a bypass for the oscillator feedback coil without upsetting to too great

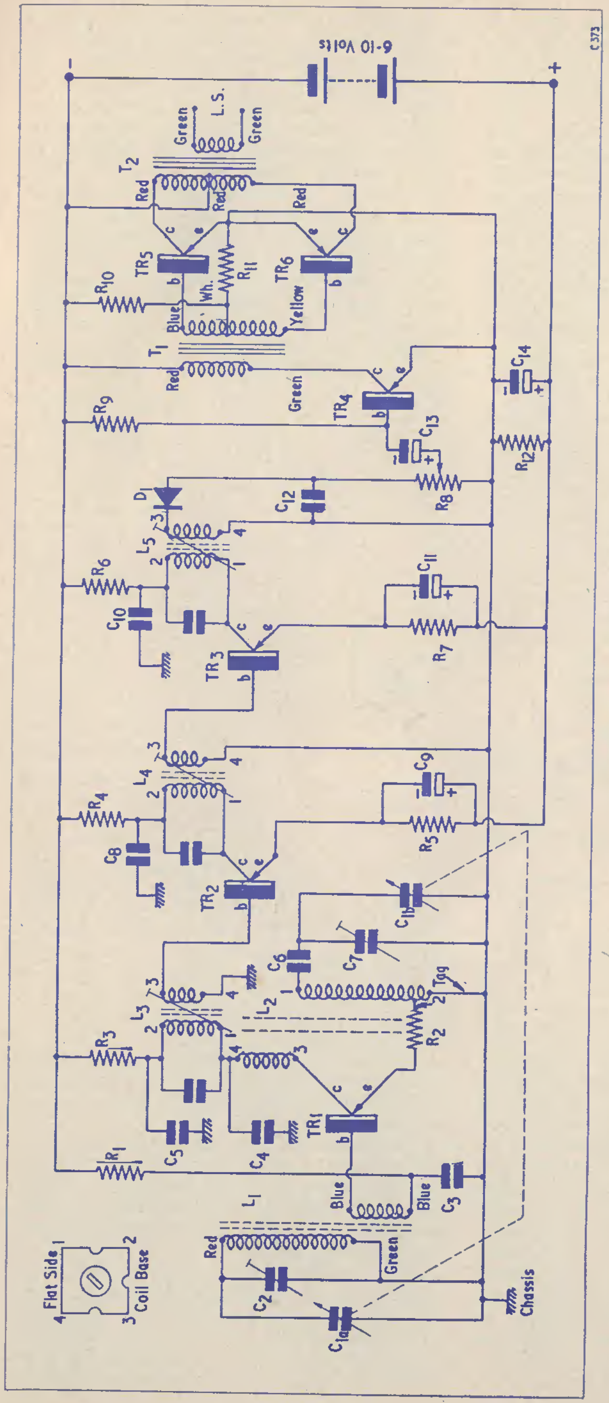


Fig. 1. The circuit of the transistor superhet

Resistors

R_1	8.2MΩ
R_2	0 to 100Ω
R_3	2.2kΩ
R_4	470Ω
R_5	2.2kΩ
R_6	1kΩ
R_7	560Ω
R_8	10kΩ
R_9	1MΩ
R_{10}	6.8kΩ
R_{11}	180Ω
R_{12}	470Ω

Condensers

C_1	365pF 2-gang (J.B. type O)
C_2	30pF
C_3	470pF
C_4	300pF
C_5	0.01μF
C_6	0.001μF
C_7	30pF
C_8	0.01μF
C_9	25μF
C_{10}	0.01μF
C_{11}	25μF
C_{12}	0.01μF
C_{13}	2μF
C_{14}	50μF

Coils
(All coils by the Teletron Co. Ltd.)

L_1	FRM2.	Ferrite rod aerial
L_2	FTO2.	Oscillator coil
L_3, L_4	FT3E.	315 kc/s i.f. transformer
L_5	FT3D.	315 kc/s i.f. transformer

Transistors

TR_1	R.F. (Blue spot) Henry's Radio Ltd.
$TR_{2, 3, 4, 5, 6}$	(Red spot) Henry's Radio Ltd.

N.B.—For direct coupled operation (Fig. 2) TR_5 and TR_6 are Mullard OC72

Diode

D_1	Crystal diode. Henry's Radio Ltd.

Transformers

T_1	Fortiphone type 203
T_2	Fortiphone type 204. (Required for Fig. 1 version only)

an extent the coupling into the first i.f. transformer. As this coupling is at low impedance, the effect of C_4 on i.f. gain is almost negligible.

The I.F. Stages

Special transistor i.f. transformers are employed in the receiver. These operate at the low impedances necessitated by transistor working, especial care being taken to ensure an accurate match into following transistor base-emitter circuits. Each of the i.f. transformers is tuned in the primary, adequate selectivity being obtained from the three transformers employed in the whole circuit. The intermediate frequency is 315 kc/s.

The first i.f. transformer in the circuit, L_3, transfers the i.f. energy from transistor TR_1 to transistor TR_2. This second transistor functions in the earthed emitter mode but its bias supply differs slightly from usual practice. Normally, it is conventional to bias the base of a p.n.p. transistor negative to chassis. In this receiver the base is kept at chassis potential, so far as d.c. is concerned, whilst the emitter is biased positive. This positive bias is obtained via R_5, which connects to the automatic bias voltage dropped across R_{12}. This arrangement allows a useful amount of stabilisation to be obtained without the use of current-consuming potentiometers connected across the h.t. line.

Transistor TR_2 amplifies in normal fashion, feeding via the second i.f. transformer L_4, into the third transistor TR_3. This transistor functions in a similar manner to TR_2.

The third i.f. transformer, L_5, follows TR_3, and has a secondary winding designed to match into the crystal diode D_1 and its load. This diode rectifies, allowing the consequent a.f. to appear across the volume control R_8. Due to the low impedance at which the r.f. and i.f. stages work, the receiver exhibits a high degree of stability, and excessive r.f. filtering does not become necessary. The condenser C_{12} adequately bypasses i.f. voltages.

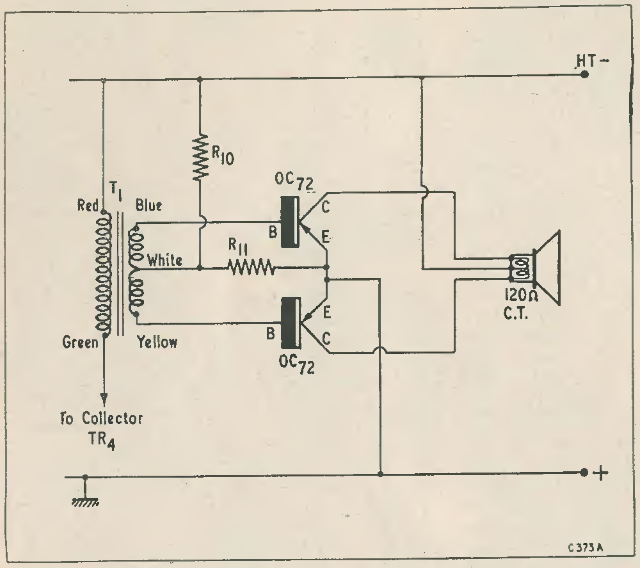


Fig. 2. An alternative output stage, in which the output transistors couple directly into the voice coil of the speaker

The A.F. Stages

The a.f. stages follow modern commercial practice, consisting of a driver, TR_4, supplying two output transistors, TR_5 and TR_6, in Class B push-pull.

Transistor TR_4 is operated, again, in earthed emitter mode, its bias being supplied via the resistor R_9. It feeds into the phase-splitting transformer T_1, this being a specially designed transistor component manufactured by Fortiphone.

The output transistors operate in push-pull, a heavily stabilised bias voltage being provided by the resistors R_{10} and R_{11}. The bias voltage is such as to allow the transistors to work in Class B, thereby enabling a high output power to be obtained without incurring distortion or the dissipation of excessive power in the transistors. The output transformer is, again, a specially designed transistor component, and is also manufactured by Fortiphone. This component matches accurately into the speaker, which requires a voice coil impedance of 3 ohms.

Alternative Output Stage

As was stated above, the version of the receiver shown in Fig. 1 is that in which a transformer coupled output stage is employed. This circuit provides an output power of approximately 100mW. An alternative output stage is also available in which the two output transistors feed directly into the centre-tapped voice coil of the speaker. The speaker is the Elac 7in. by 4in elliptical unit, having a 120 ohm centre-tapped voice coil, and it is designed especially for transistor work. The amended output stage circuit is illustrated in Fig. 2.

The new output stage employs Mullard OC72's in place of the transistors specified for TR_5 and TR_6 in the circuit of Fig. 1. It also enables an increase in output power to be realised, this now extending up to 200mW.

New Philips Car Radio

"Easy-to-Fit" Car Radio. 12-volt operation easily adapted for 6-volt.

Two wavebands—Permeability tuning covering: Long Wave 1,070-2,010 metres. Medium Wave 186-584 metres. **Controls**—On/off and volume, wavechange, tuning, two-position tone control. **Valves**—ECH42, EF41, EAF42, EL42, Synchronous Vibrator. **Consumption** (approx.)—2 amps at 12 volts, 3.9 amps at 6 volts. **Loudspeaker**—5-inch provided with universal housing. **Dimensions**—Front 7 × 2in x depth 7⅛in. Height at back 3⅛in. **I.F. Frequency**—470 kc/s. **Weight**—6lb 11oz (excluding speaker). **Features**—(1) The set fits snugly into most British cars, including many which have a special space for radio. (2) For instrument panel lip installations, the receiver can be completely fitted, including standard suppression and aerial, in about 2 hours. A single bolt only has to be released for removal of set. (3)A dial bulb can be changed by the owner without dismantling the set from the car. (4) The set can be altered from 6V to 12V operation—or vice versa—in approximately 20 mins. without changing the vibrator or dial bulb and without the use of a soldering iron. (5) Single unit receiver plus separate speaker. An additional speaker may be fitted, connected in series. (6) Easily accessible on all sides for servicing after removal of top cover. **Price**—£16 16s. 11d. plus P.T. £6 5s. 1d.—22 gns.

Radio Miscellany—*continued from p. 259*

Wot—No Moral?

No doubt many readers were amused by the recently reported story of the man who, fed up with his broken-down T.V. after having repeatedly sent it back for repair, took it back to the dealers and heaved it through the window. Although I am generally credited with a fair amount of patience, I have a sneaking feeling that we poor humans should be treated with greater understanding when driven by exasperation to take desperate measures. However, the magistrate seemed to take a dim view of the affair, and it must be admitted it wouldn't do for us all to yield to our primitive instincts even if we are unlucky enough to buy a hoo-doo t.v.

Unfortunately, the knowledge that to get redress by legal means may be a costly, hard-to-prove, time-wasting and an even chancy business, tends to heighten one's anger. So whether you have actually been stung, or you merely imagine it, experience once again teaches that it's much cheaper to grin and bear it. I once knew of a set like that. No sooner had one thing been put right than something else went wrong. Perhaps the moral should be—invest five bob in *T.V. Fault Finding*. So far any other moral to be drawn from this tragi-comedy eludes me.

Mullards Exhibits at the Society of Hearing Aid Audiologists' Exhibition

Transistors and germanium diodes were exhibited on the Mullard stand at this exhibition. In addition to the OC70 and OC71 junction transistors, now used in many normal transistor hearing-aids, there were two new subminiature transistors, the OC65 and OC66, for use in especially small aids such as those built into spectacle frames.

These subminiature types have similar characteristics and maximum collector dissipation ratings to miniature types OC70 and OC71, but they are only a quarter the size.

Point-contact germanium diodes were shown, since these are now widely used in automatic volume control systems in hearing-aids. A new subminiature diode, the OA91, is particularly suitable for this purpose.

Additionally, the OC45 R.F. junction P.N.P. transistor with a maximum alpha cut-off frequency of 6 Mc/s was on view, as well as the new OC16, P.N.P. junction power transistor, in metal construction, for use in audio output stages.

MAGNETIC TAPE RECORDERS

Some design considerations for the Home Constructor

PART 1

by A. BARTLETT STILL

READERS OF *The Radio Constructor* WILL, no doubt, recall that previous articles by other writers have given the necessary constructional details for those wishing to build a tape recorder in the home workshop designed around a particular commercial tape deck. It is not the purpose of this short series of articles to discuss the construction of any particular recorder, but rather to consider some of the more general aspects of the design of these instruments, as it affects the amateur enthusiast.

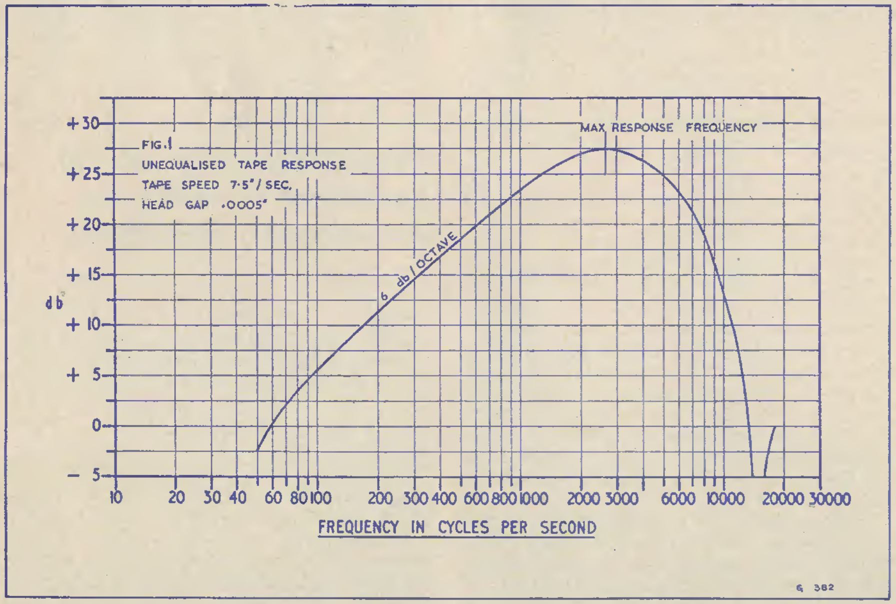


FIG.1
UNEQUALISED TAPE RESPONSE
TAPE SPEED 7·5"/SEC.
HEAD GAP ·0005"

The mechanical construction involved in the handling mechanism will generally be beyond the resources of the home workshop. As a result the tape unit, including the all-important heads, is usually bought as a complete assembly, and it may be said that units are available of good design and reasonable price.

