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<table>
<thead>
<tr>
<th>Item</th>
<th>£.</th>
<th>d.</th>
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<tbody>
<tr>
<td>Chassis, base, cover, scale, screen plate</td>
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<tr>
<td>1 mains transformer—MTX48</td>
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<td>2</td>
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<td>2 output transformers—OT2</td>
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<tr>
<td>1 mains selector plug and socket</td>
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<td>1 5-pin socket for spare power</td>
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<td>1 2-pin socket for mains outlet</td>
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<td>1 bulbholder</td>
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<td>2 ECF80</td>
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<tr>
<td>1 EZ81</td>
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<th>Model</th>
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<td>UJR-1</td>
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</table>

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<thead>
<tr>
<th>Kit</th>
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<tr>
<td>Mini-7 transistor pocket portable</td>
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<td>Transidyne transistor pocket portable</td>
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<tr>
<td>Band III Pre-amplifier</td>
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<tr>
<td>One-Valve Radio for beginner</td>
<td>1/- £11.13.6</td>
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<tr>
<td>Mercury switched F.F. Tuner</td>
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<td>Jaxon F.F. Tuner</td>
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<td>Argonaut AM/FM Tuner</td>
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<tr>
<td>Two-Valve Audio Pre-amplifier</td>
<td>1/3 £6.0.0</td>
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</table>

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The Radio Constructor
Incorporating THE RADIO AMATEUR
Vol. 12 No. 8
MARCH 1959

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ALL MSS must be accompanied by a stamped addressed envelope for reply or return. Each item must bear the sender's name and address.
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TECHNICAL QUERIES should be submitted in writing. We regret that we are unable to answer queries, other than those arising from articles appearing in this magazine; nor can we advise on modifications to the equipment described in these articles.
ALL CORRESPONDENCE should be addressed to THE RADIO CONSTRUCTOR 57 Maida Vale London W9 REMITTANCES should be made payable to “DATA PUBLICATIONS LTD.”

573
TEST EQUIPMENT

Suggested Circuits

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. 100 A Transistorised Light-operated switch

In the November and December, 1956, issues of The Radio Constructor, the first of the OCP71 circuits, was illustrated, capable of being operated by the incidence or interruption of light waves.† The light-sensitive element in these circuits was the phototransistor type OCP71, this having at that time just been introduced to the British market.

In these early devices the phototransistor operated a relay directly, and the circuits suffered from the disadvantage that this relay had to be a sensitive component capable of energising at currents of several milliamps only.

Some time after the articles had appeared the writer decided that whilst the circuits they described were practicable enough it would be desirable, when time and opportunity presented themselves, to design a circuit which, in which a much more robust relay is employed, is the result of this decision.

The Circuit

The circuit of the new light-operated switching device appears in Fig. 1, and it will be seen that it is extremely simple and employs the minimum of components. Basic operation is very straightforward: current variations in the OCP71 phototransistor are amplified by the OCT2, whose collector current then operates the relay. The device is powered by a 12-volt d.c. source.

Dealing with the circuit operation in greater detail, it will be helpful to commence with the OCP71. When the OCP71 is connected up in the manner shown, its effective emitter-collector resistance varies according to the amount of light which falls upon it. It is quite permissible to leave the base of the phototransistor disconnected in a circuit of this nature; such a method of operation being, indeed, specified by the manufacturers when constant illumination is used. With an open-circuit base, phototransistor dissipation should be kept to a conservative level, and this point is carefully observed in the circuit of Fig. 1. The value chosen for resistor R1 ensures that collector current cannot exceed 1mA (assuming the limiting case of zero volts drop in the OCP71) when collector value and supply voltage are at their nominal figures. The maximum recommended value for OCP71 collector current is the markedly higher figure of 10mA.

The collector of the OCP71 connects directly to the base of the OCT2 amplifier transistor, with the result that the following process takes place. When the OCP71 is illuminated it draws current through R1, thereby keeping the flow of current in the base-emitter circuit of the OCT2 to a low value. As a result the OCT2 passes little collector current. When the OCP71 is not illuminated it draws a very small current through R1 (if completely dark this current should be less than some 400μA), whereupon an increased current flows through the OCT2 base-emitter circuit. In consequence, the collector circuit of the OCT2 now rises. Employing the circuit values shown in Fig. 1 the difference in OCT2 collector currents between the illuminated and non-illuminated condition was found, in the prototype, to be very marked when the phototransistor. When the OCP71 is connected up in the illuminated condition OCT2 collector current was less than 200μA. When the OCP71 was in the dark condition, OCT2 collector current rose to 20.5mA. This very large change in OCT2 collector current is, of course, more than adequate for reliable relay operation.

A coil resistance of 500Ω was chosen for the relay employed in the switching device because, from the point of view of economical construction and efficiency, it was desirable to select as low a resistance here as was commensurate with safe running of the OCT2. The first limiting factor dictated by the OCT2 was that, when this is connected as a grounded emitter amplifier having 1kΩ resistance between base and emitter, the recommended maximum collector voltage is 16 volts. In consequence it was decided that a supply voltage of 12 (conveniently available from an accumulator or a simple mains unit) would represent a good choice for powering the unit.

An examination of energising currents and voltages for Post Office type 3,000 relays with two sets of change-over contacts showed that a coil resistance of 500Ω then fitted most comfortably into circuit requirements. A 500Ω relay of this type can energise reliably at a current of 20mA. Such a current would cause a drop of 10 volts in the relay coil, with the consequence that the remaining 2 volts would appear between collector and emitter of the OCT2. This figure, 2 volts, together with the 20mA current flow, corresponds approximately to a collector dissipation in the OCT2 of 40mW. At 30°C (86°F) the maximum allowable collector dissipation of an OCT2 without a cooling fin is 112mW, and at 40°C (104°F) it is 87mW. When coupled to a heat sink the corresponding dissipation figures are 105mW and 117mW respectively.

Thus, the working figure of 40mW offers a reasonable safety factor, although it would be desirable to couple the transistor to a heat sink in order to prevent excessive self-generated rise in temperature.

It will be noted that an OA70 crystal diode is connected across the relay coil. The purpose of this diode is to prevent the formation of a high reverse voltage in the relay coil if its energising current suddenly reduced in value, as might occur with sudden illumination of the OCP71. Such a reverse voltage would, of course, be the result of the consequently collapsing magnetic field in the coil. The crystal diode is so connected that it is not conductive when the lower end of the relay coil is positive. In the event of a sudden cessation of energising current, the lower end of the coil tends to swing negative with respect to the upper end, whereupon the diode conducts and prevents the reverse flow of current.

† Suggested Circuits No. 72, "A Phototransistor Light-Operated Switching Circuit," and Suggested Circuits No. 73, "Phototransistor Control of Heavy Current."
Voltage from the reading is the highest a value. Without the diode, the reverse voltage across the relay coil could reach a value which, added to the h.t. voltage, might cause the recommended maximum collector voltage for the OCP71 to be exceeded.

Practical Points

A switching device of the nature we are considering here will find many applications, one of the most obvious being the operation of subsidiary circuits by the inci- dence or interruption of a light beam. In application of this nature it will frequently be necessary for the OCP71 to be continually illuminated by a source of light. In such instances, a considerable economy in energizing light power may be achieved by using the phototransistor as a tone fitted at one end with a convex lens, as is illustrated in Fig. 2.

Fig. 2. When the OCP71 is illuminated by a small light source, a considerable economy in energizing light power may be achieved with the aid of a simple convex lens.

The convex lens does not need to be a costly item, as an inexpensive "magnifying glass" costing one or two shillings only used to prove to be more than adequate. The focal length of such a lens may readily be found by using it to throw an image of the sun or of an electric light bulb on to a piece of paper. When the image is correctly focused, the focal length will then be the distance between the image and the lens. In the writer's prototype it was found possible with a lens of about 2 in diam, to obtain reliable operation from a 12 volt bulb, without reflector, mounted some 6 ft away. An advantage of the "table lamp" arrangement of Fig. 2 is that extensive light does not reach the phototransistor, and unwanted actuation of the relay. Indeed, the circuit should function quite satisfactorily under normal conditions of ambient illumination. It must be remembered, however, that on this particular subject, there is no substitute for employing excessive light energy to illuminate the OCP71. Sufficient light energy to reduce OCP72 collector current to its mini- mum value is all that is needed. As an aid to constructors, Fig. 3 illustrates the sensitive area of the OCP71.

It was mentioned above that it would be preferable to couple the OCP72 to a heat sink in order to prevent excessive self-generated temperature rise. Such a coupling may be achieved by lightly clamping the OCP72 to a heat sink having the minimum dimensions of 1 in square. A very simple method of providing in practice by clamping the OC72 to a small metal chassis which also held the relay and, say, one or two tags for lead-out connections and the like. This chassis should be kept cool and should have any heat-dissipating components mounted on it. The clamp securing the OCP72 to the chassis should be over the end and should encircle the metal case of the transistor over a large pro- portion of its area in order to ensure good thermal contact.

Some care needs to be taken to ensure that the 12 volt supply is sufficiently well-regulated to prevent the h.t. potential approaching the recommended maximum collector voltage for the OCP72 (with 1kΩ base-emitter resistance) of 16 volts. Thus, it would be unwise to power the circuit with a 12 volt accumulator which was on continual charge, as the accumu- lators terminal voltage could rise danger- ously close to the maximum figure or even exceed it. The requirements for voltage regu- lation apply similarly to circuits using the OCP71 in the unilluminated condition a milliammeter reading of approximately 6 milliA should be given at this voltage, and should drop to a negligibly low value when the OCP71 is illuminated. Pro- vided the preliminary test is satisfactory the full h.t. voltage may be applied, upornon it should be found that the relay coil current lies between 17 and 22mA with the OCP71 non-illuminated. If the current reading obtained for the dark condition falls slightly outside these figures it may be decreased by a small

Fig. 3. This diagram shows the light-sensitive area of the OCP71. The type number should be on the same side of the phototransistor as is the light source.

A suitable relay, fitted with two sets of change-over contacts, is available from H. L. Smith & Co. Ltd., 287 Edgware Road, London, W.2.

Mullard announce

A NEW SERIES OF EDUCATIONAL FILMSTRIPS

A new series of filmstrips dealing with the history and basic principles of important scientific developments has been announced by the Mullard Educational Service.

These filmstrips are aimed primarily at Secondary Modern pupils, but will also be useful for grounding Grammar School arts pupils in some science subjects.

The first strip, entitled "The History of Radio," is available now, and brief details are given below. The next, on "The History of Television," will be released shortly.

The introduction of the Secondary Modern series brings the number of filmstrips available from the Mullard Educational Service to over 30. These include a series covering the general principles of electronics at Grammar School level, and a series for technical college students taking the Ordinary National Certificate in electrical engineering.

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"The History of Radio" reviews the pro- gress made in telecommunications from the days of the first primitive telegraph and telephone systems. It outlines the discovery of electro-magnetic waves, illustrates Mar- coni's experimental work, including the historic transatlantic wireless transmission, and ends by describing modern radio com- munication techniques and showing examples of these latest developments. Wherever it is necessary to the development of the story, fundamental principles of electricity and magnetism are simply and concisely explained.

A comprehensive set of teaching notes is supplied with the strip, which is available from the distributors: Unicorn Head Visual Aids Ltd., 42 Westminster Palace Gardens, London, S.W.1, price 20s. a copy.

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THE RADIO CONSTRUCTOR

MARCH 1959

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www.americanradiohistory.com
"I," said Dick, leaning confidentially over Smithy's shoulder, “you stuff a turkey with sage and onions, what do you stuff a parrot with?"

Recognising the signs, Smithy heaved an almost silent sigh. He allowed his attention to be distracted from his work.

"I wouldn't know," he remarked with resignation. "What do you stuff a parrot with?"

"You stuff it with Polyfilla," replied Dick.

After which, he retired to his bench, laughing loudly. Despite himself, Smithy the Serviceman grinned; and he decided to accept the fact that Dick was in one of his joke-telling moods and that he would just have to be given his head until he had run out of gags. Dick's jokes sessions occurred every two months or so, and Smithy had discovered, after careful questioning, that his assistant picked up all his new stories from that uncle of his who happened also to be the steward of Smithy's club. The main thing that annoyed Smithy was that he himself never heard any of Dick's jokes at his club yet, whenever he tried to repeat them, everybody else at the club had heard them.

**Crystal Diodes**

On this particular morning, however, Dick's output of jokes was somewhat short-lived. Almost immediately after he had left Smithy's side he ran into trouble and had to call upon the Serviceman for assistance.

The first of Dick's troubles became evident as he was looking thoughtfully at a rather venerable television chassis on the bench before him.

"Smithy," he called out after some moments, "what do you do with a television set whose video detector keeps breaking down?"

"It all depends upon the circumstances," replied the Serviceman briefly.

Leaving his own work he walked over to inspect the chassis on Dick's bench. "Look," said Dick, "I had this chassis in a few months ago suffering from a lack of vision whereupon, after a little hunting around, I discovered that the video detector had shuffled off its mortal coil. The video detector employed in this receiver is a straightforward crystal diode, and after removing its screening can so that I could fit a new unit, I got the chassis working O.K. The set has now come back to me again with exactly the same fault and I find that the video detector has once more gone kaput. I just don't get it."

"Not to worry," Smithy remarked. "This sort of thing is quite liable to happen every now and again with older sets of this type. Did you fit exactly the same type of crystal during your previous repair?"

"Not exactly," admitted Dick. "The original diode was OA60, and I replaced it with the somewhat more up-to-date OA70."

"That shouldn't make any difference in this application," remarked Smithy. "Both types are intended as video detectors. Now let's take a closer look."

Smithy examined the faulty diode.

