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VOLUME 12
NUMBER 6
JANUARY
1959

The RADIO Constructor

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by B. Shaw

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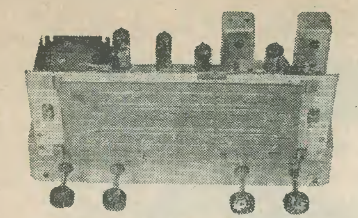

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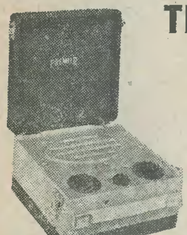

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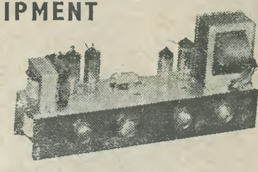

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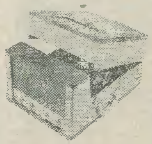

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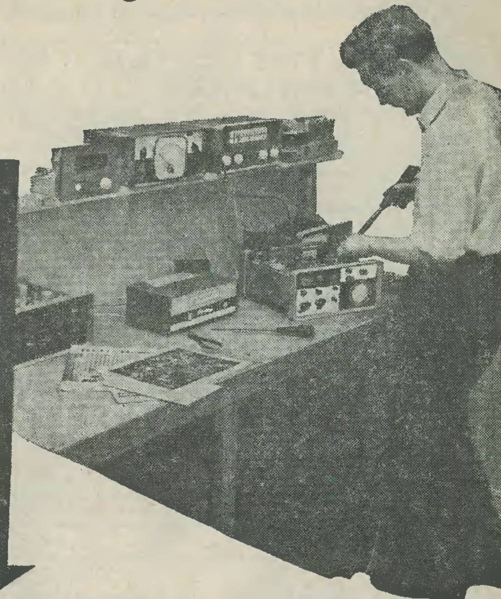

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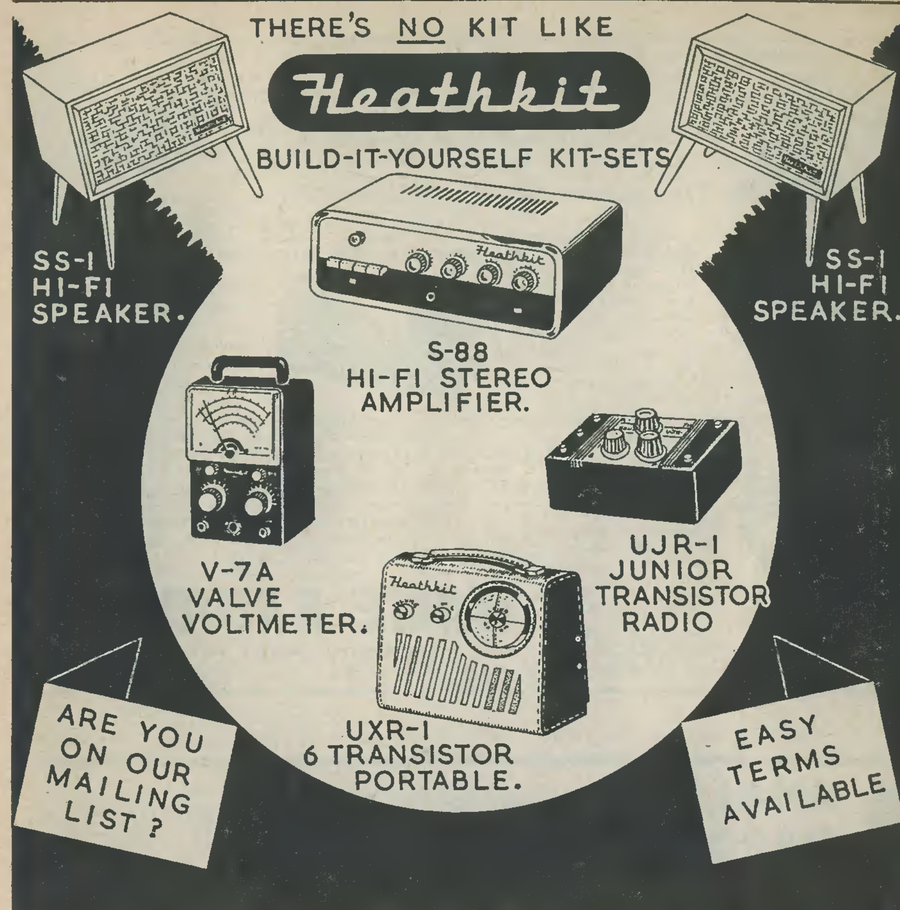

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RADIO

No. 98 A Very Close Tolerance Temperature Operated Switch

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*

Temperature operated switches and thermostats are frequently employed in normal engineering and experimental work, being used for such functional applications as automatic temperature control, fire alarm systems, and so on. In such applications temperature operated switches may take up a number of different forms, the most commonly encountered being devices whose operation is purely mechanical. Unfortunately, many of the temperature sensitive devices currently employed suffer from the defect that they do not respond reliably to small shifts in temperature. Because of this their action tends to be sluggish. This defect is particularly evident when they are employed as thermostats in heat control systems, whereupon they are liable to allow relatively large shifts in temperature to take place before they switch in or out, as the case may be. Another disadvantage with a number of current devices is that they are somewhat difficult to set up accurately for operation at a specific temperature. Indeed, it is quite often necessary to have to confirm the temperatures at which they work with the aid of an auxiliary thermometer.