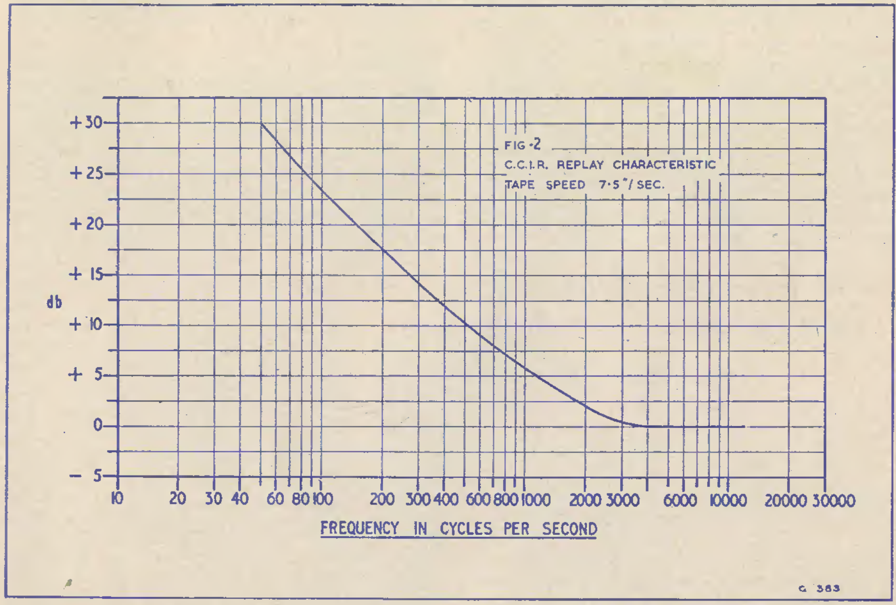
Before making a choice, no doubt the published specification will be studied, and too much care cannot be taken over this. In the writer's opinion, the most important item apart from the heads themselves, which will be dealt with separately, is the figure quoted for "wow" and "flutter." If need be, the manufacturers should be asked for this figure in order to avoid spending many pounds on a tape deck that would never give real satisfaction. Two-speed decks usually operate at 3¾ inches per second and 7½ inches per second, and it is normally expected that the wow and flutter figures are higher at the slower speed. This will more generally be used for speech, however, and is allowable. At 7½-in/sec., used for musical recording, a figure of 0.5% is the highest that should be considered, since at this level flutter would be discernible on a sustained note. 0.25% can

be expected from a well-designed, reasonably priced deck, and should prove entirely satisfactory.

The type of recording/playback head fitted is another major consideration. Heads will be of high or low impedance, or the inevitable compromise that so often proves attractive. High impedance heads, due to the self-capacity of their windings, may offer serious shunting to the higher audio frequencies, apart from the greater danger of hum pick-up on playback. Low impedance heads require a matching transformer, with consequent insertion loss, but this transformer may sometimes be positioned with advantage to "buck" any hum induced in the head. Heads of medium impedance have, however, found most favour. They may be directly coupled to the amplifier, and combine reasonable output with good frequency response. The d.c. resistance of the head will be a few hundred ohms only, but the impedance at 1 kc/s is of the order of 3 to 4 kΩ, rising to, say, 50kΩ at 12 kc/s. The head should be well shielded, and preferably fitted so that the gap may be aligned for the best high frequency response.

These considerations are, in the writer's submission, of far greater importance than ease of tape handling, fast rewind speed, and some of the more obvious "sales points."

Let us now imagine that we have decided on the deck we are to purchase, and wish to design the necessary amplifier and oscillator unit. What are the basic requirements? A flat frequency response over as wide a range as possible, a low overall record/playback distortion level, a low noise level, sufficient sensitivity on "Record" to make effective use of a microphone, and sufficient signal on "Playback" to feed the power amplifier decided upon. In the case of a portable unit the latter will usually be a single output pentode, requiring some 10 volts of drive in order to allow the degree of negative feedback desirable when a small output transformer is used.


FIG·2
C.C.I.R. REPLAY CHARACTERISTIC
TAPE SPEED 7·5"/SEC.

The overall frequency response that can be achieved in any particular case will depend on a number of factors. Those concerned on the one hand with the heads of the tape deck, and on the other with the tape in use, are beyond our control. Those that remain will be considered where they apply.

One of the biggest single factors affecting the frequency range that may be obtained is, of course, the effective gap width of the head, some 15–20% greater than the actual gap. A normal record head gap that may be expected is 0.0005-in actual, and with such a head, using a good brand of tape, a frequency response of 50–12,000 c/s ± 3db with respect to 1 kc/s should be aimed at. As will no doubt be realised, to this end a great deal of amplifier equalisation is needed, and the writer intends to consider this problem in some detail. Fig. 1 shows the unequalised response from a head such as that under consideration, when the recording is made with the audio head current constant at all frequencies. To obtain level response, therefore, the equalisation provided should result in a "mirror image" of that curve. Before we consider, however, how the equalisation shall be effected, we come to the question of "when." For a recorder that is to be used solely for recording and replaying its own tapes the question does not arise; but in view of "pre-recorded tapes," to play on that machine tapes recorded elsewhere, some standard is obviously required. Such a standard, indeed, exists and was set up in London in 1953 as an international standard governing the exchange of programmes recorded on tape. Known as the C.C.I.R.* standard, the increasingly popular "tape records" are made to the same specification. In order that a standard may be derived in spite of the many variables mentioned above, the reproducing amplifier characteristic only is specified, in terms of an "ideal" head. The record characteristic may thus be modified to suit bias, tape, head, or any other consideration.

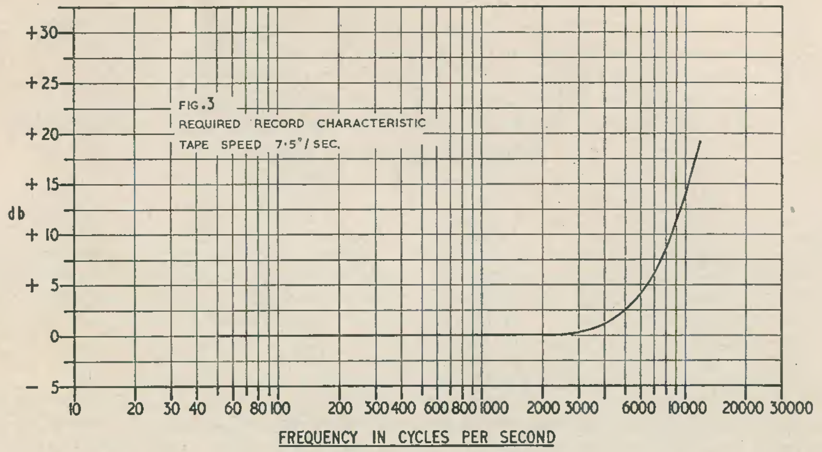


FIG.3
REQUIRED RECORD CHARACTERISTIC
TAPE SPEED 7·5"/SEC.

With the head we are considering, the replay frequency response will be as shown in Fig. 2. It will thus be seen that frequencies above the "hump" are given pre-emphasis, while those below are equalised on play-back. This arrangement, while ideal in that it reduces tape "hiss" to a minimum, does require great attention to one aspect of amplifier design and layout. On playback we have a gain amplifier, boosted at 50 c/s, with a metal-cored inductance connected to the input, an open invitation to mains hum! It should, nevertheless, be possible to obtain a noise level some 50 db down on the maximum signal level. The curve of Fig. 2 is specified as "falling with increasing frequency in conformity with the impedance of a series combination of a capacitance and a resistance having a time constant of 100 microseconds." Considered as a bass lift, it can be taken as a rise of 6 db per octave with a turnover at 2 kc/s.

By comparing Figs. 1 and 2 we can obtain Fig. 3, the recording characteristic necessary if we are to realise the flat response aimed at.

It will be appreciated that the tape curve of Fig. 1 will vary with a given tape, particularly at the high frequency end, with different settings of bias current in the recording head, so let us now examine in what other ways the bias level can affect our recording. On any given sample of tape there is a "Critical Bias" I_{bc}, being that current giving greatest output at the audio frequency of maximum response. At this point it may well be stated that, to avoid undesirable harmonic "beat" effects, the frequency of the bias should be at least 4 and preferably 5 times the highest audio. "Critical Bias," however, though assisting in obtaining a high signal output with a consequently improved noise ratio, is by no means the optimum in respect of distortion or frequency response. Minimum distortion is achieved at a bias figure about double I_{bc}, but at this setting our 12 kc/s may well have taken a nose dive! The optimum bias setting will generally lie between 1.4 and 2 times I_{bc}. Fig. 4 shows the effect of varying the bias current in respect of output from the tape and third harmonic distortion, the audio frequency in this instance being 1 kc/s. The compromise setting decided upon will, therefore, be related to those two curves and the output available at 12 kc/s.

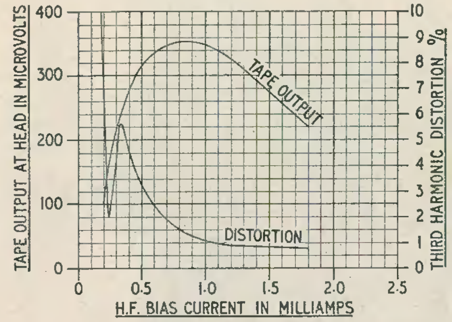


FIG. 4. TAPE OUTPUT & DISTORTION PLOTTED AGAINST BIAS CURRENT.
TAPE SPEED 7·5"/sec.
AUDIO FREQUENCY 1kc/s $I_{bc} = 0.55$ mA
BIAS FREQUENCY 51 kc/s

In order to keep the tape hiss referred to earlier at a minimum, the bias waveform should be good, as also the waveform of the current supplied to the erase head. Both heads will normally, however, be supplied from the same source and will require a total power of some two watts. This is well within the capabilities of an output pentode of, say, 4 watts anode dissipation, since it will generally be working under class "C" conditions. There are several oscillator coils available for such circuits, and the reader would be well advised to invest the few shillings involved, rather than attempt to wind a component that may prove to give a poor waveform and, consequently, recordings that suggest "frying tonight."

From our examination of the problem so far it will be seen that we are virtually faced with the two separate problems of recording and replaying. It is for reasons of economy and compactness only that a common amplifier is used in portable equipment; examination of the switching involved tends to rule out simplicity.

It is intended in further articles to consider separately and in some detail the design of, first, the recording amplifier, and, secondly, the replaying amplifier. In a concluding article the two amplifiers will be "married" together and considered as a portable unit.

to be continued

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* Comite Consultatif International des Radiocommunications.

Can Anyone Help?

continued from page 241

B. D. Mindel, 67 Templars Avenue, Golders Green, N.W.11, urgently requires any information on the Indicator Unit 62A, and any circuits for it; also any data on the R.F. Unit type 26.

* * *

F. W. Chattaway, 105 Clovelly Road, Wyken, Coventry, wishes to buy or borrow the service sheet or circuit diagram of the Etronic television receiver model ECV.1527 HM.

W. Draper, 33 Harold Road, Sutton, Surrey, requires any information on the ex-W.D. Amplifier type A.1368, ref. No. IOU/13025.

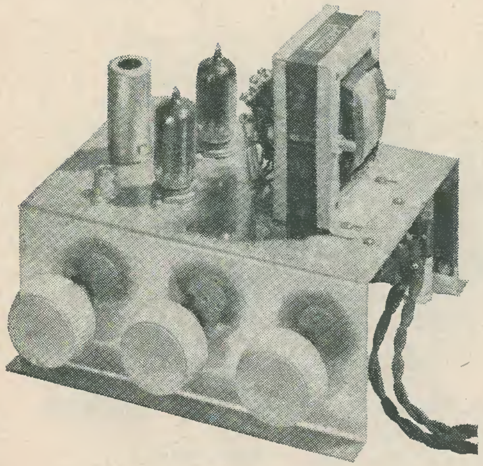
* * *

F. Hammond, 10 Vicarage Gate, Guildford, Surrey, asks if any reader can supply him with circuit details for conversion of the Indicator Unit type 6A to an oscilloscope. Any expense incurred will be repaid.

* * *

G. E. Mynott, Kinston Villa, Dolphin Road, Shoreham-by-Sea, Sussex, wishes to obtain the circuit and service data on the Philips radio type 727U.

The "JUNIOR"



4-VALVE 5-WATT ULTRA-LINEAR AMPLIFIER

PART 1

by **G. R. WOODVILLE***

Introduction

THE GENERAL ELECTRIC CO. LTD. HAVE been responsible for many high fidelity audio frequency amplifiers within the past few years. Two of the amplifiers designed in their laboratories, the "Williamson" and the "912," are claimed to have been built in greater numbers than any similar type. Even in the U.S.A. several firms market the "Williamson" as a factory assembled product.

Both these amplifiers have an output exceeding ten watts and a fidelity rating considerably better than the associated apparatus, i.e. the loudspeaker and the record player; it is, therefore, unlikely that any improvement in amplifier design would be justified at the present stage, though higher-powered "Williamsons" (50 watt) are sometimes used when a greater output is required.

It is felt, however, that many people do not require either the high power output or the exceptional fidelity and range of tone control provided by the above amplifiers and, for use with lower-priced loudspeakers, etc. (which represent excellent value for money), an amplifier having a lower initial cost is called for. This amplifier is now presented for the home constructor as the "JUNIOR."

Circuit Description

The "JUNIOR" amplifier has an output of five watts with less than two per cent distortion, with an anode supply voltage as low as 250 volts so that the smoothing capacitors and mains transformer are low priced. Four valves are used, two of which are triode-pentodes connected in the ultra-linear (UL) circuit, giving five stages of amplification with only three valves, the fourth (U709) being the rectifier. Approximately six db degeneration is applied from the output to the second stage. Before the first valve is a bass control to increase or decrease the lower frequencies, and between the first and second valves a stepped treble control giving four degrees of response to the higher frequencies. These controls are simpler and use fewer components than those employed in the "912," but are capable of giving satisfactory results from LP and from normal 78 records. The full range of control is also available when connection is made to an a.m. or f.m. radio receiver. The circuit is shown in Fig. 1.

The overall sensitivity with the tone controls set "level" is such that full output is given for half a volt input, which is more than adequate to cater for all the medium-priced crystal pickups. Lightweight needle armature pickups may require a slight modification to

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* The M.O. Valve Co. Ltd.

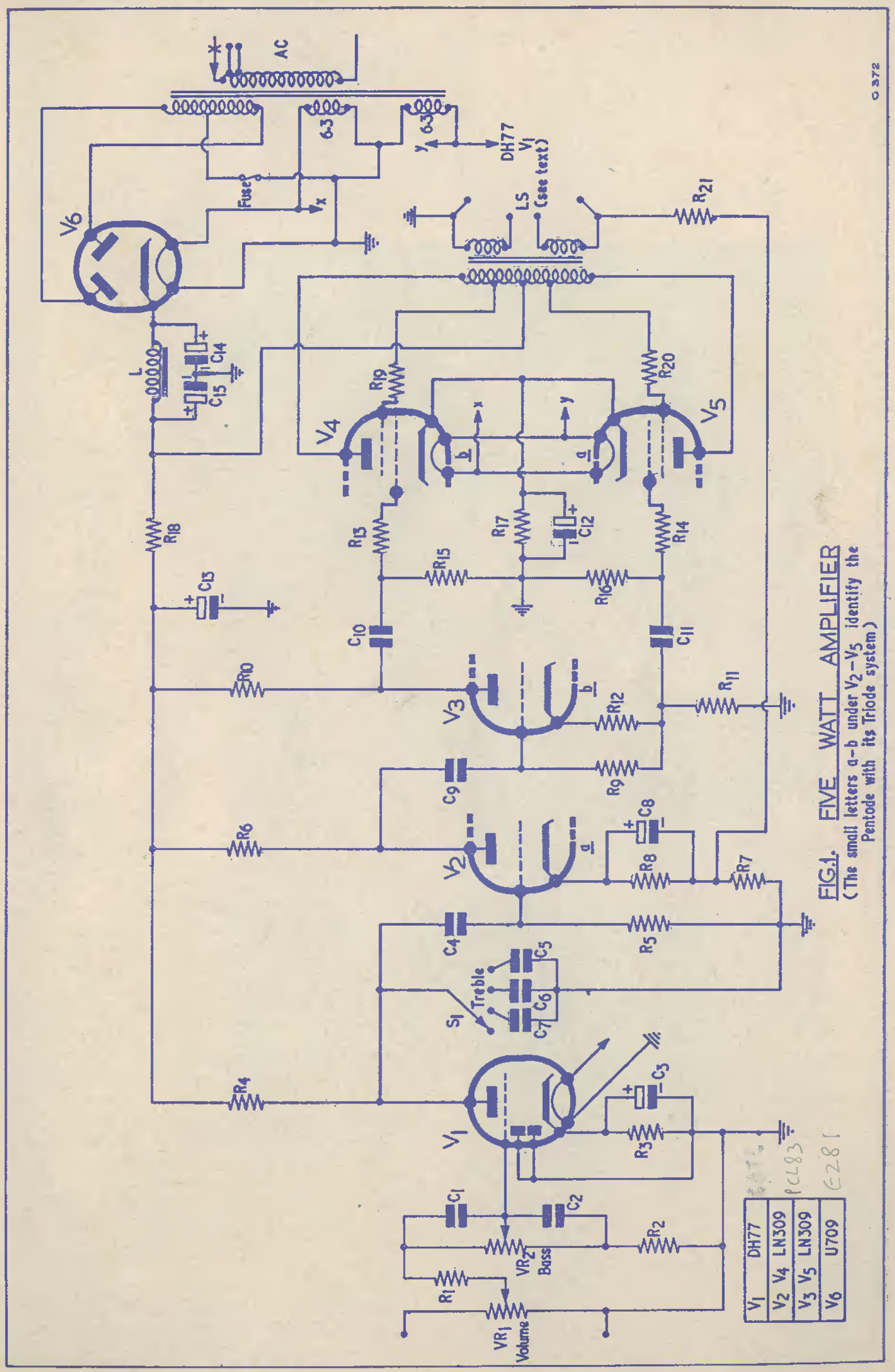

FIG. 1. FIVE WATT AMPLIFIER

(The small letters a–b under V_2–V_5 identify the Pentode with its Triode system)