"Well," he remarked slowly. "I can see no evidence of you having over-cooked the crystal when you soldered it in. To begin with, you've left a good half-inch of wire between the body of the diode and its solder joint, and this is an excellent thing to do. I usually assume that a quarter of an inch is the absolute minimum safe distance between the body of a crystal diode and its solder joint, and your half-inch exceeds this comfortably. In addition, I see that you've taken good care not to bend the lead-out wires too close to the glass, where they could cause weakening of the structure."

"As a matter of fact," put in Dick a little proudly, "I remember that I even used a heat shunt during soldering."

"Very good," approved Smithy. "There are many people who would laugh their heads off at the very idea of using a heat shunt when soldering in crystal diodes, but I can't say that I agree with their point of view. I must concede, though, that one often-advocated method of applying a heat shunt by using a pair of taper-nosed pliers (Fig. 1 (a)), can only be seriously recommended to three-handed service engineers! However, there's no need to do that sort of thing if you're sensible. As you know, we use crocodile clip heat shunts (Fig. 1 (b)) in the Workshop and the time and inconvenience incurred by their use is negligible."

"You have to admit, Smithy," said Dick, a little plaintively, "that there are very many people who put crystal diodes into circuit without heat shunts at all, and that they seem to get away with it. Do you think, perhaps, that we're being just a little too fussy?"

"Not at all," replied Smithy. "I would say with some confidence that those people who don't use heat shunts will find that a small percentage of the diodes they connect up refuse to work properly, have shifted characteristics, or fail at an early date. Mark you, this percentage may be quite low, but I still think it's good practice to obviate it altogether. The point is that the heat shunt habit is a very useful acquisition when you start tackling transistors, as these are definitely susceptible to overheating."

"Anyway, we're getting off the beam. What started our present discussion was this chassis which causes video detectors to become faulty at regular intervals. I'm quite happy that your previous replacement diode was O.K., and so we must look elsewhere. I presume that no h.t. was getting on to the diode?"

Fig. 1 (a) An often recommended method of applying a heat shunt. The taper-nosed pliers, applied to the component lead-out wire as shown, prevents the transference of excessive heat from the tag to the component body during soldering. (b) A much more convenient method of applying a heat shunt consists of clipping a crocodile clip, modified as shown here, to the lead-out wire. The slugs of brass or copper should have approximately the volume indicated by the diagram. The small V cuts ensure a positive location with the lead-out wire, together with somewhat greater thermal contact area.

"Not a scrap," replied Dick. "The detector circuit is extremely simple: it consists of the secondary of the last i.f. coil, the crystal, and the load resistor in series. It would be extremely difficult for any h.t. to find its way across the diode."

"Fair enough," remarked Smithy. "All I can then diagnose is that the crystal is burning out because of the application of too high an i.f. voltage."

"Hey?"

"I'm quite serious," continued Smithy. "In some of these early sets, many of which..."
had either a very rudimentary a.g.c. system, or none at all, it is easily possible for the customer to accidentally turn up his contrast or sensitivity control too high, and thereby cause a fantastically high video i.f. voltage to be passed on to the video detector. This assumes, of course, that the receiver is tuned in a strong signal area. If maladjustment of the contrast or sensitivity control occurs before the set is switched on, then the customer doesn’t have to untune the set or picture until e.h.t. appears—by which time the damage will have been done. I can think of all sorts of other eventualities which can similarly result in too high an i.f. voltage being passed to the video diode. For instance, the customer may have a wonky connection to his aerial, wherein he finds that he has to screw the gain of his set up in order to get a reasonable picture. All of a sudden, the aerial connection becomes good again and—bang!—goes another diode.

“It sounds to me,” remarked Dick, “as though this business of overloaded video diodes is by no means new to you.”

“It isn’t,” said Smithy. “That’s why I made such a confident diagnosis just now. If the set had been a more modern job with, say, mean a.g.c. coming off the sync separator grid, I wouldn’t have been so confident because conditions would then have been much less liable to occur.”

“That’s fair enough, I suppose,” said Dick dubiously, “but where do I go from here? If I fiddle around with this set how long will it be before that goes?”

“You do have something of a problem there,” admitted Smithy. “When I jumped into this trouble I had a tendency to warn the customer against over-running his set, and this warning usually resulted in fairly reasonable protection for the diode. Nowadays, however, I use a completely different idea, this consisting of replacing the diode with a type which has a higher turnover voltage. In your case I would recommend that instead of another OA70 you fit an OA79. The maximum inverse voltage of an OA79 is twice that of an OA70 and it is intended for use in fairly low impedance circuits, such as f.m. ratio detectors and the like. You should find that it gives just as good a picture. I know that I’ve never had one go wrong before, and I’ve often seen in receivers suffering from this sort of trouble.”

“That’s fine,” said Dick enthusiastically, “I’ll pop an OA79 in straight away. Incidentally, Smithy, why are video detector circuits nearly always screened?”

“For the same reason,” said Smithy, “as are many other receiver detector circuits which rectify signals at high levels. The presence of detection causes the rectified half-cycles to resemble square waves, and these are liable to be very rich in harmonics of high enough frequency. Unless you apply a reasonable amount of screening to the detector circuit these harmonics may find their way back to the front end of the set. O.K. doesn’t want a picture which looks like this set long until e.h.t. appears.”

“Sure,” said Dick. “By the way, have you heard about the last word in automation?”

Smithy raised his eyes to the ceiling in mock despair.

“Go on,” he intoned dolefully.

“Well,” said Dick, “it consists of a black box with a switch on the front.”

“Yes?”

“To set it in motion you push down the switch. Whereupon there is an immediate and furious whirring inside the box, the lid opens, and an arm comes out and turns the switch off.”

Dick stopped and looked expectantly at Smithy, whose expression remained unaltered.

“That’s it,” finished Dick lamely.

“Oh,” said Smithy.

With further remark he returned to his bench where, unseen by his assistant, he allowed his face to relax into a wide grin.

Printed Circuits

Crushed, Dick returned to the receiver in front of him. He soldered in a new crystal of the type advised by Smithy, found that he obtained a satisfactory picture, and fitted the chassis back into its cabinet. A final check of the boxed set showed that all was well, whereupon Dick stowed it away on the “repaired” rack.

The next set Dick took to his bench was of a much more modern type. Dick quickly checked the performance of the receiver and removed its cabinet while he gave a sharp exclamation of surprise.

“What’s up?” said Smithy, turning round.

“Would you credit it?” asked Dick, “but I’m blown if I haven’t got another video detector up the wall!”

“That’s very nice for you,” commented Smithy. “The same fault twice running should give your diagnostic powers a pleasant rest.”

“Do you think that this one went faulty due to too much signal level also?” asked Dick.

“It’s doubtful, if it’s a recent receiver,” replied Smithy, “although I should check the a.g.c. line for shorts to chassis just in case.”

He noticed that Dick’s expression was becoming more and more disgruntled as he examined the chassis he had selected.

“What’s the matter?” queried the Serviceeman.

“I’m going to have a deuce of a job replacing this diode,” said Dick lugubriously. “The manufacturers have packed it inside the same can as the coil it’s connected to, and the coil is soldered to a printed circuit board by at least half a dozen tags.”

The Serviceman went over to look at the chassis.

“All I can say,” he remarked eventually, “is that if you intend unsoldering the coil from the board, you must positively like unnecessary hard work. As Dick pointed out, the coils in this receiver are just the same as the coils in most other printed circuit television sets, insofar that the cans are held by spring clips and cannot be pulled off quite as easily as they can be. Even if you don’t simply remove the coil can, nip out the faulty diode, and solder a new one in its place whilst the coil assembly is in situ on the board.

“I must be getting a little dim in my old age, because that thought never even occurred to me,” commented Dick. “Now that you mention it, your idea seems to be the obvious thing to do.”

“Most definitely it is,” replied Smithy. “Nevertheless, you’d be surprised at the number of people who go to all the trouble of unsoldering a coil full from a printed board when all that’s wrong with it is something which can be just as easily fixed by merely taking it off. Even if the winding itself has gone faulty you can still quite often effect a repair after merely removing the can. Quite a few of the more modern television f.t.t. coils are wound with T.N.A. wire, so you don’t have to bother about stripping it—you merely apply solder and a hot iron.”

“It sounds to me,” remarked Dick, “that you have decided to evolve your own technique for printed circuits. What about components, other than i.f. coils, which are soldered to the board by a relatively large number of tags?”

“Well, you have to regulate your repair system according to the circumstances of each particular case,” conceded Smithy, a little guardedly, “but there are quite a few components such as all i.f. coils which can be repaired whilst in position on the board. For instance, I’ve had one or two cases of such a fault in the output stage transformers whereby the primary wire was taken from the winding to two tags on its periphery. All that was wrong with these transformers was that the receiver had broken away at one or other of the tags. It was quicker to repair these wires than it was to unlash the whole tranny from the board.”

“Ah, yes,” persisted Dick, “but the occasion must arise at some time when you have to unsolder multi-tag components from a board. What then?”

“There are one or two bright ideas to fall back on then,” replied Smithy. “If you possess a solder gun, then one of these tricks—making up a circular bit which is some $\frac{1}{16}$ inch in diameter (Fig. 2). You can then apply this bit to the board if you want to remove, say, a valveholder, whereupon it melts all the solder joints at once. Such a bit will usually tackle all the joints on i.f. coils and things like that as well, should this be necessary.

[Solder gun terminal pillers bit]

Fig. 2. A solder gun bit, shaped as shown here, can prove useful in removing valveholders and similar components from printed circuit boards

“An alternative idea consists of tackling one by one the joints which secure multi-tag components to the board. What you do in this case is to apply a wiped iron to each joint so that it automatically removes most of the solder. Whilst the joint is still hot you then brush it quickly with a toothbrush, thereby dispersing the remainder of the solder. When you’ve done this to all the joints it is clear that the component, it is usually possible to lift it out quite easily. This process sounds a little long-winded, I must admit, but after you’ve done it a few times you soon get the knack of it.”

“There is one method, however, that you should never use. You should never try to remove a multi-tag component by unscrewing one tag at a time and simultaneously trying to rock the component. That’s one of the surest methods of lifting the copper at the other tags that I know about.”

“O.K.” said Dick. “I’ll bear those points in mind. This printed circuit board certainly seems to have resulted in service engineers dreaming up new gadgets.”

Service engineer, said Smithy, a little pompously, “have been dreaming up new gadgets ever since radio started. It’s part of the trade. As you go around you’ll probably hear a few service engineers beheading about
printed circuits and pining for the old days when everything was conventionally wired. But I don’t lay much store by such complaints. Service engineers are rather like farmers, they just love to grumble!”

Test Prods
“Talking about grumbles,” remarked Dick, “you've just reminded me about a recent complaint of yours concerning the serviceability and upkeep of the test prods in this Workshop.”

“I seem to remember saying something of that sort,” said Smithy, cautiously.

“I have an idea,” continued Dick, “that your complaint occurred when you were checking the mains voltage a week or two ago. You may recall that the rubber insulation at the top of one of the prods you used had slipped away from the metal underneath.” Dick paused for a moment, as though savouring a pleasurable memory. “You jumped around a little,” he added.

“Merely an expression of joie de vivre.”

“Quite so,” said Dick. “At any event the occasion has resulted in my producing a pair of super-duper test prods which are not only strong but have really tough insulation.”

As (Fig. 3 (b)). A little p.v.c. tape over the joint provides extra strength here. The final process consists of covering the rod and the joint with 6ifo 3mm plastic tube of the type used for the fuel lines of model aircraft, the requisite type being that which is knurled longitudinally on the outside. The plastic tube is a little tight on the rod, but if it is held in hot water for a few minutes it can be forced on. The tube should be passed over the rod until it is some 6in past the solder joint. The final job consists of trimming the tube at the pointed end of the rod to leave, say, 11/2in of brass showing (Fig. 3 (c)). The result of all this is a really tough and reliable test prod.”

“It certainly seems to be good and strong,” remarked Smithy, examining the prods which Dick showed him. “I think you’d better knock up a few more.”

“O.K.,” said Dick. “Incidentally, talking about hot water reminds me of a joke I want to tell you concerning a commercial traveller who ran out of petrol...”

Fig. 3. Successive steps in the construction of the test prods described by Dick.

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THEORY

UNDERSTANDING TELEVISION

PART 15

By W. G. MORLEY

The eighteenth in a series of articles which, starting from first principles, describes the basic theory and practice of television.

L ast month we considered, in rather general terms, the overall requirements of the i.f. amplifier in a modern television receiver. We shall now carry on to a more detailed consideration of this part of the receiver.

The Vision i.f. Amplifier

The function of the vision i.f. amplifier is to amplify the vision i.f. signal passed to it by the tuner unit at the front end of the set. In consequence, the vision i.f. amplifier must have a frequency response which enables all video frequency sidebands to be amplified at correct level. A complicating factor is that the transmitted signal has one of its sidebands only partially suppressed. Fig. 81 illustrates the ideal British transmitter characteristic.

As may be seen, the sidebands resulting from the lower modulating frequencies appear on either side of the carrier.

Fig. 82 shows the response curve of an i.f. amplifier which would be capable of amplifying the video i.f. signal satisfactorily. It will be seen that the response is flat between approximately 35.9 and 37.65 Mc/s, after which it falls rapidly to a very low level at the sound carrier frequency of 38.15 Mc/s. Below 35.9 Mc/s the response falls more gradually, it crossing the 34.65 Mc/s line (the intermediate frequency which corresponds to vision carrier) at a level which is approximately 50% of the total amplitude of the response. The response reaches a low level at 33.6 Mc/s approximately, this low level being maintained at the adjacent channel frequency of 33.15 Mc/s.

1 This characteristic is based on the information given in Fig. 30 and Table II of Understanding Television, part 4, published in the April 1958 issue.

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3 See last month's article.
The reason for the gradual drop in the response of Fig. 82 below 35.9 Mc/s is that this helps to counteract the effect of the partially-suppressed sidebands on the vision carrier. If the i.f. response of the receiver were flat from 37.65 to 34.65 Mc/s, the lower modulating frequencies, which appear to be a deviation in response amplitude of 2 dB to occur before any visible effect becomes obviously noticeable in the reproduced picture. Some authorities give a figure of 3 dB in response amplitude as the maximum obviously-noticeable variation. Thus, the flat-topped response of Fig. 82 may change in amplitude level by 2 dB and still be considered "flat."

Another manner in which the response curve of Fig. 82 may be modified in commercial receivers is concerned with the overall frequency range covered. Ideally, the response should be "flat" up to 37.65 Mc/s so that the highest modulating frequency of in both sidebands, would be passed to the video detector at a higher amplitude than the high frequencies which appear in one sideband only, and a distorted picture would result. The fall-off in response in Fig. 82 below 35.9 Mc/s causes both high and low modulating frequencies to be passed to the video detector at approximately the same level.

The necessity for ensuring that the sound signal does not reach the video detector at sufficient level to cause interference with the picture results in the response of Fig. 82 falling rapidly to a very low level just before 38.15 Mc/s. The desirability of ensuring protection against interference from the adjacent channel sound carrier similarly results in the response being at a low level at 33.15 Mc/s.

In practice it is difficult to obtain a vision i.f. response curve equivalent to that shown in Fig. 82 whilst employing the small number of valves and tuned circuits dictated by commercial manufacturing requirements. As a consequence, the vision i.f. response in practical receivers may be degraded by smaller amounts. These should not, however, cause any noticeable degradation of the reproduced picture.

The response of Fig. 82 is flat between 37.65 and 35.9 Mc/s. In practice it is permissible for a deviation in response amplitude of 2 dB to occur before any visible effect begins to be noticeable in the reproduced picture. Some authorities give a figure of 3 dB in response amplitude as the maximum obviously-noticeable variation. Thus, the flat-topped response of Fig. 82 may change in amplitude level by 2 dB and still be considered "flat."

Another manner in which the response curve of Fig. 82 may be modified in commercial receivers is concerned with the overall frequency range covered. Ideally, the response should be "flat" up to 37.65 Mc/s so that the highest modulating frequency of

3 Mc/s may be amplified at correct level. In many practical televisions the vision i.f. response commences to drop at a frequency markedly below 37.65 Mc/s, with the result that modulating frequencies approaching 3 dB and 3 dB are equivalent to voltage ratios of 11.38 and 11.41 respectively. The expression "dB" is an abbreviation for "decibel."

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Fig. 82. A vision i.f. response capable of handling the transmitter characteristic of Fig. 81. (It will be remembered that, after conversion, the vision carrier i.f. falls below the sound carrier i.f.)

Fig. 83 (a) and (b) Typical examples of how the response of Fig. 82 may be degraded without excessive loss of picture quality. In both cases the sidebands of modulating frequencies above 2.5 Mc/s suffer attenuation

3 Mc/s are not amplified at full strength. Usually, such fall-offs commence around 37.15 Mc/s, so that full amplification is provided for modulating frequencies up to 2.5 Mc/s only. A fall-off in response at a frequency lower than 37.15 Mc/s may be encountered in some receivers, but this is not the same thing.

An i.f. response curve typical of those liable to be found in commercial receivers is given in Fig. 83 (a). In this diagram we see a response which is "flat" within 2 dB between, approximately, 35.9 and 37.15 Mc/s, which is consequently capable of handling the sidebands of video modulating frequencies up to 2.5 Mc/s without any obviously noticeable difference of level in the reproduced picture. The response curve of Fig. 82 (b) may occasionally be encountered; and this can similarly handle the sidebands of modulating frequencies up to 2.5 Mc/s.

It will be noted that the response of Fig. 83 (a) is, in reality, a broad single-peak response, whilst that of Fig. 83 (b) has the double-humped shape normally associated with bandpass circuits.

Individual Tuned Circuits

The process of designing a vision i.f. amplifier capable of providing even the slightly damped curves of Figs. 83 (a) or (b) is not necessarily as simple a process, and considerable care has to be taken to ensure that a number of conflicting requirements are satisfactorily met.

Whilst it may, at first sight, appear that a satisfactory response may be obtained by the use of a number of tuned circuits which are damped (by, say, connecting resistors across them) so that they individually give a broad response, such a technique has to be used with caution. This is due to the fact that the gain provided by an amplifier whose tuned circuits are excessively damped tends to be low. Despite this, damped tuned circuits are frequently encountered in vision i.f. amplifiers, a compromise being struck between gain and frequency response. Conflicting with the gain requirement is the point that, if a tuned circuit in a video i.f. amplifier functions very efficiently, giving thereby a sharp response, such a tuned circuit is liable to ring if shock-excited by an intermediate frequency equal to that to which it is tuned.

This little detail is perhaps better understood with the aid of Fig. 84 (a). In this diagram the tuned circuit oscillates in sympathy with the intermediate frequency during the time that it exists (points A to B in Fig. 84 (a)) but, when the intermediate frequency disappears, the tuned circuit could be left oscillating at the frequency which it is tuned, causing a "damped train" of oscillations (i.e. a series of oscillations continually decreasing in amplitude) to be passed on to the video detector. Such a damped train will appear on the picture. A damped train having a sharp response curve may also be shock-excited into ringing when there is a sudden and large change in amplitude in the signal (say, from black to white or vice versa) whereupon, once more, a damped train of oscillations is passed to the video detector. (See Fig. 84 (b).)

Another conflicting factor affecting the design of a vision i.f. amplifier is that this must be capable of offering a good transient response. Sudden changes in amplitude of the i.f. signal must be handled without the introduction of excessive distortion and must be passed to the video detector without appreciable delay or overshoot. As a rule of thumb it is normal to assume that if any tuned circuit in a vision i.f. amplifier has an excessively sharp response, the transient response may become degraded.

With the points just mentioned in mind, we may now consider the various manners in which the individual responses of a number
tuned circuit in this diagram is adjusted to 38.15 Mc/s, whereupon it absorbs energy at that frequency from the i.f. coil to which it is coupled. There is no direct connection between the i.f. coil and the repressor coil, as the coupling is purely inductive. It is possible, by varying the spacing between the two coils, to make the circuit of Fig. 86 (a) provide varying degrees of rejection.

Another simple repressor circuit is illustrated in Fig. 86 (b). In this case the repressor circuit is inserted in the coupling connection between a pair of bandpass tuned circuits. Yet another simple repressor circuit is illustrated in Fig. 86 (c). In this instance, a series tuned circuit connects directly across one of the i.f. coils, and it absorbs energy at the frequency to which it is tuned. A further method of employing a single tuned circuit for repressor purposes is shown in Fig. 86 (d).

Here, a parallel tuned circuit resonating at the rejection frequency is connected in series with the circuit of Fig. 86 (b). This is done to prevent the coupling of the repressor circuit to the original circuit.

**Fig. 86 (a)** A simple absorption repressor circuit. The repressor coil is coupled inductively to the i.f. coil. (b) A bandpass network having a repressor tuned circuit inserted in the common connection between the two tuned coils. (c) Another absorption repressor circuit. (d) Attenuation at a fixed frequency may be obtained by inserting a parallel-tuned circuit in series with the cathode of an i.f. amplifier valve.

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with the cathode of one of the i.f. amplifier valves. At frequencies removed from the rejection frequency this tuned circuit possesses a low impedance and has little effect on the functioning of the i.f. amplifier. At the rejection frequency the tuned circuit offers a high impedance, with the result that the valve functions in rather the same manner as it would if it had a high cathode bias. In consequence, it offers less amplification.

The circuits of Fig. 86 can all offer varying degrees of rejection according to the efficiency of the tuned circuits employed.

![Diagram](image)

**Fig. 87.** Two bridged-T rejector circuits. The resistances shown in series with the coils represent the losses in these components and would not appear as physical items in practical networks.

**Adequate Rejection**

In order to obtain complete freedom from sound interference on the picture presented by the cathode-ray tube it is necessary for the sound i.f. to be some 40dB or more in level below the picture signal level.6 None of the circuits of Fig. 86 are capable of providing this degree of rejection on their own, although sufficient rejection would be feasible if two or more were employed in successive stages. As a result, more complicated and more efficient rejector networks are employed in commercially manufactured receivers. The most popular of these is the bridged-T circuit. Figs. 87 (a) and (b) illustrate two popular bridged-T networks. When the correct values of resistance, capacity and inductance are employed in either of the circuits a considerable amount of rejection is obtained, and it is possible for one circuit of this type to provide all the rejection needed in a vision i.f. strip. Usually, however, a bridged-T network is employed in combination with one or more simple types of circuit shown in Fig. 86.

The sound rejection in a number of modern television sets is so sharp that it is the overall response that is similar to that shown in Fig. 88. When this type of response is obtained it is desirable to adjust the fine tuner of the associated receiver such that the sound intermediate frequency falls into the centre of the rejection trough, or “dip,” and not to either side. Failure to do this may cause sound interference on the picture.

When adjacent channel rejector circuits are fitted to a receiver these usually take up one of the simple forms illustrated in Fig. 86, because there is no necessity for as high a degree of rejection at this frequency as is required in the sound rejector circuits.

Finally, a minor point of terminology needs to be mentioned. In British literature, circuits of the type we have just discussed are normally referred to as sound or adjacent channel rejectors. In American literature such circuits are frequently called sound, or adjacent channel traps.

**Cross-Modulation**

When two separate frequencies are handled by a single amplifier which introduces amplitude distortion6 each of the frequencies is liable to modulate the other. This process is described as cross-modulation.

Cross-modulation can be very troublesome in vision i.f. amplifiers because its existence may allow the vision intermediate frequency to be modulated by the sound intermediate frequency, with the result that there is sound interference on the picture. Cross-modulation is liable to particularly troublesome in the early stages of a vision i.f. amplifier because the sound i.f. may not be fully rejected at such stages. At the same time later stages, which handle larger signals, are more prone, in themselves, to amplitude distortion and hence cross-modulation. However, the risk of cross-modulation is less severe in later stages because adequate sound rejection in the early stages will, in normal designs, have been provided.

![Diagram](image)

**Fig. 88.** If a network provides very sharp rejection, the overall i.f. response curve around 38.15 Mc/s may take up the shape shown here.

**Fig. 89.** The anode current-grid voltage curve of a typical i.f. amplifier valve. If the valve is biased at point A the input signal is applied to a relatively straight part of the curve, and the output waveform closely resembles the input. When the valve is biased at point B the input signal is applied to a noticeably non-linear part of the curve, with the result that the output waveform is a distorted copy of the input signal.

![Diagram](image)

**Next Month**

**Diomatic Frequency Controlled Switched FM Tuner**

by P. C. Michael

“Transistogram” — A Transistorised Portable Record Player

March 1959

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CRYSTAL STABILISATION
for
MODEL CONTROL

by F. G. RAYER

THE SIMPLE TYPE OF TUNABLE MODEL control transmitter can easily operate outside the permitted band, and harmonics can cause television interference over a wide area. Though such transmitters have the advantage of simplicity, economical running, and small size, there are occasions when a crystal controlled transmitter can be employed instead with advantage.

Such equipment cannot operate outside the permitted band, as wrong adjustment will prevent the transmitter operating. For short range, enough output can readily be achieved. The signal may also be used for the accurate calibration of a wavemeter, which in turn will allow a tunable transmitter to be adjusted correctly.

Surplus crystals are easily obtainable, and a frequency which falls within the permitted band, when multiplied by 2, 3 or 4, should be chosen. For example, a 9 Mc/s crystal, with a multiplier stage, will provide 27 Mc/s. Crystals requiring very much multiplication are best avoided.

The crystal forms the resonant part of the grid circuit, as in Fig. 1, and the valve commences to oscillate when L1 is tuned to the same frequency. A simple capacity coupled stage provides multiplication. For a 9 Mc/s crystal, L1 can thus tune to 9 Mc/s, and L2 to 27 Mc/s.

With an active crystal, or fairly large h.t. voltage, direct multiplication may be achieved by tuning L1 to a multiple of the crystal frequency. However, with some crystals oscillation will only arise when L1 is tuned to the crystal frequency, especially in view of the fairly small h.t. voltage which may be convenient. For this reason, it is as well to limit multiplication to the following stages.

Resonance Check
A meter should be included in the h.t. supply to L1, or in series with the h.t. battery. A sudden drop in anode current, on tuning this stage, will then show that the valve has commenced to oscillate. A small power valve is most suitable. "All-dry" output tetrodes are satisfactory, and screen grid and anode may be wired together for triode operation.

The h.t. choke can often be omitted, but it increases output, and helps to assure oscillation with a small h.t. battery. Wiring should be reasonably short and direct. L1 may be fixed, or can be wound upon a plug-in coil former, as in Fig. 4. For 9 Mc/s, 12 turns of 20 s.w.g. wire, occupying 1½in on a 1½in or similar diameter ribbed former, will be satisfactory.

L2 will radiate sufficient r.f. to light a low-consumption bulb soldered to a 1-turn coil. After tuning L1 for minimum h.t. current, it is thus only necessary to tune L2 for maximum brightness of the bulb. An output on 27 Mc/s will then be obtained, provided L2 and its associated condenser are so chosen that wrong multiples of the crystal frequency cannot be reached. Stray wiring, and the type of valve employed, exerts a fairly large influence on this stage, but 7 turns of 20 s.w.g. wire occupying 1½in winding space on a 1½in diameter ribbed former, as in Fig. 4, will usually be satisfactory.

If L2 is not tuned correctly to 27 Mc/s, output drops, or ceases. With a 9 Mc/s crystal, no output would be obtained unless L2 were tuned to 18 Mc/s or 36 Mc/s, instead of 27 Mc/s, and such a large error is extremely unlikely. This is quite unlike the results obtained with a self-energised tunable transmitter, which will radiate upon any frequency to which it is adjusted, so that operation just

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outside the 27 Mc/s band is likely, with wrong tuning.