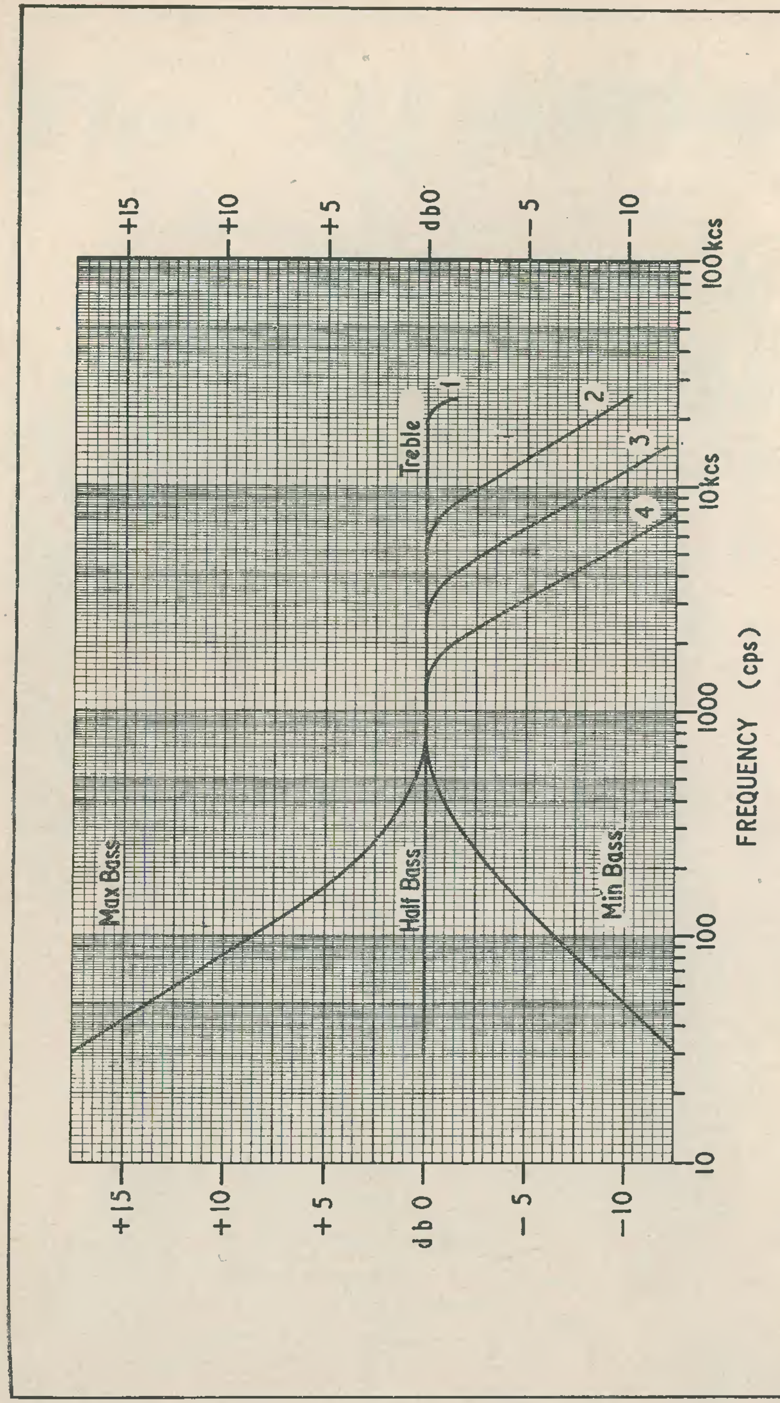

FIG.2. FIVE WATT AMPLIFIER
FREQUENCY RESPONSE

the input circuit, and the makers' recommendation should be followed. The basic sensitivity of the amplifier from the grid of the first valve is considerably higher, fifty millivolts (0.05 volt) giving full output.

In Fig. 3 is shown the behaviour of the amplifier; the distortion, which is under 2% at 5 watts, falls below 1% at 3 watts. Fig. 4 shows that the amplifier is not critical to the output load impedance used and, although 8,000 ohms is the optimum, a satisfactory performance is obtainable from 6,000 to 16,000 ohms or higher. This is one of the many desirable features of the UL circuit which enables the G.E.C. JUNIOR to outperform other low-priced amplifiers and, without change of output transformer ratio, either one or two loudspeakers could be used with no serious increase in distortion. Fig. 5 shows the total range of frequency response available at various settings of the two tone controls, which are completely independent of each other. The Bass control is so arranged that the response is level when the control knob is set half-way. When the Treble control is set clockwise the response is level to 15 kc/s.

The Operating Conditions for the Valves are as follows:

	DH77	*LN309* *Triode* 1	*LN309* *Triode* 2	*LN309* *Pentodes*
Anode voltage	100	75	120	245
Cathode voltage	1.2	3.5	50	18.5
Cathode current (mA)	0.5	1.5	3.5	28

The Power Supply

The JUNIOR AMPLIFIER requires a power supply of 250 volts at 65 milliamps d.c., and this is provided by a U709 rectifier from a transformer having a 250–0–250V winding. Two fairly large electrolytic capacitors C_{14}, C_{15} of 32 μF each are used with a choke L of 5 henrys. The two 6.3V heater windings are connected in series so as to provide 12.6 volts for the LN309 valves, whereas the DH77 and U709 are connected from one side of either winding and to their junction point, which is earthed, and so obtain 6.3 volts. A fuse protects the transformer in case of a short circuit. When connecting the two 6.3 volt windings together they must be series-aiding or the LN309 will not operate, though no damage will be done. The other two valves will, of course, heat with either connection.

Circuit Details

The output stage uses a pair of LN309 valves V_4, V_5 in the UL circuit with the screen grids connected to taps at 20% of primary turns. One of the triodes, V_3, is used as a phase-splitting stage to provide a push-pull input for the output valves. The other triode, V_2, is used as a voltage amplifier with degeneration applied to its cathode. Valves V_2, V_5 comprise one of the triode pentodes and V_3, V_4 the other, this arrangement giving the neatest wiring; however, the difference is not marked and V_4, V_5 could be interchanged. The two resistors R_{10}, R_{11} should be a matched pair, though the actual resistance is

COMPONENTS LIST

Resistors

R_1	470kΩ, 20%, ¼W
R_2	47kΩ, 20%, ¼W
R_3	2.2kΩ, 20%, ¼W
R_4	150kΩ, 20%, ¼W
R_5	1MΩ, 20%, ¼W
R_6	68kΩ, 20%, ¼W
R_7	47Ω, 20%, ¼W
R_8	2.2kΩ, 20%, ¼W
R_9	470kΩ, 20%, ¼W
R_{10}	15kΩ } Matched pair
R_{11}	15kΩ
R_{12}	470Ω, 20%, ¼W
R_{13}	22kΩ, 20%, ¼W
R_{14}	22kΩ, 20%, ¼W
R_{15}	470kΩ, 20%, ¼W
R_{16}	470kΩ, 20%, ¼W
R_{17}	330Ω, 10%, 1W
R_{18}	15kΩ, 10%, ½W
R_{19}	220Ω, 20%, ¼W
R_{20}	220Ω, 20%, ¼W
R_{21}	220Ω, 20%, ¼W

Condensers

C_1	0.001μF, S/Mica or Paper
C_2	0.01μF, Paper
C_3	50μF, 12 volt—Electrolytic
C_4	0.01μF, Paper
C_5	0.002μF, S/Mica or Paper
C_6	~~0.01μ~~F, S/Mica or Paper 0·001μF
C_7	500pF, S/Mica
C_8	50μF, 12 volt—Electrolytic
C_9	0.01μF, Paper
C_{10}	0.01μF, Paper
C_{11}	0.01μF, Paper
C_{12}	25μF, 25 volt—Electrolytic
C_{13}	8μF, 250 volt—Electrolytic
C_{14}	32μF } 450 volt—Electrolytic
C_{15}	32μF } Dual Section

Valves (all G.E.C.)

V_1	DH77	6AT6
V_2–V_5 } V_3–V_4 }	LN309	PCL83
V_6	U709	EZ81
VR_1	1MΩ Log	
VR_2	2MΩ Log	

Mains transformer: 250–0–250V, R.M.S. at 65mA D.C. 6.3V, 1A. 6.3V, 1A. Primary 200–250V.
Output transformer: Gilson, type WO905
Choke: 5H, 65mA, D.C., 100 ohms, or larger (see text)

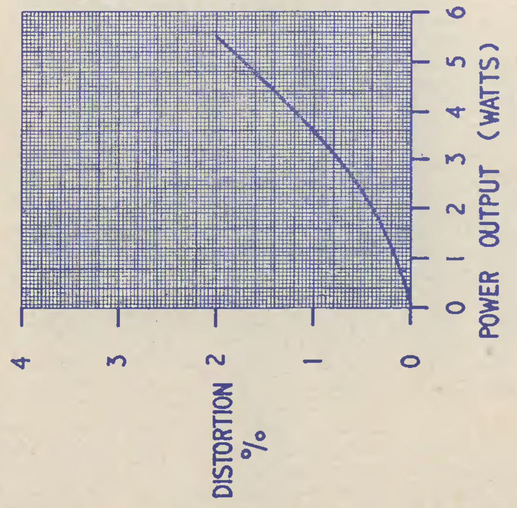

FIG.3. FIVE WATT AMPLIFIER

15Ω AT SECONDARY = ANODE TO ANODE LOAD OF 8000Ω AT SECONDARY

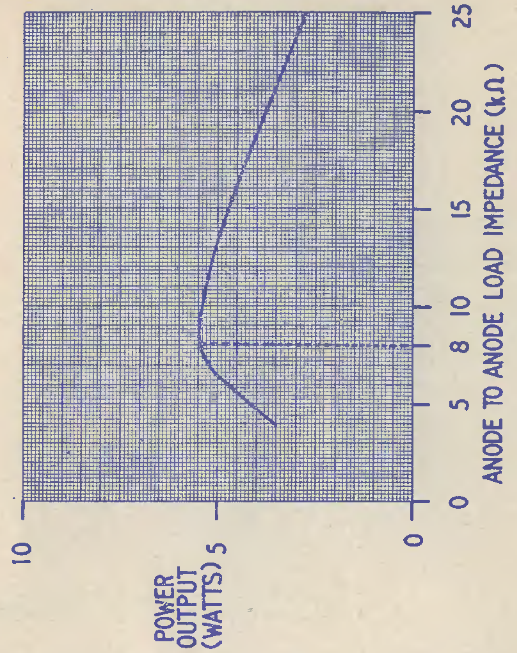

FIG.4. FIVE WATT AMPLIFIER

OUTPUT FOR 2% DISTORTION

G 373 B

not critical. From the components list it will be seen that R_{18} has a similar specification so that a pair of well-matched resistors may be selected from the three if measuring gear is available. It usually is possible to pick a pair matched to within 1,000 ohms, but satisfactory operation is given if this matching cannot be done.

The Bass control VR_2 should be wired so that C_2 is connected from the tapered end of the resistor to the slider. This is the anticlockwise end looking from the spindle. The operation will not be so smooth if the opposite connection is used. The Bass control is connected between the volume control VR_1 and the first valve, V_1.

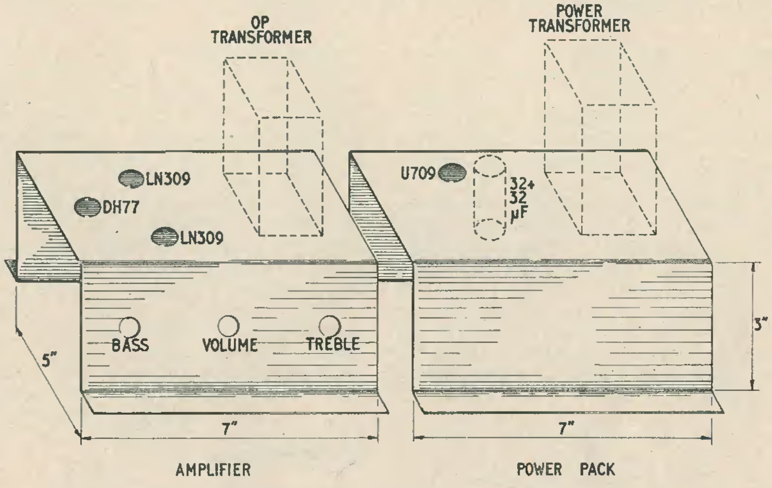

FIG.5. FIVE WATT AMPLIFIER — CHASSIS LAYOUT

A Combined Chassis may be used if preferred

G 374

Degeneration is applied via R_{21} to R_7. The value of R_{21} will depend on the loudspeaker impedance used; with a 15 ohm speaker the resistance will be 330 ohms and half this value, 150 ohms, with a 3.5 ohm speaker. However, very satisfactory results are obtainable with a compromise value of 220 ohms, giving a slight fall in sensitivity with a 15 ohm speaker and an equivalent slight increase in distortion with a 3.5 ohm speaker. The difference is inaudible and only apparent on measurement.

Mechanical Details

The amplifier has been made up on two small similar sized chassis so that, if required, the power supply may be placed at the bottom of a cabinet and the amplifier in the most convenient position for use. However, there is no objection to the use of a combined chassis provided that the input of the amplifier is kept away from the power transformer.

Next Month — Constructional Data and Point-to-point Wiring Diagrams.

TWEETER UNITS by GOODMANS

Dear Sirs,—We would like to draw your attention to a slight inaccuracy in your article entitled "A constructor visits the 1956 National Radio Show" which appeared on page 176 of your October issue.

On page 177, under the sub-heading of Audio, reference is made to electrostatic tweeters being demonstrated by Goodmans and W.B.

We feel we should point out that in actual fact the tweeter units demonstrated by ourselves, which are new products introduced for the first time at the Radio Show this year, and called the TREBAX, are in fact horn-loaded pressure units and are not electrostatic units at all.

Yours faithfully,
for Goodmans Industries Ltd.
T. R. B. Threlfall.