Output Stage

If more power is required, a power tetrode can be used. Fig. 2 shows a very simple circuit of this kind. With a large l.h.t. voltage, neutralisation may be required to prevent self-oscillation in this stage. This can be achieved by adding an extremely small fixed capacity from the grid to tank coil, in the usual way. A neutralising condenser is most suitable.

The aerial may be coupled by a 2-turn winding situated near the tank coil, or over-wound upon it near the l.h.t. tapping. If required, efficiency can be increased by adding an h.f. choke in series with the 100kΩ resistor, and this can also be done in Fig. 1. When two anode circuits are tuned to the same frequency, a careful layout is necessary, to avoid stray coupling and oscillation.

Mains Circuits

Good results can be obtained with mains valves, and a mains operated transmitter is convenient for testing model control receivers and equipment at home. Such a transmitter may also be run from a 6V accumulator, with h.f. derived from a small rotary transformer.

A 2-valve circuit is shown in Fig. 3, which operates as already described, but with much increased power. Although bias would be obtained by grid rectification, cathode bias is provided for the 6V6, to avoid heavy currents when adjusting the tuning.

Coils have already been described, and are shown in Fig. 4. Smooth formers can be used, but will usually require a turn or so less. For the 27 Mc/s coil, a self-supporting winding, of 16 s.w.g. wire, is easily arranged.

Output and Frequency Check

Fig. 5 shows a bulb loop, used to tune the transmitter for maximum output. With low-power battery equipment, the loop has to be near the anode coil, in line with it. But with mains equipment, or higher power, the loop must not be too near the coil, or the bulb may blow.

When the crystal controlled transmitter is correctly tuned, it can be used to calibrate a frequency meter. The coil for this should have turns cemented in position, so that calibration is not lost, and the tuning condenser is fitted with a pointer or dial. Two turns of thin insulated wire, overwound upon the tuned winding, and also cemented in place, are taken to the bulb. Soldered connections are preferable to a bulb holder, as changing the bulb can slightly upset exact calibration. A 6V 0.3A bulb can be used for mains equipment, but a low consumption bulb is better for battery equipment.

The frequency meter is approached to the 27 Mc/s anode coil, and the meter tuning knob rotated for maximum glow. The exact resonant point is more accurately seen if the meter is kept at a sufficient distance, so that the bulb emits only just lights when tuning is correct. This calibration point may be used to adjust a tunable transmitter, in this case transmitter tuning being set for maximum glow.

Can Anyone Help?

Requests for information and leads in this section free of charge, subject to space being available

Hallcrest S38 Receiver.—P. J. Darke, of 5 Whalley Lane, Uplyme, Lyme Regis, Dorset, requires servicing data—all expenses paid.       

“Hambler” Receiver.—J. Hibbard, of “Rose Cottage,” Cat and Fiddle Lane, West Hallam, N. Derby, requires the circuit diagram or service sheet.

Trans/Receiver RT34/APS-13.—J. Baldwin, of “The Dingle,” Habberley Road, Bewdley, Worcestershire, asks for information in particular for details of the 7-pin plug connections.  A switch may be returned and any expenses defrayed. Alternatively willing to purchase.

“Jason” Variable Tuned FM/VHF Tuner.—R. G. Harman, 11 Yew Tree Road, Birchcliffe, Huddersfield, W. Yorks, wishes to obtain the service manual.

It is not usual, in receivers covering the normal broadcast bands, to tune by means of a variable inductance tuner, but with the introduction of the Telefunken FX25, self-tuned, dual-wave inductor (which made its debut in a transistorised circuit) such a method becomes possible. Experiments reveal that the unit can give an excellent performance when associated with valves, and the practical arrangement described here results in an efficient little receiver which is not expensive to construct.

Whilst aerial/earth sockets are provided it should not be thought that they are essential; in a great many locations the receiver will function admirably without either, as the inductor has been carefully positioned in order to obtain maximum self-pickup.

Care has been taken, too, to eliminate any possibility of the chassis becoming “live,” and a negative bus-bar, to which the chassis is connected via a high voltage capacitor, makes it possible to ground the chassis in the usual way. No on/off switch is fitted to the prototype, in order to ensure that at all times when not in use the receiver is disconnected from the mains supply. In many cases this precaution might be considered unnecessary and a switch may be included, either in the flex input leads or incorporated in the regeneration/gain control. A switch of the double-pole variety must be used, however, whichever method is adopted.

As a slim construction was desired, the practical layout made to order; bending one's own is not always a practical proposition when a perfectly symmetrical end-product is required!

The Circuit is shown in Fig. 1, where it can be seen that only two valves are employed, the first being used as a leaky-grid demodulator plus low frequency amplifier. Controlled regeneration assists the tuned circuit and greatly improves sensitivity, the particular mode of control being extremely docile in operation. Feedback is obtained from the screen of V1 and not from the anode.

Switching of the tuned circuit is ridiculously simple, the long-wave winding merely being shorted when medium-wave transmissions are required.

When the inductor is purchased a capacitor of 500pF will be found connected from tag 4 to tag 6; its purpose being to roughly tune both bands. In some cases it may be left in situ and will occupy the position C3 occupies in the circuit diagram, so that the C3 shown will not be required. The slight modification shown was made in order to obtain optimum results at the high frequency end of the medium-wave band as it was discovered that by cunning variations in the values of C3, C4, the output could be made to discriminate in favour of a particular section of either band.

The output stage and the power supply arrangements are conventional, the field winding of an energised type speaker being used as a smoothing choke. A permanent-magnet type may be used if desired, but a choke will then be needed.

Construction is not difficult, but to assist beginners both chassis drilling and point-to-point wiring diagrams are given (see Figs. 2, 3, 4, 7, 8). A simple L-shaped bracket needs to be made to hold the inductor and this is illustrated in Fig. 5—16 s.w.g. aluminium will be found suitable. Once the chassis has been drilled the various components can be mounted, and to secure the speaker, a sheet of metal or plywood 6in square is recommended, the speaker being bolted to it after first cutting an aperture. The assembly may be bolted to the front flange of the chassis and held off by thin strips of wood to avoid making to make a cut-out in the chassis itself.

All controls are placed at the side, and provided a cabinet not less than 9in wide.
Capacitors
C1, C7 0.01µF
C2 75µF
C3 500µF (fitted to FX25—see text)
C4, C5, C6 150µF
C8 2,000µF
C10, C11 12+12+12µF electrolytic
350V

Resistors
R1, R4 47kΩ, 1-watt
R2 10kΩ wirewound potentiometer (see text)
R3 15kΩ, 1-watt
R4 3.3MΩ
R6, R7 470kΩ
R8 470Ω, 1-watt
R9 100Ω, 1-watt

Valves
V1 6SH7
V2 6V6GT

Rectifiers MR1-2
RM2 (2) or DRM2B (1) Brimar

Output Transformer
8,500Ω/3Ω

Inductor
Teletron, FX25

Speaker
5in energised (or see text)

Heater Transformer
230V input, 6.3V output at 1.5 amps.

Switch
Single pole, two-way

Chassis
\( \frac{3}{4} \)in x 4in x 1.1in—Oliver & Randall Ltd.,
53 Perry Hill, S.E.6

Miscellaneous
Aerial/earth socket, wire, solder tags, tagsrip—(6+1 earth), 3 control knobs, nuts, bolts, mains lead and 3-pin plug, bracket (see text), etc.

THE RADIO CONSTRUCTOR
internally is employed, no difficulty will be experienced in inserting the completed chassis.

Only one tag strip is used, and from a tag on this the negative bus-bar is run clear of the chassis in bare 22 s.w.g. wire across to pins 2 and 3. V1 (pin 1 on this valve must not be included in the connection as this is the metallising pin). To this wire all negative returns are taken.

The electrolytic capacitors are all included in a single cardboard tube type but in case of difficulty, or for convenience, C9 may be made a separate component, ample chassis mounting space being available.

Particular care should be taken when mounting the aerial/earth socket to see that no short-circuit exists between the aerial pin and the chassis. It is important, too, to ensure that C7 is included, otherwise an external aerial plugged in will become live to the mains when the set is switched on.

Detailed wiring instructions are not necessary as the diagrams are self-explanatory: it is, however, advisable to use leads with differently coloured insulation when wiring the inductor to facilitate final checking.

On completion, no difficulty should be experienced in locating transmissions on either band when the tuning knob is manipulated. By adjusting R2, optimum results will be obtained. Reception should be crisp, clear and "beefy." R2 should not be of the type where the spindle makes contact with the slider.

All that remains to be done is to house the chassis in the most attractive cabinet that one can construct, and as only the speaker occupies the front panel, a sheet of gold fret backed by plywood may cover this area, so achieving a contemporary style. Approximate internal dimensions are: 9½ in x 5 in x 6 in.

Tuning scale. Due to the fact that the tuning knob spindle (with which is supplied a brass bush to enable fitting to be made with a ½ in knob aperture) screws in and out of the inductor, the normal type of tuning dial is useless. The total length of travel is approximately 1 in, and a suitable indicating device is shown in Fig. 6, where a graduated strip of celluloid or perspex is let into the cabinet side close to the control knob. A disc of white card glued to the inside edge of the knob acts as a rotating pointer. Alternatively, a length of ½ in diameter, wooden rod can be fixed to the end of the iron dust core and extended the full width of the cabinet so that it projects ½ in through a hole drilled for it in the opposite side. The projecting end may be painted white and graduated, the principle of operation being the same as before, viz., that its marked position relative to the cabinet indicates the desired transmission.

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The "MAYKIT" TRANSISTORISED CAR RADIO

Part 1

by Richard Myers

This series describes fully a modern car radio design which may be built by any motorist—with or without experience of radio work—from the receipt of the components to the testing of the unit. Suggestions for car installation are included. The printed circuit and condensers are by T.C.C.

Test Report

Power supply voltage 14.4V d.c., gain control set to give an output of between 1 and 2 watts under strong signal conditions.
1. A.G.C. delay corresponds to 300mW.
2. With a.g.c. operative, a change of 40dB at the input gives a change of 3dB at the output.
3. Sensitivity figures at 640 kc/s, 2.5 microvolts for 100mW. At 1.43 Mc/s, 2.2 microvolts, 100mW.
4. Signal-to-noise: With a sensitivity of 2.7 microvolts at 640 kc/s, signal-to-noise is 20dB. At 1.43 Mc/s, sensitivity is 0.7 microvolts, signal-to-noise 20dB.
5. Rejection: At 640 kc/s, image rejection at 1.6 Mc/s is 60dB. At 1.43 Mc/s, image rejection at 2.4 Mc/s, 51dB.
6. I.F. Rejection: 200 kc/s is 39dB; at 640 kc/s, 10dB; at 1 Mc/s 38dB; and at 1.43 Mc/s 51dB.
7. I.F. Sensitivity: Input of 120 microvolts, 100mW out.
8. Bandwidth: 8.6 kc/s at 3dB points.

Many present-day car owners, whether brand new cars or not so new, aspire to the ownership of one of those "extras" so glibly advertised by the second-hand car marts! The "extra" referred to here is probably, after a heater-demister installation, the most important of the additional features among the whole bewildering host of extras currently being offered to the motorist.

The advantages of a car radio to the regular, or even the week-end, motorist, are many—the most important being, apart from pride of ownership, the ability at will to keep in touch with events while on the road. Newscasts, sports events and results are among those which come readily to mind. Additionally, of course, the entertainment value—particularly to the passengers on that long journey—often appears to cut many miles off the route! Jocularly, even the most rabid "back-seat driver" is silenced by the lifting melodies often to be heard from the Continental stations!

Illustration showing Car Radio components as received. Top, left to right, speaker and output stage chassis with main chassis; power filter chassis, and front panel with outer receiver casing. Tuner unit, transformers and wires. Pre-packaged components for the various stages of assembly, etc. Valves, dial and printed circuit panel.
To construct the car radio about to be described, no special skill or equipment is required other than a small electric soldering iron and a small-sized screwdriver, a pair of cutters and pliers and a razor blade. The inclusion of a printed circuit ensures that assembly is kept at a minimum, and wiring errors hardly likely which, consequently, enables the results obtained to be very largely standardised from one receiver to another. The tuner unit is complete and pre-aligned, as are the i.f. transformers.

The new hybrid design uses five Brimar valves with transistor output, and the inclusion of an r.f. stage—an often found in car radios—ensures adequate volume level under all conditions. The receiver is for use with a 12 volt battery, with a consumption of only 1.5A. It is regretted that no 6 volt models are available. Two-knob control is a feature of the receiver, that shown on the left-hand side being on/off and volume, that on the right being both the wavechange and the manual tuning control. The wavechange (Long and Medium Wave), is effected by a pull-out mechanism. The radio outer metal case is of grey hammered steel, fully louvered for ventilation purposes, this having a standard size of 8in x 7in x 21/2in to fit all modern cars.

The case itself contains the printed circuit and associated components, valves, tuner unit, and power supply filter box. The speaker and the transistor output stage are contained on a separate chassis, this stage being cable-connected to the receiver. Thus, the speaker unit is capable of being mounted, assembled as shown, at any suitable position at the front of the car according to the make and type or to the individual preference of the owner. Alternatively, of course, the actual output transistor, chassis, and associated components could be mounted in the front, i.e. under or behind the dashboard, and the speaker only, with a suitable metal grille or mesh, fitted at the rear of the car behind the back seat and under the rear window. In this latter instance, only the two speaker wires would have to be connected from the output transformer to the speaker—thus avoiding an unduly long inter-unit connecting cable.

As received, the components, any of which may be purchased separately, are as shown in the illustrations except for the speaker cabinet. In many types of cars this will not be required, it being shown here as an example for those who do require such a cabinet. The car radio supplier will, however, supply a very similar cabinet as an extra.
suitable car aerial, heavily chromed and in three pull-out sections, complete with input co-ax lead, will also be supplied as an extra.

Circuit

The theoretical circuit of the car radio is shown in Fig. 1. From this it will be seen that it consists of five 12-volt valves, in cascade, coupled into an output transistor. The valves used in this hybrid design are: V1—12AC6 tuned r.f. stage; V2—12AD6 mixer/oscillator stage; V3—12AC6 i.f. stage; V4—12AE6 detector, a.c.c. and first audio stage and V5—12KS audio amplifier and driver stage. These valves are followed by the output transistor—this being coupled via the output transformer to the speaker.

A technical specification of the receiver, under test conditions, is given later in this article.

The 12AC6 r.f. stage is both grid and anode tuned (t.p.t.g.), this being effected by two dust-core inductors, L3 and L7, in the grid and anode circuits respectively. The stage is prevented from oscillating by reason of the low h.t. voltage employed. On the Medium wave position (as shown in the circuit diagram), L5 and L9, the additional Long wave inductances, are short-circuited by the switch wavechange mechanism. On the Long wave position, both of these latter inductors are brought into circuit, they then being in series with the Medium wave windings. At the same time, the trimming condensers C2 and C3 (grid), together with C7 and C9 (anode), are all brought into circuit in parallel with the combined inductances. With the mechanism necessary for changing the wavelength is also combined that required for varying the two inductances, in step, thus tuning both the grid and the anode of this stage over the wavelength selected. The r.f. stage has a.g.c. (automatic gain control) applied via R3, C9 being the isolating condenser. The a.g.c. line is decoupled by the components R8 and C14. The tuned output from the r.f. stage is taken via the coupling condenser C9. The Medium wave trimming condensers are C8 (anode), and C10 (grid). Those for the Long wave are C8, C17 (anode), and C12, C13 (grid).

In the 12AD6 mixer/oscillator stage, L8 and L9 are the oscillator variable inductors in the Medium wave position—both L8 and L9 being short-circuited by the switching mechanism; these latter inductances are those required for the Long wave position. In this latter position both L4 and L9 are connected in series, with the oscillator anode; while both L5 and L9 are also in series, the trimming condenser C12 being in parallel across the series. These two inductors (L5 and L9) are condenser-coupled to the oscillator grid by C11, R4 being the grid-leak.

The Medium wave trimmer is C13, C14 being that for the Long wave position.

The output from the mixer/oscillator stage is passed, via the tuned coupling of IFT1, into the grid of the next stage.

The 12AC6 i.f. stage is conventional, its function being to provide additional selectivity and gain, at the intermediate frequency of 480 kc/s, and to pass the amplified signal to the following stage. A.G.C. for the i.f. stage is obtained via the components R3 and C13. The amplified i.f. signal from the 12AC6 appearing across the tuned windings of IFT1 are then rectified by the demodulator diode and taken, via the secondary winding, to the volume control VR2. R.F. decoupling is provided here by C15, R7 and C16, bypassing to chassis any residual r.f. that may still be a component of the signal at this point. The input for the triode section of the 12AE6, V4, is tapped off the volume control and passed, via C18, to the control grid.

The second diode of the detector is coupled to the anode of the i.f. stage via C17, and provides the necessary a.g.c. voltage. The a.g.c. voltage appearing across the load resistor R12 is taken, via R6, to the r.f. stage and via a further resistor R5 to the i.f. stage. A delay voltage to prevent the a.g.c. operating on weak signals is obtained via the cathode components R10 and R15. The amplified output from the anode of V4 is then taken to the grid of the second a.f. stage, V5, via the condenser C19.

The amplified audio signal is now applied to the primary winding of the driver transformer T1, from the anode of V5 (12KS). Being induced into the secondary winding, the signal is now applied to the base of the output transistor, this being operated in the earthed collector mode. Bias is applied to the base from the junction of the resistors R14 and R16, these being parallel-connected in order to obtain the required correct bias voltage and part of T2 connected, in series, across the supply. The output is taken from the emitter and thence via the output transformer to the speaker.

The power input is subject to a thorough filtering process by means of the three chokes and five condensers shown in the input supply. A 5-amp fuse is provided for protection purposes.

The ringed letters shown on Fig. 1 correspond to points similarly marked on the printed circuit panel.

Assembly and Construction

As received, the kit is mostly contained in seven polythene packets. Of these, five contain the various components necessary for the completion of each stage, as described above; while the remaining two contain the printed circuit and dial assembly, etc. In addition to these will be found the speaker and tuner unit respectively, in small cartons, and the output transistor in a small envelope. The main chassis, together with the power filter sub-chassis, chromium bezel, and the required wire and solder, etc., will be found contained within the main receiver metal casing.

The intending constructor will be wise to

Both sides of the pre-fluxed printed circuit panel are shown above. Components are mounted on the non-copper side in the positions clearly indicated and are soldered on the reverse side.

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adopt the method of assembly and construction described here, otherwise difficulty may be encountered at a later stage. The order and method has been carefully planned by the designers to ensure that no mistakes are made, no omissions possible, and no trouble experienced with the various wiring. In addition to the foregoing, it is advisable for the constructor to open only those packets as stated in the order described. The number of bags will vary, depending upon the components required for each stage. Do not throw away the polythene packets, as some will be required later.

Step No. 1
Locate the printed circuit board. Open packet No. 1 and identify the following components: R1, R2, R3, R4, R5, R6, R11, R12, R13. All these have a value of 2.2MΩ (red, red, green). R4—33kΩ (orange, orange, orange). R6—3.3MΩ (orange, orange, green). R5—5kΩ (green, blue, orange). R11—33kΩ (orange, orange, yellow). R12—10kΩ (brown, black, yellow). R13—100kΩ (brown, black, yellow). R14 and R16—470Ω (yellow, yellow, brown). The resistor board is marked with its appropriate circuit designation, i.e. R1, R2, etc. Two i.f. transformers (small metal cans marked Reg’l Design No. 1048) are for use with these components on one side, open packet No. 2, and identify the following components: C4, marked TCC 0.05µF type 346; C6 and C11, small white bodies marked 27.120%; C19, small brown body marked 220Ω; C10, marked TCC 0.01µF type T33; C14, marked TCC 0.01µF type T33; C15, small white bodies marked 100 ± 20%; C17, small rat type marked 101 SMP 30pF ± 20%; C18, small white body marked 1000pF; C20, lozenge shaped, not marked. Please note that TCC 1000pF C1543. Five valveholders, four self-tapping screws and one transformer T1 marked GB 1708.

Step No. 2
With the two packets now opened and the components identified, we now proceed to solder in position the components on the printed circuit board, the copper connections of which are pre-fused.

Mount the valveholders into position first, and do this by pushing them firmly into position, thus ensuring the correct positioning through on the side with the shiny copper markings. Note here that any valveholder will fit into any of the five positions; it does not matter which one is fitted into any particular position.

Solder each valveholder into position on the circuit board in the order 1 to 5 and do not forget to solder the central metal spigot.

The soldering should be done with a hot iron which must not be held on the printed circuit any longer than is necessary to make a good joint.

Step No. 3
With each valveholder now fitted, proceed to solder in position each individual resistor. The positions for these are plainly marked on the circuit panel (see illustration). The best method of mounting the resistors, in order that no mistakes are made, is to first deal with R1, R2, R3, R4, R12 and R13, these all being 2.2 MΩ. The wires should be straightened, and then bent at right-angles to the resistor body, the wires then being inserted into the panel and soldered by the holes. With this the surplus wire should then be removed with a pair of cutters. When soldering R3 into position, note that the end wires, in this single instance, will have to be bent at right-angles at a greater distance from the component owing to the greater length of wire required to fit the resistor to the panel.

Again, when dealing with the remaining resistors, commence soldering the individual resistors in numerical order, i.e. from R4 to R16. This is in order to sequence is to be found in packet No. 3, and will be dealt with at a later stage. Having dealt with the resistors, we now proceed to deal with the capacitors, and place these in position, the setting aside for the moment the i.f. transformers.

Step No. 4
Proceed to solder into position, in numerical order, the condensers contained in packet No. 2, commencing with C12, which should be so positioned that the end marked with a black line is nearest to R1. C5, C9, and C11 may be mounted either way round. C14 and C17 should both be so positioned that the small end is towards the top of the printed panel, ensuring that the green spot on the base of the can is in the same corner as G’ shown on the panel. Bend over the two metal tags of the outer can and solder into position. Finally, cutting off the surplus wire. With this completed, we can now solder into position the condenser C7, this being so positioned that it is entirely and NOT touching the metal casing of the i.f. transformer.

Step No. 6
The last component to mount on the panel is the transformer T1 (marked GB 1708), from packet No. 2. It is only possible to position this component the correct way round, there being three tags on one side and only two on the other, each corresponding to similar cut-outs on the printed panel. This transformer must be soldered in position along the side of the panel as the other components.

Bar both ends of three lengths of black p.v.c. wire, each about 1 lin long (it is only necessary to bare about ½ in at each end), and solder one wire end to point K on the printed panel, the second wire end to the point L, and do not to the third end to point M. The three free ends will be dealt with at a later stage.

(Book Reviews)


There are hundreds of receiving and transmitting valves listed in the pages of this comprehensive data book. Valves made by most of the manufacturers in the world are to be found in the listings. The various types are shown with those prefixed by figures first, in numerical order. Then follow types prefixed by letters, in alphabetical order.

The aim of the book is to provide the constructor with all details that can be seen at a single opening of the book. The type identified, and the performance of the type, the maker, the classification, then characteristics. A column then follows, defining the specific applications to which the valve can be put, together with further characteristics of the valve in some particular functions. The last column in the data gives a reference or base details, which are separately tabulated at the end of the book.

A preface has been translated into eight languages. Details of the book, the author, the publisher. Much of the information presented in the body of the data sheet is of a technical nature. A very useful and convenient means of interpreting these conventions into understandable form, which has printed on both sides all the abbreviations and their meanings. It is therefore possible to find the list at each opening of the book being studied, where it can be consulted immediately and without the necessity of having continually to turn to another page to interpret symbols.

Wherever possible direct equivalents for certain valve types are also given in the table. These identities refer to the similarities of electrical characteristics and operating conditions. If such equivalents exist, these are indicated in the Addenda column. Large figures or letters on the page margins assist considerably in locating a particular valve quickly. In some instances this is added to those listed in the first and last type listed on the page, and it is thought that this system could be used throughout the book to some advantage.


This handbook should find considerable appeal among those seeking to learn the basic principles of amateur radio and how to operate the equipment by an operator. Even with the advent of the electron tube there are still people looking for answers to the questions of the old-timers, a younger reader purifying it and it is now in hot pursuit of the necessary qualifications to acquire a transmitting licence.
that a metal woodworkers’ vice is often much more useful for radio work than the more usual engineers’ vice. A 6-in carpenters’ vice costs only 22s. 6d., and easily opens up to 5 in, but one of the engineers’ pattern with a comparable jaw capacity is a much more expensive item.” He is right, too, although I cannot recall anybody drawing attention to it before. Worth bearing in mind by those newly starting off, or re-designing their workshops.

Incidentally, I recently added to my range of workshop “furniture.” Treated myself to a ball-based vice which tilts to any angle up to 30 degrees in any direction. Can’t say I have found any special use for it yet, but it’s a nice sort of thing to have. Impresses visitors, too. Everybody who has come so far has played with it and adjusted it to all sorts of improbable angles. Then they ask the price and say “I’ll.” Next time I do the rounds I must see how many have bought one like it.

Hard Lines

In writing about the possible uses to which the vacant t.v. channels might be put, I should be kept going for ten years. By that time our present sets will be so outdated that even the most parsimonious will have no cause for complaint.

Better Late than Never

Some years ago I wrote at length on what I thought to be a strange omission in all the American technical books I checked on—the absence of any mention of Oliver Heaviside. Within the Empire we were much in theShipping memory by naming one of the ionized layers above the earth’s atmosphere after him, in the same way we speak of the lower layer by calling it after Sir Edward Appleton. In the United States it is spoken of simply as an upper ionized layer and no credit is given to Heaviside.

Oliver Heaviside died at the age of 75 some 34 years ago, embittered and practically penniless, much of his work unpublished—and unpublicised. Recently, as the result of a close examination of many of his scribbled papers and formulae found long after his death, he has been proved to be an even greater original scientific thinker than previously believed. Perhaps with the full unravelling of his scientific notes he will receive greater recognition here, and, at least, acknowledgment abroad.

How often in the history of scientific discovery have men with ideas a generation before their time been snubbed by their more orthodox contemporaries! Maybe today our attitude isn’t always much more enlightened towards those who think differently.

I recall that when I wrote of the failure of American technicians to connect him in any way with the layer we name after him in the rest of the English-speaking world, I asked if any reader had found mention of the Heaviside Layer as such in an American work. No replies were received. A good publicity agent seems to be a greater asset than a brilliant brain.

Unkind

Quote, from an amateur film critic: “Third rate? I’ll say it was. Not even good enough for television.”

Anyway, viewers, you will have to wait at least another twenty years before you see it.

**Centre Tap talks about items of general interest**

mentioned a number of alternatives. One was to start 625-line transmissions to ease an export problem and at the same time enable an inexpensive (for viewers) gradual change-over as existing receivers become obsolete.

J. A. C. (Gilda Crescent, Polegate) takes me to task over this, but I rather imagine his real idea is to provoke discussion. He says he receives many technical writers advocating sticking to our 405 line system so convincingly that he has been won over to their way of thinking. He is satisfied, too, that B.B.C. transmission quality is good enough even for exhibition photographers, and hints that those who complain ought to look to their receivers!