Radio Miscellany

CENTRE TAP *talks about* *Items of General Interest*

DESPITE MY RATHER GLOOMY APPRAISAL last month of the prospect of line amateurs being able to collaborate in the matter of radio tracking the Earth Satellite next year, quite a number of readers seem to feel they might as well have a go on their own initiative, and they press for further details. There is certainly no reason that a lone amateur should not startle the experts, especially if the totally unexpected happens. It has happened before. Experts are apt to prepare for the expected and base their plans on theoretical suppositions. When Marconi first spanned the Atlantic by radio, the "experts" not only said it was impossible but even doubted it after it was achieved. Few of them believed that signals might follow the curvature of the earth, and reflection from ionised layers was undreamed of. In later years the "short waves" were given to the amateurs to play around on because they were thought to be of little value for much else. Yet it was short-wave radio which proved to be the most valuable medium for world-wide communications!

Project "Vanguard"

Here are a few details that may be helpful by way of supplement to those given last month, for readers hoping to follow the Satellite's fortunes when it starts on its journey from Cape Canaveral, Florida. The frequency selected for its radio transmitter is 108 Mc/s, but the power output will be only of the order of 10 milliwatts. This is expected to last out for a minimum period of two weeks. The aerial is to consist of four radiators spaced equally in a circle around the sphere, which will produce circular polarisation in the plane of the radiators. Thus the location of optimum reception (the area receiving circular polarisation) will shift with the Earth's and the Satellites rotation.

There will certainly be quite a thrill in detecting signals from the Satellite, but accurate measurement of them would be a big undertaking requiring numerous expensive components. Attempts to get universities and big industrial concerns to back club projects are afoot; but, so far as I know, nothing definite has yet been decided.

Propagation Research

While on the subject of specialised listening and reporting, mention should be made of an interesting mass observation programme planned by the A.R.R.L. It is to cover v.h.f. propagation (at 50 Mc/s) and the co-operation of both transmitting and listening amateurs is invited. The data will be collected and analysed for the A.R.R.L. by W1VLH to supplement the scientifically more exact, but less extensively covered, information obtained from scatter soundings.

The programme includes observation concerning trans-equatorial scatter on 50 Mc/s, auroral communication on *any* frequency *above* 50 Mc/s, and sporadic-E skip. Full details are to be published in QST of a later date, and there will probably be a monthly bulletin for circularisation among contributing observers.

International Friendship

Many readers will have already heard with pleasure of the award by the Council of the R.S.G.B. of the Calcutta Key to our old friend Dr. Arthur Gee (G2UK). Better known for his writings on amateur radio, both as a contributor and Editor, R.A.E.N. and local club activities, and his work with the Solar Eclipse Expedition in 1954, he has also rendered much good service behind the scenes. With this award his service to the cause of international understanding and friendship—a cause in which our interests lie most closely parallel—is at last recognised. In linking myself with this very worthwhile cause, I should hasten to add that he has on occasion attended international conferences on amateur affairs. My own contribution has, perhaps, been of a more personal nature, although once again it has to me been more of a pleasure than a sense of duty. It is nice when you can combine a worthwhile cause with your own pleasure, although I must confess that I should feel rather ashamed of my modest part if publicly given credit for it.

I hope no one will feel I have implied that Arthur's concern has been chiefly confined to the business side of international radio. Indeed, we both share many good friends among European amateurs, and if at any time I have been guilty of plugging anything in this column, it has been the encouragement of the radio fraternity to get to know and understand other nationals who share their interests. You quickly find you have not only a hobby, but a great many other things in common.

The continentals do see much more of each other than we ever see of other nationals. Consequently they mix more easily. Our geographical insularity, too, seems to have become reflected in our national character. We are certainly slower to make friends, but at the first sign of a friendly gesture you invariably find the European peoples quickly responsive. In the early days it was hoped that broadcasting would be the means of promoting better international understanding. Unhappily it was, and still is, used for propaganda and sowing the seeds of international distrust. Amateur radio, by its very nature, has done more for a better understanding than any other single medium. Unfortunately it has not been on a wide enough scale, and anything that furthers this excellent work deserves the widest encouragement.

Looking back over the years I often feel a touch of remorse at having achieved so little, but I can always find a grain of consolation at the solitary small item I can honestly claim on the credit side. I am the "English Uncle" to quite a lot of continental junior ops, and I feel rather proud about it. I use the phrase English rather than British Uncle, because that's how they themselves put it. Curiously enough, to most continental people we are all English, whether Scots, Irish or Welsh, but perhaps that merely proves what I have already said about not properly knowing each other!

Ham Bands

Close on the heels of the "888," about which I had a few words to say last month, comes news of a converter of considerable interest to those specialising in amateur bands reception. It is of very neat appearance and thoughtfully designed to make it equally as useful for mobile operation as it is for shack use. For this reason, especial attention has been given to compactness (8in × 7in × 6½in) and power economy (6.3V at 0.6 amps, and 150–200V at 15mA). The built-in power supply uses a contact cooled metal rectifier which may be switched out under mobile conditions, and its modest requirements in this respect can often be satisfied from the receiver itself.

It is supplied with i.f. outputs of either 1.5 or 6 Mc/s to order, making it equally suitable for use in conjunction with either a communications type or ordinary broadcast receiver. This converter covers the five main amateur bands, 3.5, 7, 14, 21 and 28 Mc/s, giving full bandspread over a wide, full-vision "slide-rule" scale. When used with a superhet receiver, of course, the advantages of double-superhet reception are obtained. Provision is made for remote control receive/stand-by switching.

While the value of a converter on the 3.5 and 7 Mc/s bands is debatable (except in cases where the receiver itself does not cover them), the advantages gained when used on the three Dx bands are enormous, and are readily appreciated by transmitting amateurs and the keen shortwave listener. The performance of even the best receivers tends to fall off sharply at this part of the radio spectrum.

Most readers will, I imagine, have had some experience of converter construction, and invariably the first question asked by the converter-minded is "What valves does it use?" The answer—6BX6 and 6AJ8. Priced at £17, it fills a definite gap in the range of equipment for amateur band enthusiasts, and will add still further to the high reputation the Minimitter Company have earned for well-designed ham band gear.

Dilemma

Now that I.T.V. is in its second year, perhaps those who not only opposed it bitterly but also foretold an early failure are feeling a bit foolish. Fortunately for them the public have short memories for such things. Certainly, an impressive number of advertisers are buying more space, and the proportion of viewers who have a choice is now nearing a ratio of 7 to 3 in favour of I.T.V.

We already know the answers to questions such as "Do the public want I.T.V.?" and "Will the B.B.C. programmes improve as a result of competition?" to be a couple of yes's. As a consequence it is the turn of the B.B.C. itself to find the answer to a question that is becoming increasingly important. It is, "What do we do next?" The choice is either to spend more money to recapture the Light programme audiences, or to concentrate on the more serious viewers. What would you do, chums?

(*continued on page 247*)

Technical Forum

A Method of Modifying a Standard Audio Amplifier for use with a Tape Deck

JUDGING FROM OUR CORRESPONDENCE, there can be very few home constructors who have not by now made an audio amplifier, either to one of the many excellent published designs or to a developed circuit which had some particular merit at the time. Whilst this may be a slight overstatement of the true position, there can be little doubt that the making of amplifiers has gained considerable popularity of late, and that there must by now be many thousands giving good service. More lately the marketing of several very good tape decks at reasonable prices has prompted constructors to consider the possibility of using the existing amplifier in a complete tape equipment. There are two ways in which this may be achieved; one is to make a self-contained add-on unit which drives the recording head and merely utilises the main amplifier for replay purposes, and the other method involves making minor additions to the amplifier so that it performs both record and replay functions. It almost goes without saying that the second method is the cheaper of the two, and this is the one which we will consider in this and the ensuing article.

Basically, the additional circuits which are required are in themselves simple and can be conveniently divided into three parts, the pre-amp/equaliser, the bias and erase oscillator and the level indicator. The need for adding these sections will be considered in some detail so that the reader may better understand the problems involved in converting the amplifier.

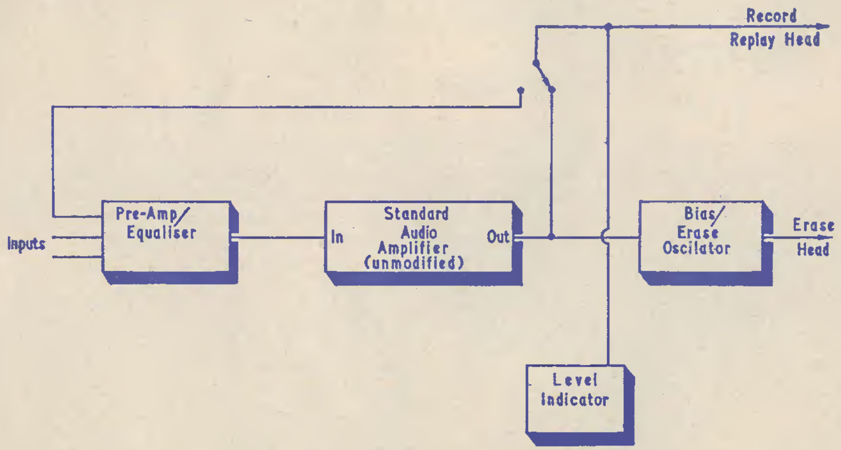

FIG. 1. Block diagram showing the additional sections which are required

Pre-Amp-Equaliser

No doubt the basic amplifier will have a substantially flat response curve over the audio range, and in all probability some form of tone control will be incorporated. However, because of certain shortcomings in the method of tape recording, this flat response will need some correction or equalisation during both record and replay. The main reasons that such correction is required are as follows:

(1) The degree of magnetism retained by the tape after recording decreases as the frequency increases. As the tape is drawn past the recording head the magnetic molecules which it contains are orientated to form tiny north and south poles along its length corresponding to the positive and negative half-cycles of the signal being recorded. As the frequency rises these opposing poles become closer together and thus some demagnetisation takes place due to partial cancellation of their fields. This effect can obviously be reduced by increasing the speed of the tape, but this has practical limitations.

(2) There is a greater tendency for the a.c. bias to act as an erase signal at the higher audio frequencies.

The recording attenuation of the upper frequencies because of these points is quite considerable; and, to prevent the signal falling to a point near the noise level, appreciable treble boost is used when making a recording. Also the following factors affect the replay response and require compensation during the play-back process.

(3) The voltage induced into the playback head by the passage of the magnetised tape depends upon the rate of change of the flux which cuts the coils in the head. Now the rapidly changing flux set up by those sections of the tape carrying a high frequency induce a greater voltage than a section carrying a low frequency, even though the level of magnetisation may be the same in both sections.

(4) The physical dimensions of the gap in the replay head gives rise to a small reduction in treble response when the individual magnetic components on the tape are of similar width. This effect is small compared with that described in (3) and does not compensate for it.

The main replay characteristic thus has a rising frequency response, and to equalise it without any substantial increase in noise level appreciable bass boost is used. Thus to summarise the foregoing, it is standard practice to record with boosted treble and replay with boosted bass. As these are fundamental requirements in tape equipment, a standard has been generally agreed in a similar fashion to that now adopted for long-playing gramophone records. Thus if the characteristic of the tape equipment is made standard it may be used to play any of the pre-recorded tapes which are now appearing on the market. This point is well worth bearing in mind when making tape recorders, as it is quite probable that in the near future pre-recorded tapes will become as popular as L.P.-records are today.

Standard R–C filters are employed in the equalising circuit, and to make up the loss over these a single stage amplifier is added.

Bias and Erase Oscillator

If a tape is subjected to a given magnetising field it will retain a certain degree of magnetism. It is possible to plot a curve showing this characteristic for various degrees of magnetising field; such a curve is shown in

(*continued on page 235*)

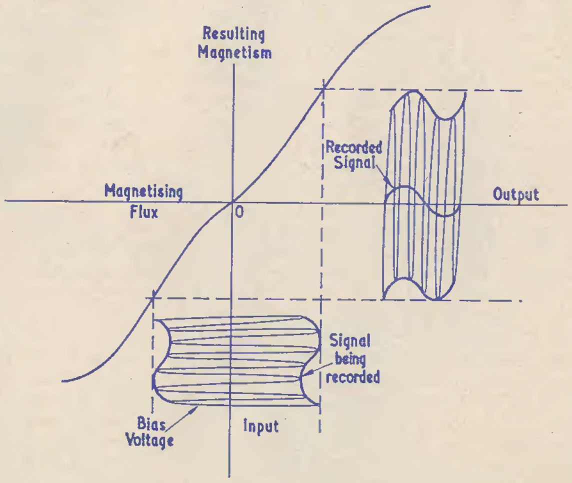

FIG. 2.

Radio Control of MODEL AIRCRAFT

PART 2

by "QUENCH COIL"

Actuators

THE TWO-PAUL ACTUATOR ALREADY described in previous notes can be applied quite well to model aircraft control. Some constructors may feel that the two-pawl actuator is better for the newcomer to radio control of aircraft, and the writer used this type himself to start with. One of its greatest advantages is that one has only to release the transmitter key and stop the signal, when the actuator will return the rudder to neutral. Unfortunately, there are, of course, two neutral positions; one with right rudder following and the other with left following. This is a distinct disadvantage when the model is flying at a distance, as it is very difficult to see whether the model is being turned one way or the other. Furthermore, this type of actuator draws current during the whole of the time when the rudder is deflected.

This drain on the batteries can be reduced, however, by fitting an economy switch, the principle of which becomes apparent by referring to Fig. 5. It depends for its operation on the fact that once the armature is fully attracted, it will need considerably less current through the coil to keep it there. Referring to Fig. 5, we see that the current to the coil passes through a resistor R. This has two flexible contacts "A," "A" across it as shown. In the neutral position these contacts are shorted by the arm of the escapement, so that full current can flow through the coil. Once the armature has been attracted to the coil, and the arm turned by the actuator rubber motor to the dotted position, the contacts open and the current to the coil must then flow through the resistor "R," being decreased according to the resistor's value.

This value must be found by trial and error. To do this, set up the actuator on a small wood frame exactly as it would be in the model (Fig. 6). Obtain a length of 36 s.w.g. silk-covered resistance wire and connect one end to one of the contacts. Connect in the battery to be used with the actuator. Then, by trial and error, find what length of resistance wire will just hold the armature against the pole piece of the coil. Shorten the length of the wire an inch or two to allow for voltage drop in the battery when in use, and wind on to a short length of ⅛in dowel and connect permanently across the contacts. In the case of a low resistance actuator which normally takes about ½ to ¾ amp., the current can be reduced to 100–150mA by this method, the full current flowing for a fraction of a second only.

A Three-Pawl Actuator

This type of actuator has a number of advantages over the two-pawl type, as a description of its mode of operation will illustrate (Fig. 7).

The receiver relay operates in the usual way; with no signal from the transmitter the anode current is at a maximum and the relay is pulled in, thus breaking the actuator circuit. With the transmitter on, the anode current drops to zero, and the relay drops out, thus making the actuator circuit and energising the actuator coil. This will attract the armature of the escapement and the claw *a* will disengage the pawl *c* and allow the pawl wheel to be turned in a clockwise direction by the rubber motor until pawl *e* is stopped by claw *b*. On switching off the transmitter, the receiver anode current will rise, pull in the relay, break the actuator circuit and de-energise the actuator coil, thus allowing the armature and the claws to be pulled back by the return spring, releasing pawl *e* from claw *b* and allowing it to rest against claw *a*. Thus pawl *c* has now been moved through 120° and its movement transmitted via the coupling rod to the rudder crank, thus deflecting the rudder to the left.

It will be seen that by quickly switching on and off the transmitter, we have moved the rudder from the neutral position to the left. Similarly another pulse will give "right rudder" and a further pulse will return the rudder to neutral once more. If the aircraft is on a straight course and a left turn is desired, the transmitter key is depressed and released immediately. When the turn is completed, two pulses following each other will neutralise the rudder—the rudder passing through the right rudder position sufficiently quickly not to affect the course of the model.

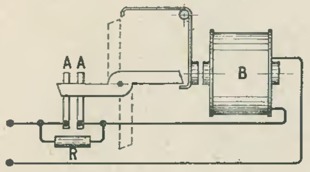

FIG.5. ECONOMY SWITCH

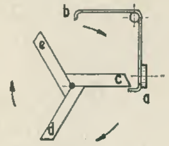

FIG.7.

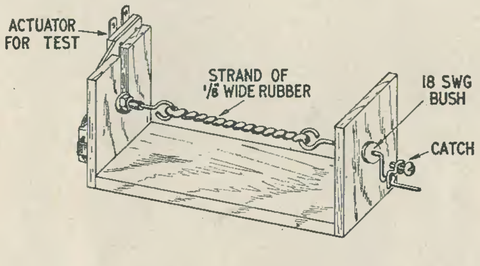

FIG.6. TEST FRAME

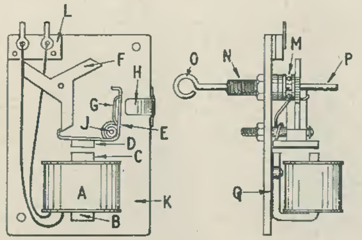

FIG. 8.

KEY TO 3-PAWL ACTUATOR

A	4 ohm coil wound with 30s.w.g enamelled wire
B	Soft iron core
C	Brass 'anti-residual' strip
D	Soft iron armature
E	Escapement arms
F	3-Pawl escapement
G	Return spring
H	Return stop
J	Pivot
K	Paxolin base
L	Terminal block
M	Miniature thrust race
N	Shaft bearing
O	Hook for rubber motor
P	Shaft coupled to rudder crank
Q	Distance piece

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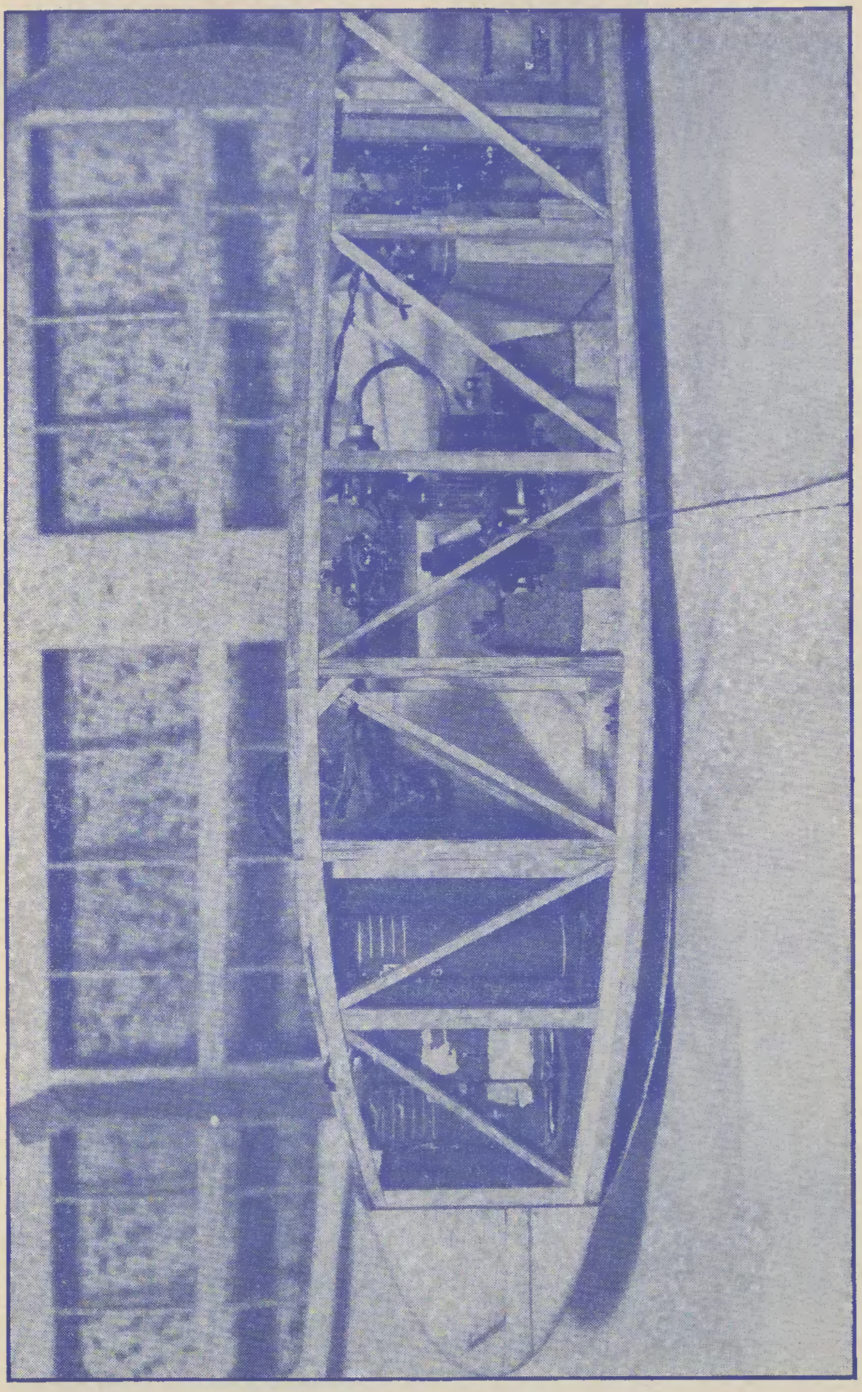


Fig. 10

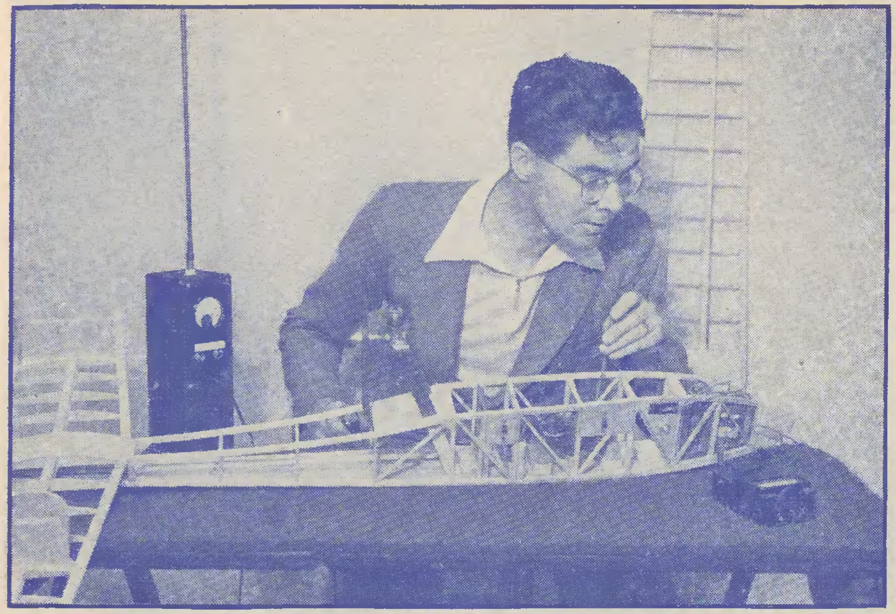


Fig. 9. This illustration shows the receiver being tuned, and gives an idea of the size of the model. In this case a large meter is being used, but on the flying-field a smaller type is employed, as shown in Fig. 11.

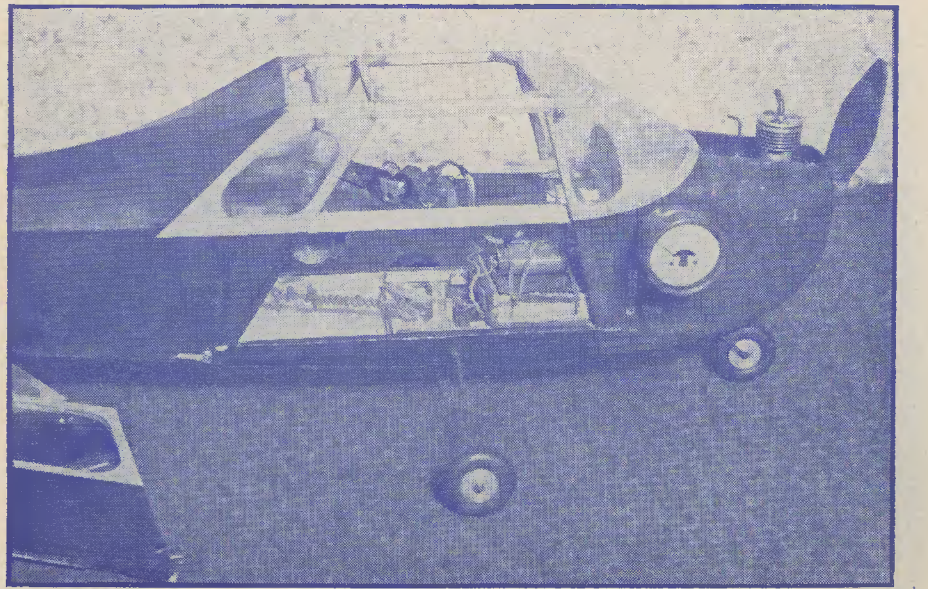


Fig. 11. This plane has had over 150 *flights under radio control. The receiver uses an XFG1 valve. Note the meter plugged in for checking just above the on-off switch.*

If from a straight course a right turn is desired, two pulses together will give the turn, one pulse neutralising it. Thus we get the sequence; one pulse for left turn followed by two to neutralise, and for a right turn two pulses followed by one to neutralise. This is much better than the "left-centre-right-centre" sequence of the two-paul actuator in which one's memory must be relied upon to say whether a right or a left turn is coming next!

The other great advantage of the three-pawl actuator is that it draws current only when changing rudder position, and therefore short pulses of current are required which can consequently be of a high value allowing the use of an efficient, powerful coil of low resistance. Fig. 8 shows the general construction of a relay of this type, an illustration of a similar relay being shown in Fig. 2 at the extreme left of the photograph.

General Constructional Principles

As has already been mentioned, the association of an experienced aeromodeller with an R/C enthusiast makes for rapid success in this field; but as the writer has already suggested, the R/C enthusiast who has no aeromodeller friends should not be put off from entering this field by assuming that he will find the intricacies of aeromodelling too difficult to master. Patience, and the ability to take pains with one's work, are the main requirements—coupled with a readiness to learn by one's experiences.

There are a number of factors inherent in the constructing of model aircraft for radio-controlled flying to which it is well to draw the attention of the prospective constructor. Once again readers are reminded that much of the radio gear must be installed at the time of building. Do not build the aircraft first with a view to getting it flying and then hope to fit the radio equipment. Reference to Figs. 9, 10 and 11 show very well just how intricate is the installation of the R/C gear, these illustrations showing clearly how the panels, bulkheads, mountings, etc., for the R/C gear must be part of the general construction. For this reason the newcomer to this field is advised to start with a model specifically designed for R/C, such as those already mentioned. Later on, when he has gained the necessary experience, he can adapt other models to his requirements. The three main items for consideration are mountings for the receiver, suitable containing racks or boxes for the batteries, and the mounting of switches, potentiometers, etc., so that they can be manipulated from outside the fuselage or are otherwise easily "get-at-able."

(*To be continued*)

British Radio Valve Manufacturers' Statement

Collective Price Fixing Abandoned

Changes in the constitution and trading practices of the British Radio Valve Manufacturers' Association, having effect from September 1, 1956, are announced in the following statement issued to the Press:

"It will be known that the Association abandoned its 'stop list' and allied provisions some years ago and it has now discontinued all arrangements for collective resale price maintenance on the part of the manufacturers. This has been made necessary by the Restrictive Trade Practices Act which, in effect, prohibits this practice. It will in future be for each individual manufacturer to maintain the prices of his own valves and tubes if he so desires.

"Hitherto 'B.V.A. Prices' have been fixed by agreement of all manufacturers who are members of the Association. This policy has also been abandoned. From knowledge of the structure of the industry, however, and in view of the present period of recession with continually rising costs, it will be appreciated that although prices are no longer to be fixed by agreement it does not follow that the prices of comparable valves and tubes will necessarily vary between one manufacturer and another in the immediate future.

"In coming to the decision to abandon collective fixing of prices, the Association has had in mind that if this practice were to be continued it would in all probability have to be justified in the very near future before the Restrictive Trade Practices Court in the light of the narrow economic criteria set out in the Act. The practice of fixing prices by agreement is not in the present state of the industry of the same degree of importance as it has been in the past or as it may well be in the future.

"Apart from the foregoing the Association is continuing its general policy in the interests of the public, the trade and the industry itself, including its vast field of technical collaboration between the manufacturers, with the Services and in international fields."

Members of the B.V.A. are:

A. C. Cossor Ltd.
Edison Swan Electric Co. Ltd.
Ever Ready Radio Valve Co. Ltd.
Ferranti Ltd.
General Electric Co. Ltd.
Marconiphone Co. Ltd.
Mullard Ltd.
Philips Electrical Ltd.
Standard Telephones & Cables Ltd.

RIGHT—*From the Start*

PART 9. VALVES

by **A. P. BLACKBURN**

As we have already said, valves are the real "meat" of radio, but since their rather vague introduction into this series, very little more has been heard of them. We have accorded them scant attention, other than a brief examination of their applications, and the time has now come when a more detailed study of their function, characteristics and performance is necessary before we can go any further into the theory of radio.

On opening a list of valve types, it is always something of a surprise to see how many types there really are. Of course, we know that many are almost or directly equivalent to some other type, but there are probably hundreds whose characteristics differ substantially from one another. What are these characteristics? How does one relate them to a particular valve's capacity to do a particular job? These are the questions with which this article is going to deal.

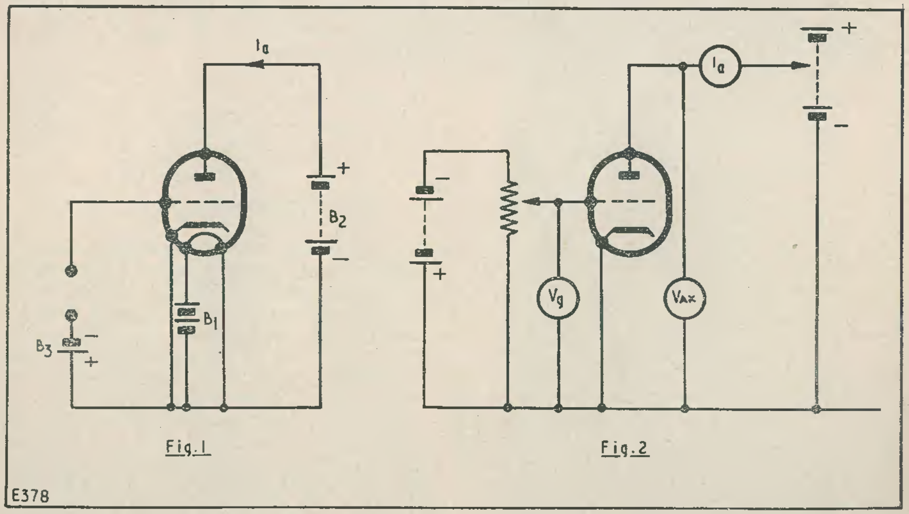


Fig. 1

Fig. 2

Valve Action

Before we get too deeply involved in the ins and outs of this subject, let us briefly remind ourselves of the way in which a valve works.