I am afraid it is a bit too late to start an argument now, J.A.C. Since receiving your letter it seems that the Television Advisory Committee (set up to advise the Government on such points) suggest that we change over from our “old-fashioned” 405-line system to the international 625-line. They recommend that transmissions at the present standards
TRANSMITTING

JINGLEBELLS

AMATEUR RADIO TELETYPE

Part 2

By JIM HEPBURN, VE7KX

To receive an F.S.K. radioteletype signal the receiver must be properly set up. The oscillator is turned on, the same as for C.W., and the receiver tuning adjusted to produce two audio tones from the RTTY receiver. The frequency of the signal is transmitted alternately from the sending station. This has converted the F.S.K. signal to A.F.S.K., and in order to be compatible with audio frequencies, some form of audio decoupling must be used for each channel. For RTTY purposes, some form of audio amplifier should be used.

This two-toned audio signal must now be converted into d.c. pulses to operate the selector magnet in the teleprinter, and this is accomplished by the "converter" unit. The converter is shown on the accompanying diagram, Fig. 2. In this converter the two audio signals are separated by tuned filters and rectified so that the 2,975 c/s signal applies a negative voltage and the 2,475 c/s signal applies a positive voltage to the grid of a d.c. amplifier stage, V2, which in turn drives the keyer stage, V1. The input transformer, T2, is a midday model 500-ohm line-to-voice coil transformer; this can be eliminated if it is desired to run the converter directly from the receiver speaker coil circuit, but as it will be necessary to make use of test equipment, audio oscillators and bandpass filters, etc., it is desirable to keep all station audio lines at 500 ohms impedance.

The transformers, T1 and T2 are made up from high "Q" 88 millihenry toroids. These toroids are known locally (in Canada) as "load pot toroids" and are employed in vast quantities for telephone cable loading or "Pupin coils." They are also available on the surplus market as the C-114 line loading coil having been used for army (U.S.) field telephone lines. These latter are encased in a small cast metal case and need not be depotted for this application. These coils have two windings which are connected in series to give the 88 mH inductance. On each toroid a small signal winding of six or four turns of small hook-up wire is added and these links are connected in series across the secondary winding of the input transformer, T1. Link coupling is used in preference to capacity coupling to avoid stray capacities and possible resonances which might affect the tuning of these extremely high "Q" toroids. If these toroids not available, small audio coils of fractional henry inductance or the 500 ohms winding of midget speaker transformers may be substituted. However, these are very low "Q" inductances and it will be necessary to use several tuned stages in cascade, with probably additional amplification to achieve the selectivity of this simple toroid circuit.

The rectifier stage, V1 consists of a 12AU7 with the grid and anode of each section connected together to form diodes. A double diode such as the 6ALS could also be used, but the 12AU7 was chosen to keep valve types to a minimum. The d.c. amplifier stage, V2, is one section of a 12AU7 and its anode supply is stabilized by an 8uF 150V condenser and two small neon bulbs in series. Condenser coupling is employed between the amplifier and keyer stages; this 0.5uF condenser should be of good quality and low leakage. The 6V6GT keyer stage, V3 has its screen voltage regulated at 60 volts by the 47k ohm screen resistor and another small neon bulb. The printer selecter magnet is connected in series with the keyer tube anode and this coil is shunted with a 10k ohm 1-watt resistor to absorb transient surges created in the printer magnet coil. The keyer valve is normally conducting and the current through the printer magnet coil is adjusted to the required value (usually 30mA) by the adjustable 10k ohm 10-watt resistor. Should the printer be one that requires a 60mA current it will be necessary to add a larger keyer valve in parallel and adjust resistor values and power supply requirements accordingly. The cathode of the keyer valve is connected through the teletype machine keyboard contacts to ground. These contacts are normally closed and remain so during reception. The keyer valve is conducting during no-signal and space signal conditions; the positive mark pulse from the filter-rectifier stage is inverted by the d.c. amplifier and applied as a negative pulse to the grid of the keyer valve, cutting off the keyer valve and releasing the printer selector magnet.

Operation of the keyboard opens the cathode of the keyer valve, thus operating the printer for "local copy" from the keyboard.

The 60 volts regulated screen voltage appears across the keyboard contacts during this operation and a lead is brought out from the keyer valve cathode so that this key voltage can be used to control an RTTY radio transmitter. The receiver must be shut off or disconnected from the converter during transmission so that key clicks and noise will not feed through the converter and cause garbling.

In this circuit the printer magnet coil is connected in the anode circuit of the keyer valve and is subjected to full power supply voltage to ground. Should there be any doubt as to the insulation of the magnet windings, the magnet coil can be connected between the cathode and the keyboard contacts. However, this causes degenerative feedback into the grid of the keyer valve and pulse-shape distortion. If this circuit connection is used, the spare section of V3 should be connected as a dumper diode between grid and ground of the keyer valve.

The only critical adjustment required to get this converter into operation is the tuning of the toroid filters. This requires a calibrated audio signal generator and either an oscilloscope or a valve voltmeter. Feeding the audio signal into the converter input and reading the d.c. voltage generated at the grid of V2, different values of condensers are connected across the tuned circuit until the frequency-voltage curve resembles that shown in Fig. 3. The ideal condition is when the positive and negative curves are the same height and cover equal areas, when random noise signals are balanced out and do not affect the keying. It may be necessary to adjust the number of link
turns and/or add shunt resistors to the tuned circuits to achieve a perfect balance. This detail is only required for weak signal work. On strong signals a five to one imbalance will still print perfect copy. An oscilloscope makes an ideal indicator for tuning RTTY signals. Connect the horizontal input to the “space” or bottom anode of V₁ and the vertical input of the scope to the other anode of V₁. A properly tuned space signal will show as a clean horizontal line and a mark signal as a clean vertical line, and a properly transmitted and tuned RTTY signal as a perfect right-angled cross. Any distortion, improper shift or incorrect tuning can be read off the scope pattern.

Power supply requirements for this converter are 50A at 200 volts. Filtering and regulation are not critical; but this power supply should not be used for any other equipment, as the sharp massive pulses of the keyer output will affect any other gear drastically.

Very accurate audio frequencies can be obtained from a BC-221 frequency meter by beating its low frequency band against a 125 kc/s oscillator. On this band the BC-221 has a bandwidth of forty dial divisions per thousand to a tenth of a division, thus any audio frequency can be set up to an accuracy within three cycles.

An Explanation of Low Power Ultrasonics

—continued from page 626

tioned, and that is the successful use of ultrasonic soldering. Being able to solder aluminium in this way is extremely useful when it comes to repairing castings, and the aluminium speech coil wires of loudspeakers are soldered by ultrasonics.

Before concluding, it might be as well to classify the generators available today. This is usually done by means of a small classified table.

As far as “Do-it-yourself” or home construction goes, it is inadvisable to think of building one’s own equipment. A considerable amount of research has gone into achieving the present high standard of commercial equipment, and there is every indication that the prospects of being successful with a home-built equipment are remote. In the first place, a rather ambitious generator is necessary, giving 50-60 watts output as the minimum requirement. It is true that some public address amplifiers provide such an output quite easily and could be adapted to amplify the waves generated from an oscillatory circuit. Provision can be made fairly easily for the polarizing voltage for the transducer, but the story does not end there because one would have to consider the provision of the transducer for drilling which must be mounted on a suitable stand, or alternatively, a cleaning bath. It would be an interesting proposition which would open up a number of possibilities for the man with engineering and electrical instincts, and perhaps the day will come when some enterprising manufacturer will turn his thoughts to designing something in the nature of a kit partly assembled which will enable the average handyman to obtain the benefits of ultrasonic cleaning and drilling for jobs about the home or for his hobby.

In the meantime, there are efficient commercial equipments available to industry which are proving their worth every day in tackling problems which before use was made of ultrasonic waves were difficult, laborious, costly or even impossible.

MARCH 1959

MISCELLANEOUS

The AMPLIFONE

by

I. F. Gregory

A neat and functional device which enables telephone conversations to be amplified and reproduced over a loudspeaker

IT IS A FUNDAMENTAL AXIOM OF MODERN living that, whilst the telephone has introduced many advantages and has resulted in considerable savings in time and energy, it has also been guilty of causing probably more general frustration and inconvenience than has any other electrical or electronic instrument. When it occurs, frustration is almost always due to the human element than to the mechanics of the telephone itself, and it is probably at its worst when the telephone is employed for purposes of trade. A subscriber rings up a particular person at his place of business, only to be told by an impersonal operator that he must hang on until the required person has been found. After this initial contact, the process of hanging on may last for a few seconds only or it may extend to as long as ten minutes, during which time the caller is tied to his own telephone and is unable to take the receiver away from his ear in case he misses the person called up. Under these conditions it is impossible to concentrate fully on any other work. In addition, the vexations of hanging on frequently make themselves evident outside the realms of business, as many subscribers who have attempted to reach particular departments in large stores or other organs will bear out. A typical instance occurs when the enquiry offices of some of the London railway stations are run up, the state of affairs here having been sufficiently bad in the past to cause letters of complaint to appear in such newspapers as The Sunday Times.

The inexperience given by the telephone becomes very apparent when long conversations take place. The necessity of keeping the receiver held to one’s ear means that a single hand only is free for purposes of making any notes that may be required.

The “Amplifone” overcomes these disadvantages at one step, this being due to the fact that it enables telephone conversations to be reproduced at loudspeaker level. In consequence, any subscriber who is told to hang on has merely to switch on his “Amplifone” whereupon he can place his receiver down on the table and concentrate on any other jobs he wishes to handle. As soon as the required person is found, the caller will be advised over the “Amplifone” loudspeaker. Similarly, when long conversations take place, it is necessary merely to turn on the “Amplifone” whereupon all information may be heard at comfortable level, both of the subscriber’s hands being free for any action that may be desired. With the aid of the “Amplifone” it is in many cases possible to hold two-way conversations without the necessity of handling the handset at all. The telephone microphone is sensitive enough to pick up speech when it is quite some way away from the speaker’s mouth and it may be kept in this position for, at least, local calls.
The "Amplifone" Circuit

An amplifying device of the type we are concerned with here has, apart from such obvious features as those of providing adequate volume and acceptable fidelity, two special requirements. The first of these is that it must be capable of being brought into use at a moment's notice. This point makes it undesirable to employ an amplifier having mains valves because of the necessity of waiting for these to warm up after the amplifier has been switched on. A possible solution, that of keeping the mains valve heaters supplied all the time and switching on h.t. only when the amplifier is required, is rather clumsy and wasteful of power. A battery-powered amplifier provides a much more attractive possibility; and battery costs can be kept to a very low level by the use of transistors. The "Amplifone" employs four readily obtainable transistors, these being powered by a 6 volt battery.

The second requirement of a telephone amplifying device is that no connections must be made directly to G.P.O. lines. This point is met in the "Amplifone" by the aid of a special pick-up coil which is held close to the base of the telephone instrument, an inductive coupling being obtained with the transformer which is fitted therein.

The circuit of the "Amplifone" amplifier appears in Fig. 1. As may be seen, this consists of a conventional four-transistor amplifier whose input terminals are fed by the pick-up coil, and whose output connects to a 3 ohm loudspeaker. The first two transistors, TR_1 and TR_2, operate in earthed emitter stages, a volume control, R_5, being inserted between them. According to individual choice, R_5 may be combined with the on-off switch S_1, or it may be separate. The first alternative is worth consideration insofar as it allows a single panel control to be fitted; whilst the second gives the advantage that, once the volume control has been set to the level required by the user, it does not need to be adjusted further. Whether or not the volume control is combined with the on-off switch is left to the choice of the individual constructor.

Transistor TR_3 drives the two output transistors in a normal push-pull stage, adequate volume being provided for normal purposes. The two transformers T_1 and T_2 are miniature components and they are specified in the

Fig. 1. The circuit of the "Amplifone" amplifier

Components List

<table>
<thead>
<tr>
<th>Resistors</th>
<th>Values</th>
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</thead>
<tbody>
<tr>
<td>R_1</td>
<td>47kΩ</td>
</tr>
<tr>
<td>R_2</td>
<td>10kΩ</td>
</tr>
<tr>
<td>R_3</td>
<td>470Ω</td>
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<tr>
<td>R_4</td>
<td>2.7kΩ</td>
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<tr>
<td>R_5</td>
<td>5 or 10kΩ potentiometer</td>
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<tr>
<td>R_6</td>
<td>22kΩ</td>
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<tr>
<td>R_7</td>
<td>4.5kΩ</td>
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<tr>
<td>R_8</td>
<td>180Ω</td>
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<table>
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<tr>
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<th>Values</th>
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<table>
<thead>
<tr>
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<th>Types</th>
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<tbody>
<tr>
<td>T_1</td>
<td>Ardente, type T131</td>
</tr>
<tr>
<td>T_2</td>
<td>Ardente, type T152</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Switches</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>S_1</td>
<td>On-Off, s.p.s.t. (May be combined with R_5, if desired.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<th>Impedance</th>
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<table>
<thead>
<tr>
<th>Battery</th>
<th>Type</th>
<th>6V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pick-Up Coils</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>&quot;Red Spot,&quot; p-n-p, junction transistors</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 2. The assembly of the pick-up coil. This consists basically of a 3 x 1 x ½ in wooden block to which are fixed two rectangular cheeks (a) The coil is then wound on the central wooden block (b) after which two end pieces and two side pieces are glued into position (c)

MARCH 1959
amplifier section, together with their small size, it is possible to make this part of the "Ampliphone" very neat and compact. A photograph of the housing employed by the designer accompanies this article and gives an idea of the dimensions required. It should be pointed out that the amplifier fitted in this particular housing was laid out very comfortably with no emphasis on saving space, and that a significantly smaller cabinet could be used, should this be desired. The speaker employed in the designer's prototype is a 2½-in unit, and the power is provided by four U.16 "open-type" cells connected in series-parallel to give a potential of 6 volts.

From the point of view of construction and layout, the amplifier offers few difficulties. The first transistor stage should, preferably, be mounted at the opposite end of the chassis (or component board) to the output stage. If the two transformers are fitted very close together they should be at right-angles to each other.

The pick-up coil can, most conveniently, be connected to the amplifier via a socket fitted to one of the walls of the cabinet. The designer used a miniature hearing-aid socket here. The length of lead between the pick-up coil and the amplifier may be left to individual preference.