Fig. 1 shows the elementary valve circuit; in this case it is a triode. The cathode is heated by the filament, which in turn is heated by the passage of current from battery B_1. The cathode is coated with a material which gives off electrons (negatively charged particles) when heated. Battery B_2 charges the anode positively with respect to the cathode, and the electrons are attracted towards the anode. The electron flow through the valve appears as a current flowing from cathode to anode. A fine wire mesh is inserted in the electron stream between the cathode and anode, and is called the "grid." By controlling the potential on this grid, the number of electrons reaching the anode may be controlled. In this way the current flowing in the

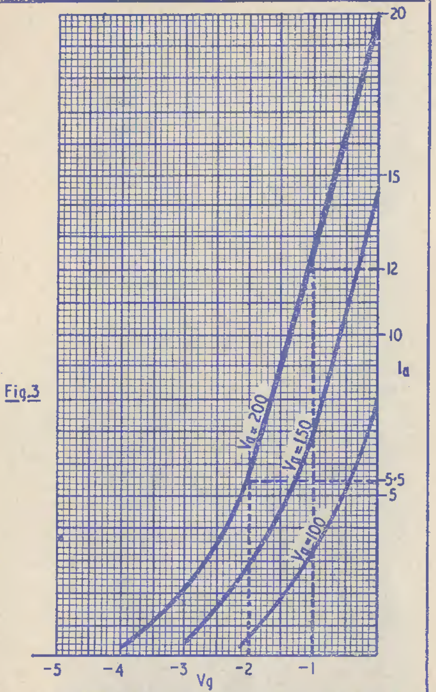


Fig.3

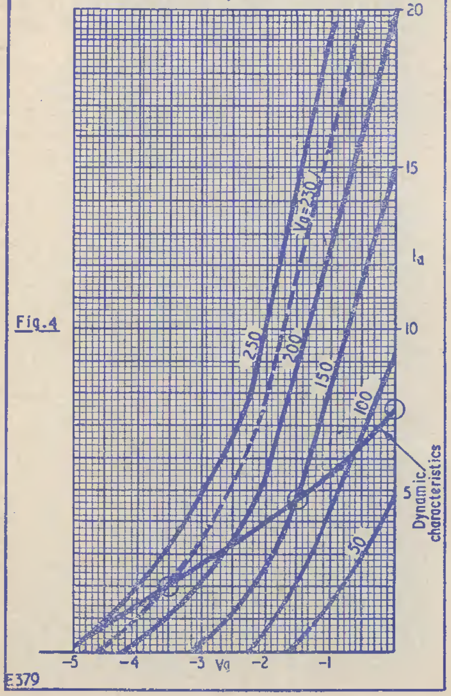


Fig.4

valve is regulated. If a fluctuating voltage is applied to the grid, representing speech, for example, the current in the valve will fluctuate in sympathy.

If a resistor is placed in the anode circuit, the current through the valve will develop a voltage across the resistor in accordance with Ohms Law. If the current is fluctuating, therefore, the voltage across the resistor will fluctuate. Should the anode voltage fluctuation be ten times greater than the grid voltage fluctuation, the valve is said to be giving a gain of ten times.

Mutual Conductance

A valve's performance is defined by three major parameters. This is a rather pompous (but properly accepted) way of saying that a valve may be selected by three features. One of these is the "mutual conductance" and is usually denoted by g_m. This is defined as the change in *anode current* for a given change in *grid voltage*.

$$\text{i.e. } g_m = \frac{\text{change in anode current}}{\text{change in grid voltage}}$$

$$= \frac{\Delta I_a}{\Delta V_g} \text{ mA/volt}$$

The symbol Δ is used as a shorthand contraction for "change in." In Fig. 1 there are two other elements in the circuit that are not considered in this definition of g_m. The grid voltage is taken care of because we are changing it, and the anode current is similarly dealt with because we are observing its change. What about the heater and anode voltages, though?

It is always simplest to deal with two variables only at a time. The heater voltage is fixed at a value specified by the manufacturer, and the anode voltage must be fixed also. So the definition becomes:

$$g_m = \frac{\Delta I_a}{\Delta V_g} \text{ anode voltage constant}$$

The best way of demonstrating all this is to perform an experiment. Suppose we first connect up the circuit in Fig. 2. Fix the heater voltage to the value recommended by the valve manufacturer, and adjust the anode voltage to, say, 100 volts. Then set the grid at various voltages by means of the potentiometer and make a table of these voltages and the corresponding anode currents. Then plot the result. Change the anode voltage to 150 volts and repeat the process. For each anode voltage a curve will be obtained, and a "family" of such curves should look like Fig. 3.

The value of grid voltage and anode current will not necessarily be the same as in Fig. 3; this will depend upon the type of valve, but the shape should be the same. The important thing to note is that the curves are approximately parallel and that a comparatively straight portion exists at the lower grid voltages (that is, grid voltages nearer zero).

From these curves it is possible to see where the definition of g_m came from. The dotted lines show that at -1 volt on the grid the current is 12mA and at -2 volts the current is 5.5mA. For a *change* of 1 volt (ΔV_g) the current has *changed* 6.5mA (ΔI_a). The g_m is therefore 6.5mA/volt.

The g_m is really a measure of the *slope* of the curve, because as may easily be seen, if the change in current were greater for a 1-volt grid change, the line would be steeper, i.e. the slope would be higher. For this reason, g_m is sometimes referred to as the slope of the valve. A high slope valve is, in effect, a valve with a high g_m. Values of g_m for modern valves vary from less than 1mA/volt to 15mA/volt.

got 1 volt out at the anode, the gain is, of course, 10. Note all the grid and anode voltages, etc., are *changes* of voltage.

If a voltage (change) of 5 volts were applied to the grid, the anode voltage would change by 50 volts, since the gain is ten times. But a condition in the definition of g_m was that the anode voltage should be constant. It seems that the whole idea of g_m is useless, then, because if we are to get any good sized signal from the anode, obviously the anode voltage must change, because the signal is a changing voltage.

Actually, this is not completely the case, and the way out is to plot the "dynamic characteristic." The curves of Fig. 3 are called the static characteristic. Fig. 4 shows a rather extended version of Fig. 3 in that more curves have been plotted for a greater number of anode voltages.

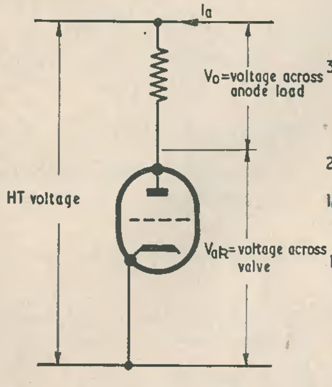


Fig.5

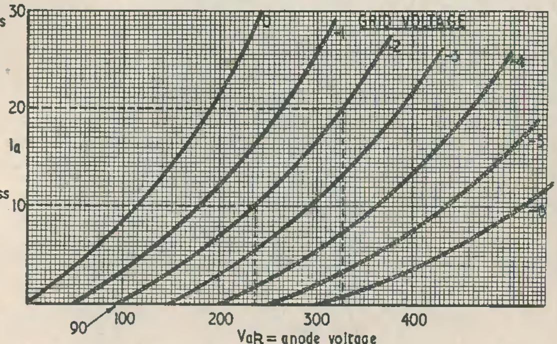


Fig.6

Dynamic Characteristic

For very small signals (small changes in grid voltage) all one has to do is find the change in anode current and multiply by the anode load resistor to obtain the output voltage. For example, if the input voltage were 0.1 volt, the g_m 10mA/volt, and the anode load 1,000Ω, we could proceed as follows:

$$\text{As } g_m = \frac{\Delta I_a}{\Delta V_g}\text{, then } \Delta I_a = g_m \Delta V_g$$

$$\text{From the values given } \Delta I_a = 10 \times 0.1$$

$$= 1\text{mA.}$$

One milliamp will flow through 1,000Ω and from Ohms Law, therefore, the anode or output voltage will be

$$E = IR = 0.001 \times 1{,}000 = 1 \text{ volt.}$$

(The 0.001 is one milliampere, remember; just 1 would mean one ampere).

As we have applied 0.1 volt to the grid and

Now at -5 volts the current is zero, so there is no voltage drop across the anode load (see Fig. 5). At -4 grid volts, however, for $V_a = 250$, 2mA flows and if the anode load is 10,000Ω the voltage drop will be $0.002 \times 10{,}000 = 20$ volts, so we need a curve for $V_a = 250 - 20 = 230$ volts, and the 2mA point should be plotted on this curve instead of the $V_a = 200$ volt curve.

At $V_g = -3$ volts 5mA flows and the voltage drop across the anode load resistor is 50 volts and the anode voltage is $200 - 50 = 150$ volts. So the 5mA point should be plotted on the $V_a = 150$ volt curve. If this process is repeated for all grid voltages, a modified "g_m" curve is obtained as shown. This curve is the dynamic characteristic and has a much lower slope than the static characteristic. This shows that the gain and output voltage would be lower than one would expect by computing them purely from the static g_m and anode load resistance, as we did originally. What we need is some other characteristic which will allow the gain to be calculated more easily than the dynamic characteristic process.

Anode Characteristic

Another family of curves may be drawn which defines another parameter of the valve. This parameter is called the "a.c. anode resistance" or "differential anode resistance" and is usually designated by the symbols R_a. This may be defined in a similar manner to g_m, i.e.:

$$R_a = \frac{\text{Change in anode voltage}}{\text{Change in anode current}} = \frac{\Delta V_a}{\Delta I_a}$$

when the grid voltage is held constant; in other words, the change in anode voltage required to produce a given change in anode current when the grid voltage is held constant.

Let us refer once more to Fig. 2. The anode curves could be plotted by fixing the grid voltage V_g at some value and changing the h.t. voltage and noting the anode current at each h.t. voltage. If the result were plotted it should look like Fig. 6. By changing the grid voltage to another value and plotting another set of anode voltages and currents, another curve would be obtained, and so a complete family of curves could be drawn up.

Once again it can be seen that R_a is a measure of the slope of these curves, i.e. one case shown dotted in Fig. 6, $\Delta I_a = 10\text{mA}$ and $\Delta V_a = 90$ volts and therefore $R_a = 9\text{k}\Omega$.

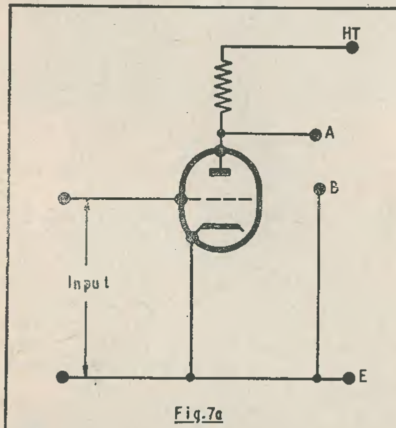


Fig.7a

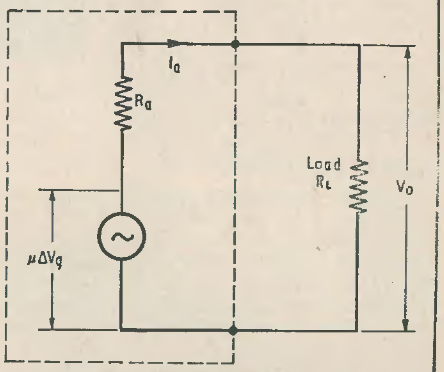


Fig.7b

The anode characteristics are particularly useful for assessing the performance of a valve, as we shall see in a later article. In manufacturers' complete valve data books, the g_m and R_a curves are always given, and the designer may assess the possible performance of circuits on paper with a fair degree of accuracy.

Amplification Factor

There is yet another parameter of a valve which is of considerable importance. This is the amplification factor. This is defined as the change in anode voltage for a given change in grid voltage, when the anode current is held constant.

Mathematically,
Amplification factor μ =

$$\frac{\text{Change in anode voltage}}{\text{Change in grid voltage}} = \frac{\Delta V_a}{\Delta V_g}$$

Anode current constant.

It is easy to see why this is called amplification factor. ΔV_a is normally the output voltage and ΔV_g the input voltage.

We can now try a small mathematical experiment.

Remembering that $g_m = \frac{\Delta I_a}{\Delta V_g}$ and $R_a = \frac{\Delta V_a}{\Delta I_a}$

we shall multiply g_m and R_a together:

$$\text{then, } g_m \times R_a = \frac{\Delta I_a}{\Delta V_g} \times \frac{\Delta V_a}{\Delta I_a} = \frac{\Delta V_a}{\Delta V_g}$$

But we know from above that $\frac{\Delta V_a}{\Delta V_g} = \mu$, so $\mu = g_m R_a$. This simple formula neatly ties the three main parameters of the valve together.

Gain

The use of μ in estimating the gain of a valve amplifier is very important. A very simple valve stage is shown in Fig. 7a. No grid bias is shown as this is unimportant, in this argument. If an input signal is applied, the output will appear between points A and B. To any circuit connected to A and B, the valve will appear as merely a generator of the output voltage. Now in an earlier article it was said that all generators and batteries have some internal resistance, so that even if they were shorted the current that would flow would be equal to the generator voltage divided by this internal resistance. The valve may be represented then by a generator and some internal resistance. Fig. 7a can be redrawn, therefore, as in 7b. Note that the internal resistance is the R_a of the valve, and that the load the generator is feeding is the anode load of the valve. Fig. 7b is called the valve "equivalent circuit." It has no practical use on the bench, but it is a very convenient way of simply representing the valve for analytical purposes. The generator voltage is $\mu\Delta V_g$. This is derived from the fact that

$\mu = \frac{\Delta V_a}{\Delta V_g}$, $\therefore \mu\Delta V_g = \Delta V_a$. The valve (and generator) output voltage is ΔV_a, or from above, $\mu\Delta V_g$.

Now the total resistance in the circuit is $R_a + R_L$, so the current is:

$$I_a = \frac{\mu\Delta V_g}{R_a + R_L} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The true output voltage is that which is developed across R_L.

$$\Delta V_o = I_a R_L; \quad \therefore \; I_a = \frac{\Delta V_o}{R_L}$$

If we substitute $\frac{\Delta V_o}{R_L}$ for I_a in the above expression (1), we get:

$$\frac{\Delta V_o}{R_L} = \frac{\mu\Delta V_g}{R_a + R_L} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

Now the gain of the stage is $\frac{\Delta V_o}{\Delta V_g}$, the output voltage divided by the input voltage.

Rearranging (2):

$$\frac{\Delta V_o}{\Delta V_g} = \frac{\mu R_L}{R_a + R_L} = \text{Gain N} \ldots\ldots (3)$$

So if we look up R_a and μ in the valve book, we can choose R_L to give the gain we require.

Now if R_L were made, say, $100\text{k}\Omega$, and R_a were only $10\text{k}\Omega$, the denominator of (3) would be hardly changed by ignoring R_a altogether.

Then N becomes: $\frac{\mu R_L}{R_L} = \mu$

So the gain of a valve can be equal to μ if R_L is sufficiently high, and this value is the maximum a valve can have.

As an example, if $\mu = 30$, $R_a = 6\text{k}\Omega$ and $R_L = 10\text{k}\Omega$, then the gain will be:

$$N = \frac{30 \times 10}{10 + 6} = 19 \text{ times approximately.}$$

If R_L is increased to $100\text{k}\Omega$, the gain becomes:

$$N = \frac{30 \times 100}{10 + 100} = 27 \text{ times approximately.}$$

So the higher R_L, the higher the gain, but the maximum gain possible can never exceed μ, in this case 30 times.

New Audio Output Valve — The G.E.C. KT88

A new audio output valve, the KT88, with an anode dissipation of 35 watts has been introduced by The General Electric Co. Ltd. This valve is a higher-power version of the familiar KT66, although it is smaller in size. It does not replace the KT66, but is complementary to it for output powers in excess of those readily available from existing KT66 circuits.

An example of the usefulness of this new valve for public address equipment is that, at a supply voltage of 500V, with auto-bias operation, the available power output is 50W or twice that obtainable from a pair of types KT66. At a supply voltage of 560V, with fixed bias operation, output power of 100W is available.