The Pick-Up Coil

Due to the low input impedance of the "Ampliphone" amplifier, the pick-up coil differs somewhat from the type of coil encountered with tape recorders and the like. The coil may be made at home with little trouble as there are no very critical points which have to be satisfied. The pick-up coil is constructed in the manner illustrated in Fig. 2. As will be noted, it consists basically of a wooden block to which are fitted two side cheeks. The latter should have a thickness of approximately ½ in and may consist of wood or any suitable insulating material such as Perspex or Porelon. The coil is wound on the central wooden block, after which side and end pieces are glued into position as shown in the diagram, giving a final "solid" effect. A hole may be made at one end of the assembly to take the lead-out cable, connections to the coil ends being made inside. The outer surface of the assembled coil unit may then be cleaned up as required.

The coil itself is simple to wind, consisting of 2 ounces of 38 s.w.g. enamelled copper wire fitted as illustrated in Fig. 2. There is no need to count the number of turns provided that the correct weight of wire is employed. The coil is scramble-wound.

Operation

After completion, the "Ampliphone" needs to be fitted up to the telephone instrument with which it is to be used. All that is necessary here is to switch on the amplifier and apply the pick-up coil to the base of the instrument, leaving it finally at the position which provides greatest pick-up of telephone speech. Coil positioning is liable to vary for different types of telephone.

It is possible in some cases that, at the full volume setting, feedback may occur between the loudspeaker and the telephone microphone. This will most probably occur if the "Ampliphone" loudspeaker is directed towards the telephone microphone. The solution consists of orientating the loudspeaker. The final volume setting for the "Ampliphone" amplifier is that which gives adequate output at normal telephone speech levels.

**PHILIPS**

**Transcription Pick-up Arm & Stereo Head**

Philips Electrical Ltd. have introduced a Transcription Pick-up Arm (Type NG5400/S) fitted with a pick-up head (Type AG3060) which is designed for reproduction of stereophonic as well as monaural long-playing records. Arm and head complete sell at 13½ gns. (List £1 £4 10s. 6d.).

The precision-engineered arm, well known for its association with the Philips magneto-dynamic pick-up head, is professional in appearance, with a durable satin chrome finish. It is equipped with a micrometer playing weight adjustment, and the arm pedestal and rest are adjustable in height so that the pick-up can be used with any separate turntable.

Close attention has been paid to the matter of minimising resonance and friction. The crystal pick-up head has a diamond stylus and a frequency response of 30-12,000 c.p.s. The recommended load for each channel is 5000Ω, and the output is approximately 0.5 volt for each channel. Suggested playing weight is 4-6 grams.

**MAKING A GLASS STATION DIAL**

by B. B. Rafter

Most readers will be familiar with the Panel-Signs sets of transfers issued by the publishers of this magazine and designed to give a professional finish to the visible parts of home-constructed equipment. Many may not yet have realised the value of the fairly recent additions to Sets 3 and 4, the lists of names of the main Long, Medium and Short Wave stations to be found on the average dial plate. Indeed, the writer himself had not seen their possibilities until a friendly hint from the Editor in response to a desperate appeal got him out of a very awkward situation indeed.

It was the usual story; not leaving well alone. Some very extensive repairs had been carried out to modernise an "old-timer" for an elderly lady who couldn't bear to part with what had been her wedding present, an H.M.V. Model 486. As the rehabilitated watts poured over the bench, it seemed a good time to remove some of the dust and stains of the years from the glass station-dial, which had never been touched since the day it was fitted. Out it came, and into a bowl of tepid, just to ease the pain. Time for a few adjustments to the set, then out of the wash with the dial, a quick rub with a clean cloth and... large swathes of the pre-Copenhagen names and wavelengths came away on the cloth! Disaster!!

It was no return to the set to the owner with its dial in that condition. The makers, when approached, hadn't, of course, run out...
of spares before Hitler ran into Austria, where the original plates were made, being a sort of transfer on glass, station names in black on a white frosted background, with slots at appropriate places for fitting the pointer. Restoration of the original in anything like its previous form seemed impossible, as did various other solutions that sprang to mind, so the circuit remained the Long, which it was decided to cut down to three (Prague, Droitwich, Allous) and the Medium band. Here, as no attempt was to be made to cut tiny slots under each name, as in the original, the names had to be placed with their centres corresponding approximately to the reading in metres on the scale below. A list was made of all the principal British Medium Wave stations, with wavelengths from Third (463) to Light (247) and a choice of the four best for this area (Third, North, Home, Midland) was made, these names to be placed lowest, that is just above the wave scale, for ease of reference.

The actual process of printing these transfers was incredibly simple, with results the writer would never have believed possible. The backing paper was removed from the completed sheet and the cut completed from the transparency as required, trailed across the surface of a saucer of clean water with a pair of stamp tweezers and placed in position on the glass above the proper section of the wave scale. Linearity was checked with a ruler after positioning, the tissue gaily padded with a piece of blotting paper and all dry. After this other names were added at each end of the bottom line (Athlone, at the right, Luxembourg at the left, then another line was begun, above the first and slightly staggered to the right (Brussels, Welsh, West, Light) and finally, above these a row of foreigners (Lyons, Sottens, Paris, Hvilleux, Berleng). This set of fifteen names very conveniently filled the space available and gave a useful choice and neat display, completed by the words Short, Medium and Long at the left-hand end of the wave-scale slots.

When all the transfers were dry, the tissue was slightly damped with a cloth and peeled off with tweezers, to reveal a most satisfactory print. A little cleaning at each end and, when dry, a coat of transfer fixing varnish over the names completed the job, which, when fitted into the set, gave a smart, clean, flat, perfectly adequate for all normal domestic requirements.

This method of making a station dial could be adapted to almost any home-constructed set, with most pleasing results.

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A Battery Power Unit

by J. HILLMAN

This unit will supply both LT. and HT. for most battery sets, and provides a convenient source of supply for servicing these sets. It consists of two units, the main unit having the controls on it, and a plug-in unit with a flexible lead having various sockets on it to suit the different types of battery plugs. The off-load voltages are: L.T., variable from 0 to 7.5V; H.T., variable from 0V to 100V; H.T.2, variable from 110V to 250V. With controls at maximum, on-load voltages are L.T. 3V at 100mA; H.T. 7.5V at 100mA; H.T.2 25V at 50mA. The H.T.2 variable control is rated at 3 watts and up to 15mA can be safely taken through it, whilst the H.T. variable control is rated at 1 watt and up to 5mA can pass through it. For test purposes these figures can be exceeded, but not if the unit is to be kept on for very long.

Construction

First mark out the chassis in aluminium as Fig. 1 and bend the brass edges up at right-angles to form a shallow box. Drill in holes at corners and secure with 8BA nuts and screws. Next cut out the panel as in Fig. 2 and bend up the brass edges at right-angles, then drill holes as marked out in Fig. 4. Now fix the panel to the chassis as in Fig. 5 and assemble components as in Figs. 7 and 8. Next fit components to switch block as in Fig. 10. For the wander plug sockets use plain sockets and drill 8BA holes; for the 8BA terminals drill 8BA holes, and for the flexible lead drill a 8BA hole.

Wiring

Wire up as in Fig. 9, using stranded wire to cut down voltage drop in leads. For the flexible lead use 4ft lengths of 23/36 single rubber flex; five lengths are required, and after connecting them to the various sockets on the switch block twist them together one by one to get a smooth cable, and finish off with a turn of insulating tape, finally soldering them to the valve plug as in Fig. 10.

Meter

The meter used had a F.S.D. of 300V, with a resistance of 500 ohms. The values of series resistors are as shown in Fig. 9. A 1MA meter may be used, but in that case the series resistors will be different and for a 10 ohm resistance meter the values will be: 3V range, 2,900 ohms; 15V range, 14,900 ohms (a 15Ω will do); 150V range, 150Ω; 300V range, 300Ω. Meters having a greater 1mA-scale deflection than 1mA may be used, but will increase the consumption of the unit and will therefore lower the voltages which the unit will supply. The meter should be checked against a standard one if possible as its accuracy is important to ensure that the sets are not over-run, especially on the LT. ranges. If no meter is available to check against, then the meter can be checked against a freshly charged accumulator which has been allowed to stand off charge for several hours and which should read 2.2V.

The meter resistors are made up from standard 10% tolerance ones; the 5.17kΩ being made up of 4.7kΩ and 470Ω in series; the 278.2kΩ one is made up of 270kΩ and 8.2kΩ in series; whilst the 526kΩ one is made up of 470kΩ and 56kΩ in series.

The flexible lead plug is made from an old 5-pin valve. Wind a cloth around the valve and break it with a hammer, remove all the broken glass and scrape out the old cement with a knife, and then apply a hot soldering iron to the tip of one pin and pull out the old wire from inside with a pair of pliers. The new lead can be threaded down inside
the pin and resoldered at the tip again. The L.F. choke was one that came from an old battery converter, but any L.F. choke will do provided that it is wound with heavy gauge wire, 16 or 18 s.w.g., so that the voltage drop across the winding is negligible. Failing a suitable L.F. choke, then a heater transformer can be used; ignore the mains side and use the L.T. side.

The 10-watt resistor is mounted by passing a 4BA threaded rod down through its centre and through the chassis, securing with 4BA nuts and bolts, and using a large plain washer on top of the resistor. There should, of course, be no contact between the resistor element and the fittings or chassis. The h.t. fuse is a 0.04-amp M.E.S. bulb, and this rating will ensure that the majority of the voltages are protected in case the h.t. and L.T. leads are plugged in wrongly at the set. If, however, it is intended to use the unit to supply 80mA current, then the fuse bulb should be altered to 0.1 amp.

The meter can be used as a separate volt-meter but in this case it will be necessary to fit a S.P.D.T. switch in the negative lead from the meter to S1, and a separate negative socket on the front panel as Fig. 12. The 5V d.c. positive socket is therefore the L.T. positive socket of the output and the 150V socket is the H.T.-1, whilst the 300V socket is H.T.-2.

When first connecting up the power supply lead use a 3-pin plug top so that the correct polarity is observed, the live lead going to the lead marked L and the neutral lead going to the lead marked N. These markings are usually on the plug top when its cover is removed, but if there are no markings then with the large pin uppermost and looking at the back of the plug top, the L pin is to the right and the N pin to the left. If it is required to keep the unit isolated from the mains, then a mains transformer giving 250V at 80mA and 6.3V at 1.5 amps may be used in place of the heater transformer. The connections are then modified as in Fig. 13. (This is the better method—Ed.)

In operating the unit always make sure that the variable controls are at minimum before switching on the unit, so that no excess voltages are applied to any set connected up. Bring up the L.T. control, having first switched the meter to the “L.T.” position, and adjust the voltage to its correct value on load. Then switch meter to H.T.1 and adjust its control to give the correct voltage, and similarly with H.T.2. Use H.T.1 for the lower voltages, including 30V, and H.T.2 for the highest voltages.

When using the unit with sets incorporating automatic bias, do not plug in an earth to the H.T.-1 socket as this is the L.T. positive socket of the output and the 150V socket is the H.T.-1, whilst the 300V socket is H.T.-2.

To finish off the unit, mark out a panel of aluminium as in Fig. 3, then cut out and bend to form a cover as Fig. 6.

List of Parts Required

1 6.3V 1.5 amp, or 250-0-250V 80mA and 63V 1.5 amp mains transformer
1 6/12V 1-amp full-wave rectifier
1 L.F. choke or L.T. transformer
3,000uf 12V wkpg tubular condensers
1 250V 80mA half wave rectifier
2 1½ in. 1-amp fuses
1 twin fuseholder, baseboard mounting
1 32+32F 450V wkpg tubular condenser
1,500uf 10-watt wire-wound resistor
1 M.E.S. 0.04-amp bulb, any voltage
1 M.E.S. holder, baseboard mounting
1 3-pole 4-way rotary switch
1 meter, 0.5mA or 1mA
1 50Ω 4-watt wire-wound potentiometer
1 50Ω 3-watt wire-wound potentiometer
1 50Ω 1-watt carbon potentiometer
1 33Ω 1-watt resistor 10%
1 4.7kΩ ½-watt resistor 10%, see text
1 470Ω 1/2-watt resistor 10%, see text
1 27kΩ ½-watt resistor 10%, see text
1 270kΩ ½-watt resistor 10%, see text
1 8.2kΩ ½-watt resistor 10%, see text
1 470kΩ 1-watt resistor 10%, see text
1 50Ω 1-watt resistor 10%, see text
1 4.4Ω 350V or 300V wkpg tubular condenser
1 2:350V or 300V wkpg tubular condenser
2 British 5-pin valveholders
4 plain metal wander plug sockets
2 0-BA terminals
1 M.2 all-dry battery socket
1 S.2 all-dry battery socket
20 23/26 single rubbers
1 6in x 3in x 1in wire switch block
1 sheet aluminium 10[jin x 12[jin
1 sheet aluminium 10[jin x 21[jin
Panel signs transfers, Set No. 4

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Hastikits (Daystrom Ltd.) have made arrangements to display and demonstrate their audio and other equipment at the Royal Hotel, Russell Square, W.C.1, from 2nd to 5th April, inclusive. The model S-88 Hi-Fi stereo amplifier and the SS-1 Hi-Fi speaker will be particularly featured.

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THE RADIO CONSTRUCTOR

A Comprehensive Mixer-Fader

by J. G. RANSOME

This unit was originally designed for a friend who was suffering from "the tape bug." His requirements were for a two-channel high-gain mixer for two microphone inputs, the output of which could be mixed with the output from a gramophone.

The actual circuit designed was for an amplifier-mixer for four channels, two high gain and two low gain, each channel of which could be mixed or used independently, or use mixture of all channels at once. The prototype has been in use for some time now and is giving quite pleasing results.