The KT88 has a larger cathode, allowing for a higher mutual conductance, and a more modern type of construction permitting the use of higher anode voltages and dissipations. It is designed for use mainly in a push-pull circuit and will operate satisfactorily as either a triode or a pentode. In the ultra-linear (UL) circuit, satisfactory operation is obtained with the screen grids connected to tapping points including from 20% to 40% of the total turns of each half-primary.

Catalogues Received

DUKE & CO., 621 Romford Road, Manor Park, London, E12.—A nicely duplicated three-colour illustrated list of ten foolscap pages, containing many real bargains. Who, for example, could resist a three-band coil pack, pair of 465 kc/s i.f.t.'s, two-gang condenser and printed dial for the nominal sum of 3/9, post 1/9? The catalogue is sent free to readers.

DIRECT T.V. REPLACEMENTS, 134-136 Lewisham Way, New Cross, London, SE14.—This catalogue commences by introducing "The most complete T.V. Component Replacement Service in Great Britain." After reading through the items listed, not forgetting technical information, we think few would dispute this claim. Available for 1/–. Post free on mentioning this magazine.

DESIGN CHARTS FOR CONSTRUCTORS

No. 11 SINGLE-LAYER INDUCTANCE WINDING DATA 0.3μH TO 60μH

by HUGH GUY

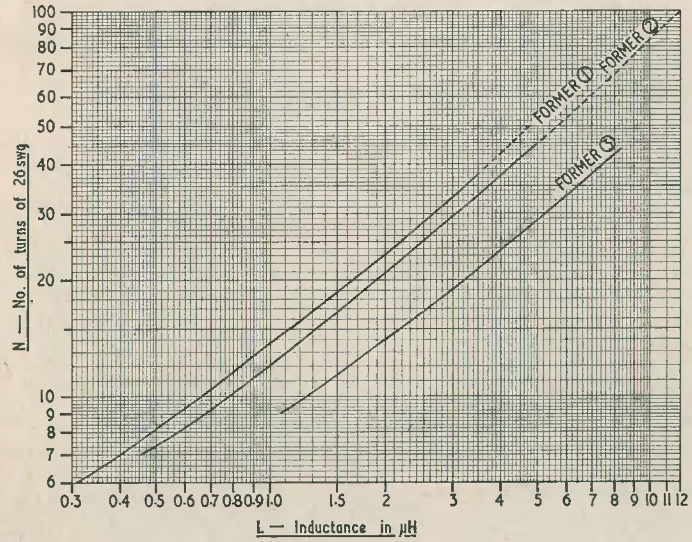
REGULAR READERS WILL NEED NO FURTHER explanation than that given in last month's issue of *The Radio Constructor* to enable them to use the two further charts in this issue of the series of four, comprising the single layer inductance data.

These charts relate the number of turns of either 26 or 36 s.w.g. enamelled copper wire each gauge covered on a separate chart, wound on any of a given series of formers, with the value of inductance thereby obtained.

The formers that may be used are in three groups, each group being determined by its diameter. Thus formers under the heading Former 1 have a diameter of 0.276in, whilst those under the headings of Former 2 and 3 have respective diameters of 0.300in and 0.415in. Formers of these diameters are among the most widely used in radio engineering these days. They are all of the iron-cored type, and a representative range is illustrated in Fig. 1. This range is manufactured by Aladdin Radio Industries of Greenford.

Since there are two different lengths of former available in both types 1 and 2, it has been necessary to indicate the distinction on the charts. Obviously the longer formers will

DESIGN CHART No. 11a



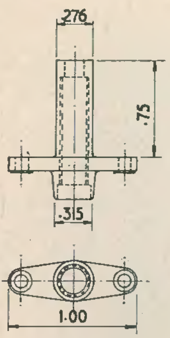
Former	Dia.ins.	Length ins.	
①	0.276	0.75	1.00
②	0.3	0.91	1.96
③	0.415	0.875	

COIL DATA for 26swg enamelled copper wire
SINGLE LAYER — CLOSE WOUND

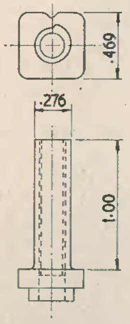
G 381

TYPICAL COIL FORMERS
SUITABLE FOR USE WITH
DESIGN CHARTS

FORMER ①

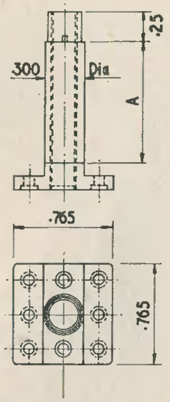


TEE BASE
Chart Code — Former ①
Aladdin Types-5961, 5959



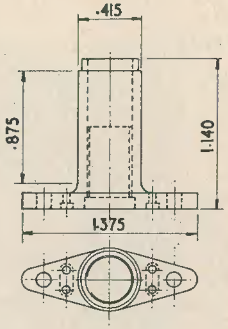
CAM BASE
Chart Code — Former ①
Aladdin Types-5947,5948

FORMER ②



MOULDED BAKELITE
Chart Code — Former ②
Aladdin Type — 5938
A 0.910ins.
Chart Code — Former ②
Aladdin Type — 5937
A 1.96ins.

FORMER ③



MOULDED BAKELITE
Chart Code — Former ③
Aladdin Types — 5892, 5925

SCREW DUST CORES FOR FORMERS

Dia. m/m	Pitch m/m	Length ins.	Aladdin Type	Associated Former Type
6	0.75	0.500	5921	5947 5959
6	1.0	0.315	5972	5937
6	1.0	0.375	5942	5938
6	1.0	0.500	5839	5961
6	1.0	0.625	5884	5948
8	0.75	0.675	5920	5925
8	1.25	0.500	5918	5892
8	1.25	0.675	5804	

Drawings reproduced by kind permission of 'Aladdin Radio Industries' Greenford.

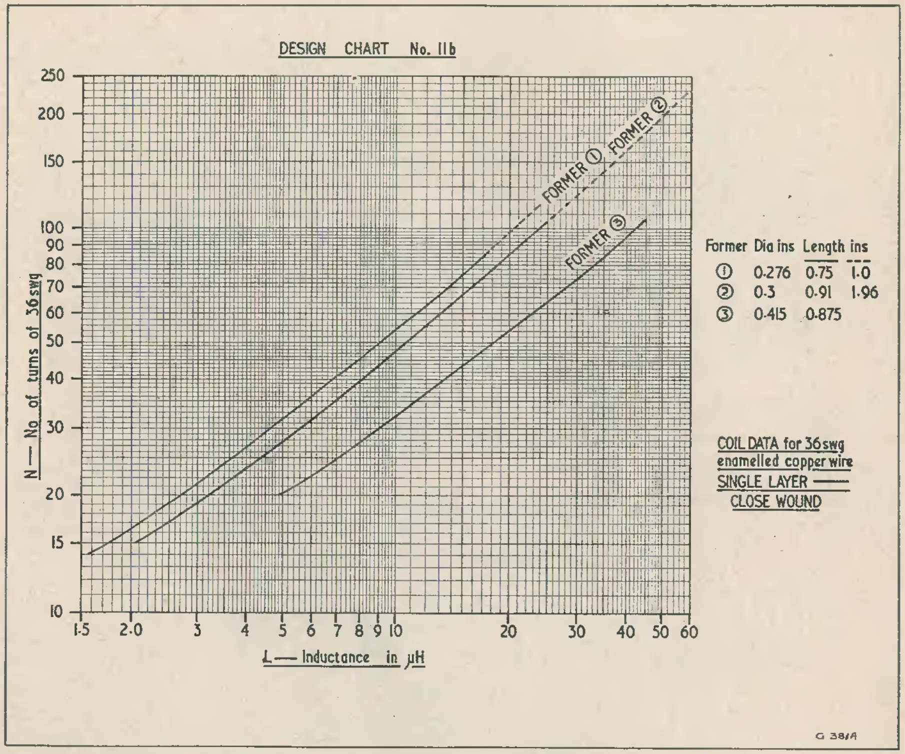
G 371

accommodate most turns of wire, and therefore the difference in lengths has been indicated by a continuation of the heavy data lines in dotted form.

For example, the maximum number of close wound turns of 26 s.w.g. wire that can be wound on the shorter type of Former 2 (i.e. the former of length 0.91in) is seen from Chart 11a to be 45, (since this is the finish of the heavy data line for Former 2. Up to 100 turns may be wound on the longer Former 2, however.

is Former 3, in the first instance. Then the charts show that 36 s.w.g. must be used, since the data line for Former 3 on the chart for 26 s.w.g. does not extend to 10μH inductance. On chart 11b 32½ turns are seen to be required.

If the longer of the types of Former 2 were being used, then we have a choice of wire gauge; using 26 s.w.g. wire we would need 84 turns, whilst using the alternative gauge only 47 turns would be required. In the latter case we see that a short former could be used here.



Using the Charts

The use of the charts is quite straightforward. To wind a coil of some specific value of inductance it is merely necessary to select a former from the range for which the charts are applicable, and read off the appropriate number of turns for this inductance using the data line corresponding to the chosen former. Certain inductance values overlap on the two charts, providing an alternative wire gauge in these instances.

Example

As an example, consider the process of designing a coil for an inductance of 10μH.

We will assume that the former to be used

Iron Dust Cores

All the coil data quoted here is for formers with the iron dust core removed. When the core is screwed in the inductance will increase, in some cases by as much as 2 : 1 on its design figure. This effect should be borne in mind when designing coils, a good policy being to wind coils to say two-thirds of their required value, using the iron core as a means of variable control on the final value of the inductance. The actual amount by which the core increases the inductance depends not only on the core material, but also on the penetration of the core within the coil. If the length of the core is greater than that of the coil, then the variation in inductance will be much greater than if the core is only a fraction of the coil length. As mentioned last month, at very high frequencies the cores can lessen the "Q" or magnification factor of the circuit in which the coils are connected.

A table showing cores available for use with the formers is included in Fig. 1, enabling the constructor to make a suitable choice on the basis of the above comments.

As a very simple series of design charts for coil winding, the results obtainable are surprisingly accurate, being better than 10% in the majority of cases and as accurate as 2% at low frequencies. Inaccuracies at high frequencies are due in the main to the effect of lead length on the inductance, something which produces, in practice, a higher value than designed for. By winding a coil to give half the designed inductance for such frequencies, any errors can be eliminated by the adjustment provided by the iron core. In extreme cases it is possible to use a core made of brass to reduce the inductance of a coil.

A SIGNAL GENERATOR—FREQUENCY METER

by E. GOVIER

A voltage regulated Signal Generator/Frequency Meter covering 15 to 550 metres in three switched bands, incorporating an Audio Modulator and using Mullard B8A valves together with Osmor coils

In the design about to be described, ease of construction and several other factors have been borne in mind. Portability, use as a combined generator and meter, availability of component parts on the market at the present time, and, last but not least—especially in a measuring unit—stability, ease of operation and reliability over a long period of operation.

It is well known that the greatest snag with many signal generators, as far as the home constructor is concerned, is the coil winding procedure—with its cut-and-try methods usually adopted both by older hobbyists and newcomer alike. As an added complication, most of these coils are tapped one-third from the earthy end, and upon this tapping depends much of the efficiency of the unit, at least as far as r.f. generation is concerned. The first specification was, therefore, the use of commercial coils, iron cored, physically small and efficient. The adoption of these coils ruled out the coil tapping business and, in the writer's opinion, overcomes the main obstacle besetting the home constructor.

With one eye on the cost of components, three valves were chosen which would: (*a*) keep the unit small and portable, (*b*) act most efficiently, and (*c*) produce an overall top rate standard of reliability, ruggedness and accuracy. This has been achieved by the choice, after carefully studying valve tables, etc., of the Mullard EZ41 as rectifier, 7475 as stabiliser and the ECC40 as combined r.f. generator and audio modulator. Intending constructors are advised to adhere to these specified valves if maximum efficiency and results are to be achieved.

The dial and vernier block is the Eddystone Cat. No. 594, available from Webbs Radio. This dial is most important in that it has a 10 : 1 slow-motion drive and is capable of being read to very fine limits. It is of little use producing an instrument which is perfectly satisfactory in every way, except that it cannot be relied upon to produce consistent results, solely because the dial mechanism is unreliable in itself and, in addition, is incapable of close tolerance interpretation. It has been said that a frequency meter is only as good as the dial; if this is so then the undoubted answer is to obtain the specified article.

Circuit

From Fig. 3 it will be seen that the first half of the ECC40 is used as an r.f. generator, a function which it performs extremely well over the entire range. S_1 and S_2 are the range switches, and on range 1 the secondary winding (L_2) of the first coil is brought into circuit. At the same time L_1, the aerial or primary winding of the same coil, is brought into the anode circuit. The three coils used are specified in the component list and in each case the connections are as given in Fig. 1. C_4 is the tuning condenser. The bandspread condenser is C_5.

The coils are the Osmor type QHF2, QHF4 and QHF11, which allow a coverage of from 15 to 50, 70 to 230 and 190 to 520 metres. Some variation of this coverage is, of course, possible owing to the inclusion of dust iron cores. These three ranges are covered on the fundamental frequency. The r.f. choke, in conjunction with C_3, effectively prevents unwanted coupling via the power leads and supply.

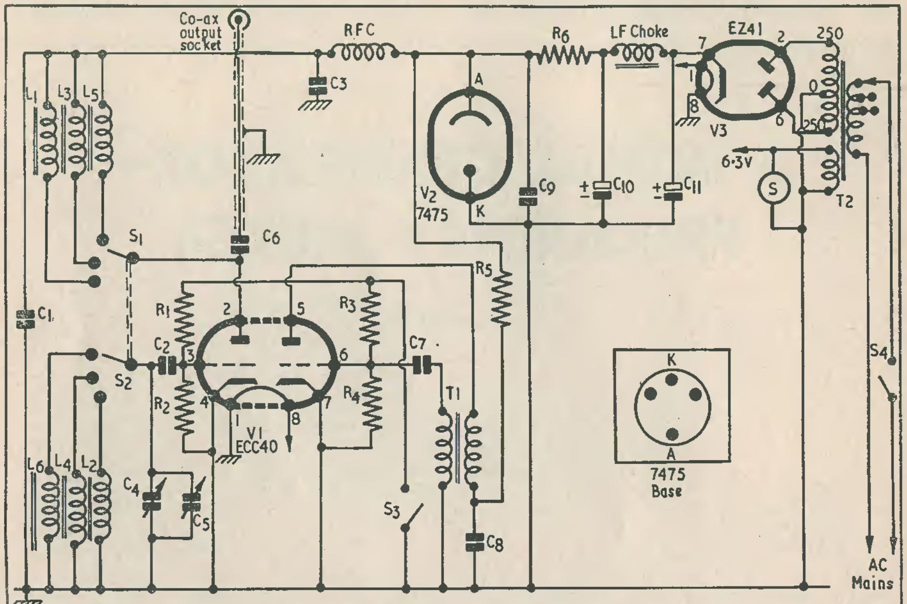


Fig. 3
Circuit of the signal generator–frequency meter

CIRCUIT VALUES

Resistors	
R_1	100kΩ ½ watt Dubilier
R_2	10kΩ ½ watt Dubilier
R_3	100kΩ ½ watt Dubilier
R_4	100kΩ ½ watt Dubilier
R_5	47kΩ ½ watt Dubilier
R_6	4kΩ 2 watt Dubilier
V_1	Mullard ECC40
V_2	Mullard 7475
V_3	Mullard EZ41
T_1	Elstone LF36
T_2	Ellison MT162
Choke	10H 60mA
B8A bases	McMurdo
Pilot light assembly	Bulgin
C_1	0.1μF tubular TCC type CP45N
C_2	300pF mica TCC
C_3	0.002 pF mica
C_4	500pF variable
C_5	100pF variable
C_6	0.001 mica TCC
C_7	0.005μF mica TCC
C_8	0.1μF tubular TCC type CP45N
C_9	0.1μF tubular TCC type CP45N
C_{10}	16μF electrolytic, 350V wkg.
C_{11}	8μF electrolytic, 350V wkg.
S_1, S_2	2-pole, 4-way, Yaxley type
S_3, S_4	Single-pole, single-throw
Dial, Eddystone, Cat. No. 594 (Webbs Radio)	
Cabinet and chassis (Kendall & Mousley)	
Aerial and test probe plugs and sockets (Belling Lee No. L734/P)	
Flexible Coupler, Eddystone Cat. No. 529	
RFC, Osmor QC1 (Osmor Radio Products)	
L_1–L_2	QHF2 (Osmor Radio Products)
L_3–L_4	QHF4 (Osmor Radio Products)
L_5–L_6	QHF11 (Osmor Radio Products)

The output is taken from the anode via C_6 and thence through a length of co-ax cable to the output socket. Into this, when used as a frequency meter, is fitted a short length of 18 s.w.g. tinned copper wire which acts as a self-supporting aerial. The strength of the output as heard in the receiver will then depend upon the distance the unit as a whole is placed from it.

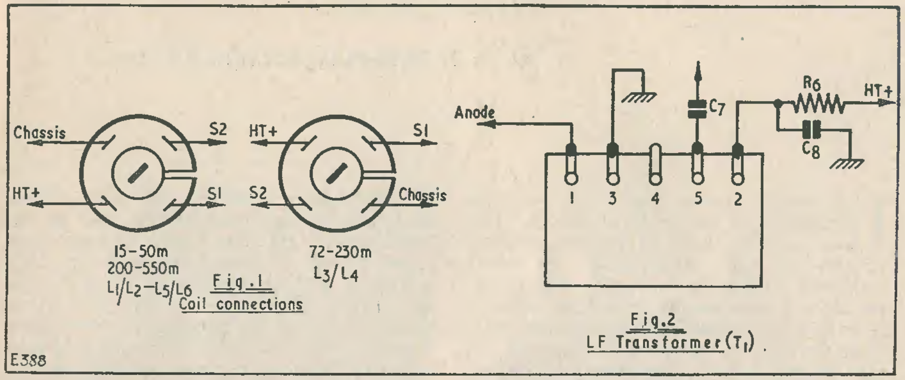


Fig. 1
Coil connections

Fig. 2
LF Transformer (T_1).

The second half of the ECC40 is used as an audio modulator in a conventional circuit; and with the component values shown, a good audio response of some 400 c/s is obtained. The switch S_3 is the modulator on/off control; it will be noted that this allows the modulator valve to oscillate all the time, and is not, as is very often the case, in the h.t. line to the intervalve transformer, thereby causing a sudden variation in voltage supply and a consequent change of oscillator frequency.

The depth of modulation may be adjusted by varying the values of R_1 or R_3 and the a.f. tone may be varied by substitution for C_7 of a different value than that specified.

Connections to the l.f. transformer are shown in Fig. 2.

Power Supply

The h.t. supply is regulated by means of a 7475 valve, and it is to this inclusion that much of the stability of the meter depends. It assures a constant voltage supply to the oscillator and modulator and it follows that any of the usual variations in the mains supply will not affect the frequency stability of the unit.

The power pack uses the EZ41 as rectifier. The mains transformer specified supplies adequate current for the meter without being overrun and generating undue heat, a possible cause of frequency instability in the tuned circuit.

Alternative Output

This is provided by removing the aerial as previously described and inserting into the output socket a co-ax cable, at one end of which is fitted a test prod. A portion of the outer plastic covering of the co-ax cable is first removed leaving the screened braiding intact. A short length of the inner conducting wire is then bared and the braiding cut so that it does not make contact. This is then fastened and so adjusted that the whole assembly now forms a very handy test probe. With the probe in position, the unit now becomes a very handy signal generator. The degree of coupling with the circuit under test will depend on the distance between the probe and the circuit.

This simple instrument will be found most useful in the workshop and also of great help to those who require a frequency check device when testing, constructing, or calibrating receivers. It is extremely stable, relatively easy to construct and a worthwhile addition to any radio enthusiast's test gear.

Next Month . . .

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LEWIS RADIO COMPANY. The "Continental" cabinet advertised last month should have been priced at £24. 15s. unpolished, or £28. 15s. polished to customers' requirements.

THE POOR MAN'S GROUND-PLANE

by O. J. RUSSELL, *B.Sc.(Hons)*, G3BHJ

THE GROUND-PLANE AERIAL IS RIGHTLY acclaimed by many Dx operators. The low-angle radiation of the ground-plane provides the ideal characteristic for omni-directional extreme Dx working. In fact, the low-angle discrimination effectively reduces the impact of short-skip European and near-Dx on the receiver when one is fishing for the really distant ones. Conversely, of course, this also attenuates the QRM which *you* cause the near European amateurs who may also be fishing for Dx. All in all, the ground-plane is a well liked and useful aerial. We discount here and now, of course, the growlings of the Lids who tried a ground plane on near-European contacts and found that it attenuated their own radiation and the received strength of signals within the "local" radius of, say, 500 up to 1,000 miles. Of course it did!

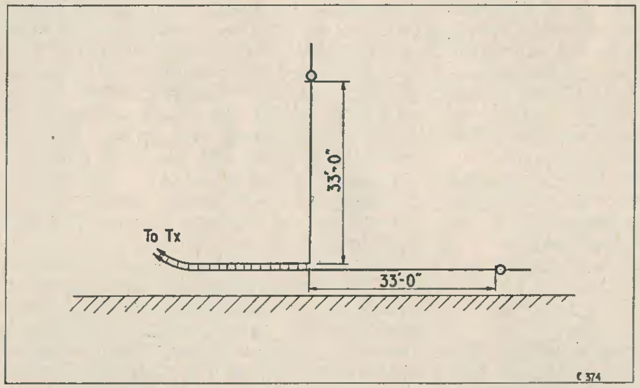

Fig. 1. The lower 33-ft horizontal element may be from one to a few feet above ground. 33-ft tuned feeders, which may be of 300Ω moulded line, are suggested for a three-band feed system

Yet some have discarded the ground-plane after this, complaining bitterly that it was "inefficient." Had they tried it on a nice weak signal trying to plough through the DL4 Kilowatts, and the rest of Europe, they would have found differently. In fact, they would have found the Dx boosted by some three S-points, while the "local" QRM would have subsided by about the same amount; net gain of some six S-points discrimination in favour of the Dx!

All right, then, the wise birds are already "sold" on the value of the ground-plane. Unfortunately, when those who dwell in "restricted" areas consider the problem of erecting a pukka full-dress ground-plane, they may well be defeated by the problem of sheer space considerations. Take a genuine 20-metre band ground-plane. This has four

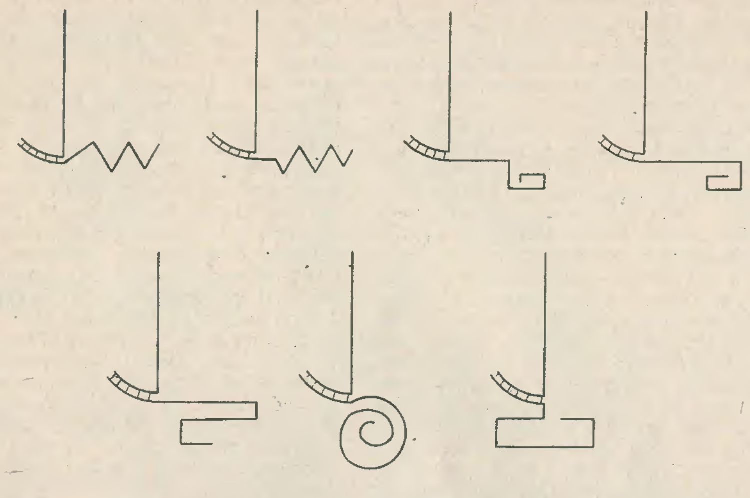

FIG. 2

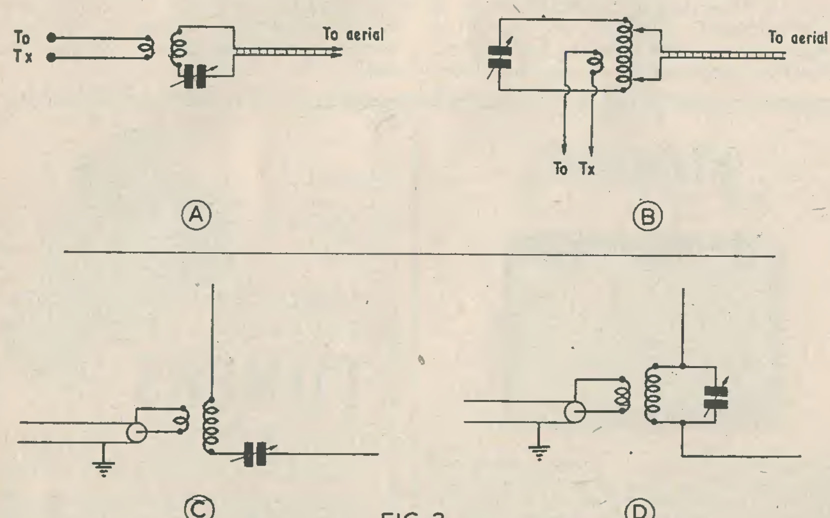

FIG 3

Fig. 2. Some suggestions for the placing of the horizontal portion if space is really tight. The reader can no doubt think of many others! Fig. 3. Feeding and coupling systems. "A" and "B" are tuned systems when using 33-ft of feeder, "A" for the 80-metre band, and "B" for higher frequencies. "C" and "D" are alternatives employing coaxial feed from the transmitter with the tuning unit at the aerial base. "C" is for the 80-metre band, and "D" for higher frequencies

radials of 16 feet each. Thus it requires a sizeable area to accommodate them. This, it is true, is usually possible in an average location. However, the prospect of a 40-metre vertical plus 33 feet radials, requiring a space some 66 feet square to accommodate them, is generally impossible.

For those brethren in such a plight the aerial sketched in Fig. 1 is offered as a possible solution. For 40 metres it is, in fact, a dipole with one leg horizontal and the other vertical. Length of each for 40 metre operation is thus 33 feet. However, such an antenna will also operate on 20 metres. Here again it will give low angle radiation, so that two-band operation is possible. It is also possible to operate with tuned feeders so that 80-metre operation is possible. Here, however, the radiation efficiency suffers a little, so that losses are higher. Despite this, if used with, say, 33 feet tuned feeders of either spaced wires or 300 ohm moulded twin, the antenna will load up and radiate well upon 80 metres. The 33 feet of height can almost always be obtained, and the 33-foot run can generally be accommodated.

However, if the 33 feet of horizontal run cannot be obtained for the counterpoise, it can be zigzagged, kinked, bent double or provided with a bend near the end. These possibilities are sketched in Fig. 2. If the suggested 33 feet of vertical, 33 feet of horizontal plus 33 feet of feeders is used, the Tx coupling arrangements will need a series tuned circuit for 80-metre loading, and parallel tuned loading for 20 and 40-metre operation. The aerial *will* load up on 21 Mc/s and on 28 Mc/s, but on 21 and 28 Mc/s the low angle property of the ground-plane proper will be lost and radiation will be at medium to high angles. This will, in fact, be better for semi-local ragchews on short skip. On the higher frequencies of 14, 21 and 28 Mc/s it is generally practicable to use a genuine ground-plane. However, a scaled down version, i.e. 16½ feet dimensions, will be a 20 metre version also operable upon 7 Mc/s and, of course, on 28 Mc/s—yes, and on 21 Mc/s as well. The use of tuned feeders does, in fact, make multi-band operation easier than with the pukka coaxial-feed ground-planes. It is unlikely, though, that this simple system will be *quite* as effective as a pukka ground-plane. It *does*, however, offer hope to those in a very restricted space. An "invisible" version of fine wire is also quite practical *if* you have one of that sort of landlords! Anyway, try it out and see if you can snag that elusive rare Dx better than with the old horizontal. Come to that, you can always suspend the aerial from the existing one!

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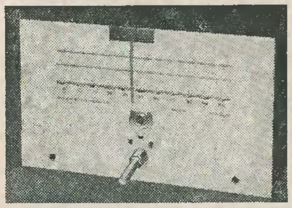

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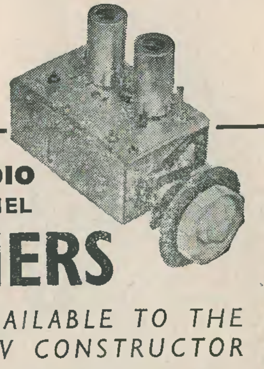

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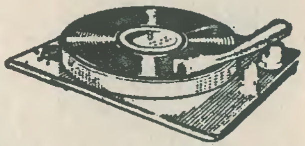

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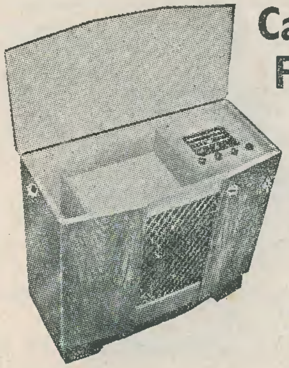

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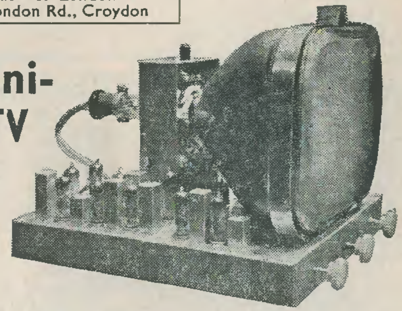

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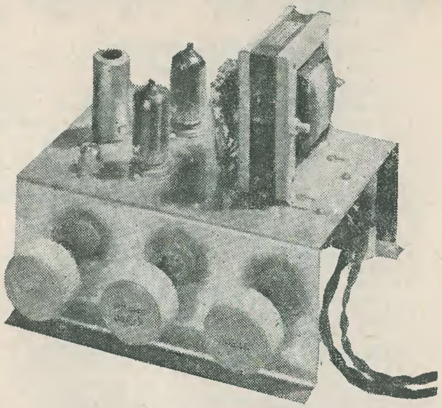

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(continued on page 287)

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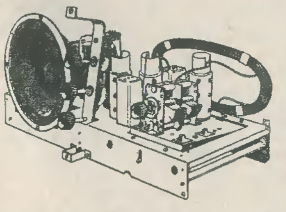

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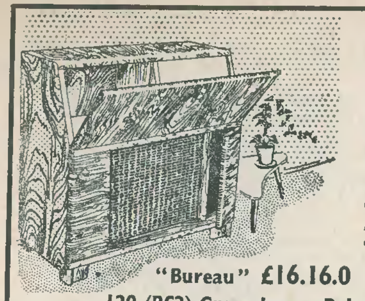

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(*continued from page 285*)

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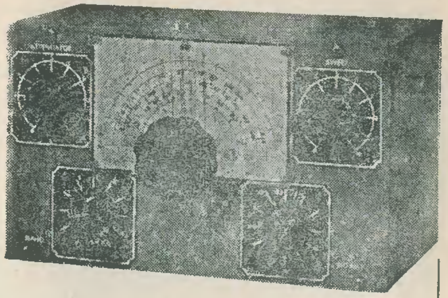

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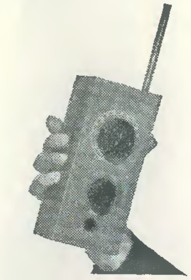

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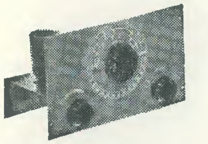

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