In order to keep the cost within reasonable limits, the circuitry has been devised for equipment which, to a certain degree, might be found in the "spares box" (modern euphemism). The high-gain channels are designed around the EF37A, but there is no reason for not employing valves of the EF40 type or EF36 variety; no circuit changes will be required. The EF37A is used in conventional circuitry and really needs no comment save for the fact that the decoupling provided by R3-C3, R2-C4 is essential, to prevent cross-talk on the channels. The wiring to V1 and V2 must be as short as possible to avoid hum pick-up; mixing four sets of 3 in a circuit like this is rather aimless! R9 controls channel I gain, whilst R10 controls the gain of channel 2. The two load resistors marked R1 are to suit the impedance of the microphone being used; the original circuit used, rather wastefully, two 5 MegΩ potentiometers here, and these

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MARCH 1959

The Low Gain Mixer

This mixer is, in effect, a triode version of the pentode high gain section. The signals are fed into the grids of the twin triode by way of R13 and R14, which provide individual channel gain controls. The amplified signals are passed in the anode circuit via R19 and R20 through the coupling condenser C12 to the channels 3 and 4 master control and to the other mixer. The decoupling afforded by R15-C11 will be found to be indispensable.

The Master Mixer

This is the unit where all of the incoming signals have a final mixing before being passed on to the main amplifier. The mixed signals from the high gain channels are put on to grid 1 (a) of the twin triode and the mixed signals from the low gain amplifier mixer are put on to grid 1 (b). The resultant signals are mixed in the anode circuits of this valve and passed via C13 and R27, which latter acts as the master gain control, to the final amplifier.

The overall gain of the system is 16 x 150 or 2,400 for the microphone channels, and about 16 for the low level amplifier. The output for the system may be too high for the amplifier to be used, and if this is so, some simple attenuation circuits will have to be evolved. A cathode follower was used for feeding the output from the mixer into the tape recorder amplifier and this method of coupling was found to be excellent. For a simple fading likeness, for the lazy, the bias resistor R23 is switched; this by virtue of the discharge of the bypass condenser C15 which is very large and consequently discharges slowly, produces a slow fade—this being very useful for the busy chap who has probably his hands full with the recorder.
It may be inferred from the circuit diagram that the unit is riddled with lurking potentiometers, and in order to clear up any difficulty the use of each will now be given:

R9 channel 1 gain control, R13 channel 2 gain, R14 channel 3 gain control, R15 channel overall master control.

Each potentiometer may be labelled as to its function for easy reference.

Main Components List

**Resistors**

- R1, 6, 11, 12, 17, 18, 19, 20, 21, 22, 23, 24 220kΩ
- R9, 10, 13, 14, 25, 26, 27 500kΩ pot.
- R3, 5, 16, 28 3.3 kΩ
- R2, 7 1mΩ
- R4, 8 2.2kΩ
- R15 47kΩ 1W

**Capacitors**

- C7, 8, 12, 13, 14 0.05μF 350V
- C2, 4, 11 8μF, 350V electrolytic
- C3, 6, 9 25μF 25V electrolytic
- C1, 5 0.25μF 350V
- C15 1,000μF 6V

**Valves**

- V1 EF37A
- V2 EF37A
- V3 6SN7
- V4 6SN7

**Miscellaneous**

**An Explanation of LOW POWER ULTRASONICS**

By R. Webb, M.I.P.R.E.

If the Bible is to be believed (and far be it from me to discredit it), the principle of ultrasonics was used by the attacking hosts who, by raising a great sound, caused the premature collapse of the walls of Jericho. Seriously, though, it was towards the end of the 19th century that it was first shown that fine particles could be agglomerated at the nodal or "no-movement" point of a sound-wave, and thus a sense rendered visible. It had been realised for some time that vibratory waves did not cease at the upper limit of hearing, but continued to be propagated at much higher frequencies, and whistles and tuning forks capable of producing high frequency sound-waves had been constructed. The sound energy produced by these means was of extremely small magnitude, but interest in the subject increased with the discovery of piezoelectricity, for it was soon seen that a crystal element was capable of providing large power outputs when driven by a suitable alternating supply source of energy. The application of magnetostrictive materials for the same purpose soon followed, and present-day research has been almost entirely built up around these sources of ultrasonic energy.

Wartime requirements—that is the 1914-18 war—showed a useful application of ultrasonics, in that under-water detection was developed when it became necessary to find out the whereabouts of enemy submarines and mines. The period 1919-1939 showed the first real effort being made to investigate the physical effects of high intensity sound, until today there is quite an army of interested research engineers progressing the subject, and it is the intention of this article to cover some of the various applications, together with certain basic methods of generation.

In the first place, let us be quite clear what the term ultrasonics means. The term is used to describe a vibratory wave of a frequency above that of the upper frequency limit of the human ear. Therefore, we are thinking of all frequencies above 16 kc/s. For a time the word "supersonic" was wrongly applied, and this term has now rightly taken its place as meaning "above the speed of sound."
As far as we are concerned, the frequency is only limited for our requirements by the type of transducer employed. The thing that determines the transducer is very largely the medium into which the waves are to be propagated, and the various frequencies conveniently allocate themselves to various applications. In the main, the ultrasonic band we find a suitable frequency for a transducer which can undertake drilling and solid work is not over 20 kc/s.

For submarine detection, 30 kc/s transducers are suitable, whilst for flaw detection in metals and glass—for example—we move up to a maximum of 10-12 megacycles. A certain amount of heat is generated in the materials into which the waves pass. Making use of this property it is possible to scramble an echo, viz. different parts of the shell, and plastics may be welded by this means. Again, an ice cube subjected to ultrasonic waves for a short time will break into small fragments when squeezed in just the same way as the sun will melt it—in other words, liquefaction has occurred. Similarly, if a block of wax is placed in the path of the wave it will melt in a pattern that shows the conical focusing of the beam inside the block.

Measurement of these ultrasonic frequencies is done in a number of ways, e.g. for over 100 kc/s and by direct-reading frequency meter of the counting or integrating type for the range below 100 kc/s.

Generation
As far as the means by which the required ultrasonic wave is produced, we can break these up into four various types or methods, viz:

Piezo-electric
Magnetoostrictive
Jet and
Electromagnetic.

I will describe each briefly.

The first one—piezo-electric or crystals—will be familiar to us; the main point in using this method is to remember that the crystal will present a main resistive load to its power supply equivalent to anything between 10 and 250 thousand ohms shunted by a capacitance of about 100 pic-farads. As mechanical energy generated by the crystal is primarily a function of voltage, it must be borne in mind that we have one impedance matching to the supply will be necessary to develop a high voltage across the crystal. This impedance refers, of course, to quartz crystals. The main impedance that the minium used material is a ceramic, barium titanate, which looks at something like 15 ohms plus 18,000 ohm of Pd, but, of course, it is dependent on the frequency. Quartz is usually used for the higher ultrasonic frequencies (5-10 Mc/s range)

whilst barium titanate is used for normal industrial frequencies up to 1 megacycle. The quartz does present some insulating difficulties for high power levels, and the physical change brings about a change in the magnetic properties of the material and is called magnetoostriction. Nickel is such a material, and is used as a transducer or generator for small applications such as drilling, cleaning, processing, etc. Ferroxcube is another material which is technically suitable, but mechanically weak for our purposes, though it may be used in special circumstances. If a nickel rod is brought into a magnetic field, it is shortened. If it is put into a field which is not previously magnetised, it will vibrate with double the frequency of the alternating field, whereas if suitably pre-magnetised, the mechanical change in length will be in step with the applied alternating frequency. If there is resonance between the natural elastic period of the rod and the frequency of the alternating current, the amplitude of the oscillation will then be at its maximum, and sound waves of the same frequency will be sent out from the end of the rod.

With various materials the frequency varies with the length, e.g. a rod of nickel 12.5 cm long vibrates at a natural frequency of 20.4 kc/s, whilst the highest frequency obtainable is of the order of 60 kc/s for a piece about 4 cm long. In such a rod or tube, set in longitudinal oscillation by magnetoostriction, we find sound waves are only emitted from the ends of the rod. This would be useless for such things as submarine work, and so a means of radiating in all directions in one plane must be found. The answer lies using a ring set by magnetoostriction into elastic oscillation in such a way that the ring forms a circle with a periodically changing radius, the sections of the ring then moving radially. Waves are then radiated from the outer edge in a radial direction. A ring of this sort may be excited by a toroidal winding through which an alternating current is sent.

Under the heading of jet can be grouped sonic and ultrasonic generators employing high velocity liquid or gas streams, such as resonant ventilated air horns and liquid and gas and liquid operated sirens. One main advantage of jet generators is the simplicity of the power source, this being either a compressor or a high speed motor. An example of this type of generator that comes to mind is the General dog whistle—a whistle which we cannot hear but to which dogs respond from quite astonishing distances.

The electromagnetic method of converting electrical energy to acoustic energy by the movement of a coil carrying a varying voltage fed from a field of constant intensity is well known; a loudspeaker or earphone, of course, everyday example. With slight modification to the moving coil system it is possible to utilise it for ultrasonic frequency generation. In such a device the efficiency falls off considerably as the frequency of the system is raised, and the application is really restricted to fatigue and vibration study at I.F.

Now, whilst all these various methods and applications are all very interesting, they cover a very wide field. It seems advisable, therefore, to concentrate on a particularly useful one, in this instance the generation of drilling and cutting by low power generation (approx. 50 watts). Let us take drilling first. The chief advantage of ultrasonics for drilling is that materials which are too brittle to drill by ordinary means can be handled satisfactorily. It is, in fact, the only practical method of producing shaped holes in brittle material, and for round holes under 1/4 in. it is claimed to be the best method. The small portable equipment can be used for electrical work, metal work, and a number of biological applications which will be described later. Coming back to drilling, there is a saying which can be loosely applied to this method, viz., "If you can't drill it, you can drill it," thus indicating the suitability of the ultrasonic drill for materials such as ceramics, glass, tungsten carbide, germanium, synthetic gems, and similar materials which have previously presented difficulty when drilling has to be performed. An ultrasonic drill is used for drilling diamond dies for tungsten wire drawing, etc., and it has been drawn down to something like 10-12 microns thickness. For this purpose, an ordinary sewing needle may be used, and how it is possible to use this needle for this process will become apparent when the principle of the drill is explained.

Explanation of Ultrasonic Drill Principles
In the drill-head, there is a laminated nickel disk which is secured at the nodal, or "no-movement" point. By setting up an alternating field round a nickel element the nickel may be set at an instant frequency of 20 kc/s, this being the natural or resonant frequency of this transducer. (The frequency range of the generator is 15-25 kc/s.) Nickel is ideal for this particular purpose as it has a very high fatigue strength. The stack, or transducer, movement up and down is 3/10 thou. at 20,000 c/s. Not only is movement of this kind not to our purpose, so the problem arises as to how to increase this movement from 3/10 thou. to something of the order of 2 to 3 thou. The answer is to fit what is called a stub, or velocity transformer made of alny, bronze. The size of the drill head of contact is then screwed in tightly. Now if you visualise something the shape of a Rawplug tool, you can realise the shape of one of the original types of these stubs. There is a mathematical law which the design of the stub follows which is rather outside the scope of this article. What matters is that the stub is radiused out of the drill, and if you wish to have a size reducing to 3/10 in start off with the part of the stub which screws into the stack at 3/10 in diameter, thereby giving a step up of amplitude of physical movement. This increase in amplitude is determined by the ratio of the square of the end diameters. There is a limit to this step up, in amplitude and material generally will not tolerate without fatigue or crack-up more than a 9:1 increase. To keep within this limit on this low power equipment the size of the working tip diameter cannot go below 3/10 in this giving a 9:1 increase of amplitude, that is from 3/10 thou. to 2.7 thou. The working end of the stub is drilled and tapped to take any tool shape required. The use of the drill makes his own tools to screw into the stub, as they are quite simple to make and using this model is very cheap. The tool which is abrasive-proof. There is a law here that the diameter of the tool must never exceed the diameter of the working tip, in this case, this limit being as little can be less than the diameter of the working tip. It is interesting to note whilst on this subject that a 6 thou. hole in soda glass has been achieved.

Materials
Pure nickel and various nickel alloys give good results, e.g.:

(1) An alloy of 36% nickel-64% iron called "invar."
(2) 68% nickel and 28% copper with small amounts of iron silicon, manganese and carbon called "monel."

The natural frequency of a nickel tube can be changed by filling with, say, lead. A proprietary brand of this is known as "Permason." A word about the tools. As already stated, these can be of some tough material, such as tool steel or M2, and it is important to remember that it is not the tool which does the cutting. This is done by an abrasive carburettum powder suspended in water, known as "froth." It is important to remember that the tool guides the slurry only. A further point is that it is usual to tampon the holes. This, in itself, is useful because it causes a final movement of the piece removed may be required as a lens. As the user makes his own tools, he can lay

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- Med. short and gram.
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(2-transistor pocket receiver)

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- Variable tuning on medium waves
- Highly sensitive
- No aerial or earth
- Economical
- Drilled and mounted chassis

Size 4½” x 3½” x 1½”

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POCKET TRANSISTOR RADIO

- 6-transistor Superhet
- Medium and long wavebands
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- Attractive moulded cabinet with full trimmings
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This Portable 8-transistor Superhet is tunable for both Medium and Long Waves and is comparable in performance to any equivalent commercial Transistor Set.

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**COMBINED PORTABLE/CAR RADIO**

Two sets for the price of one

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- Highly sensitive
- No aerial or earth
- Economical
- Drilled and mounted chassis

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**MINOR—1**

- Variable tuning on medium waves
- 3-stage reflex circuit
- Highly sensitive
- Internal ferrite aerial
- Drilled chassis
- Economical
- Complete construction details

Size 3½” x 2½” x 1½”

**Total cost, including transistor, personal miniature phone, case, battery and complete circuit and layout diagrams, £14 post free. All components sold separately. Circuit and shopping list FREE.**