The device which is described this month consists of a temperature operated switch which is capable of being set up very accurately to any temperature within its range, and which is capable of operating at given temperatures within a very close tolerance. When employed as a thermostat, the range between switching in and switching out should be better than ±1.5° C. of the required temperature. (The limits of ±1.5° C were chosen arbitrarily in the case of the present design after an initial study of its capabilities had taken place).[1] In addition, the device may be set up to any desired control temperature by purely visual means. There is no necessity to check, with a separate thermometer, the temperature at which the device "regulates." Finally, there is the fact that the absolute accuracy of the switch, temperature-wise, is equivalent to the accuracy of a laboratory mercury thermometer. The reason for such accuracy is that the temperature sensitive instrument in the circuit *is* a laboratory mercury thermometer!

This device has one main disadvantage. This is that since it has, of necessity, to work on electronic principles it employs valves which require h.t. and l.t. supplies in consequence. However, only two valves are needed and h.t. requirements are low, being of the order of 20mA at 200 volts. In addition, the number of components required in the switching circuit is low.

[1] This tolerance applies for a temperature range of 0° C to 105° C under the conditions in which the original design was investigated. Better, or worse, tolerances are possible according to the dimensions and range of the mercury thermometer which forms the temperature sensitive element.

Basic Control

The temperature operated switch described here actually takes advantage of the height of the column of mercury in a thermometer, and the writer conceived the idea of employing the mercury column to operate a switching circuit after he had studied the results given by purely mechanical thermostats. If the idea were to have any practical value it would next be necessary to find what electrical effects are given by the column of mercury in the thermometer as it advances to a previously chosen height, and this the writer set out to do.

One possible line of approach in this direction would consist of having an ascending column of mercury alter the inductance of a coil. Thus, if a coil were wound around the glass stem of a thermometer its inductance would be reduced when the mercury column commenced to enter it. However, this scheme was discarded without bothering to carry out any experiments due to the fact that the change in inductance given by the mercury entering the coil would be, as a proportion of the total inductance, very small; whereupon it would be difficult to design a switching circuit around the coil which would be inexpensive and reliable.

A second method of taking advantage of the column of mercury would consist of having it form one electrode of a condenser, the second electrode being fitted around the stem in the form of a cylinder. This scheme had the potential advantage that, whilst the capacity given when the column had risen sufficiently high to enter the cylinder would be small, such a capacity should still be considerably greater than that existing when the column was some distance away from the cylinder. The writer decided that it was quite possible that the change in capacity provided as the column approached the cylindrical electrode would be sufficiently dramatic and large in extent to enable a reliable and cheap switch to be coupled to it. In consequence, the following experiment was carried out.

A perfectly ordinary and inexpensive laboratory-type mercury thermometer was obtained, this having the approximate dimensions illustrated in Fig. 1 and having a scale calibrated between 0° C and 105° C. Two electrodes, A and B, were fitted to the thermometer. Electrode A consisted of a number of turns of narrow-gauge tinned copper wire close-wound around the bulb. Electrode B was made up in the same way, consisting of a number of turns of narrow-gauge tinned copper wire close-wound around the stem. The ends of the wires constituting the two electrodes were twisted together to prevent their unwinding. For the purpose of the experiment, both electrodes could be considered as being solid cylinders of metal. The length of electrode B was ⅜in, as shown in Fig. 1, and it was arranged on the stem of the thermometer such that its lower-temperature end was exactly over the 40° C graduation on the scale. The device then effectively formed a variable condenser, this being comprised in fact of two condensers in series: one condenser consisting of the unaltering and relatively very large capacity between electrode A and the mercury in the bulb, and the other consisting of the capacity between electrode B and the column of mercury. As the capacities existing between the two electrodes were likely to be small, an earthed screen was fitted between them, as shown. This screen consisted of a flat disc of metal some 3in in diameter and having a hole in its centre through which the stem of the thermometer could pass.

A capacity bridge was then connected to electrodes A and B, and the height of the mercury column varied by applying radiant heat to the bulb. To prevent any errors the source of heat was removed when capacity measurements were being taken. The curve illustrated in Fig. 2 was then obtained, this showing the capacities given between electrodes A and B over the temperature range of 10° to 70° C.

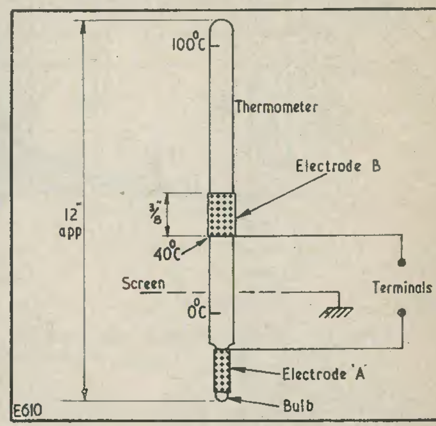


Fig. 1. The dimensions of the thermometer and electrodes used in the initial experiment

It is extremely interesting to observe the capacity variations which occur in the curve. Commencing at the lower temperature end, it will be seen that, for temperatures up to 25° C, the capacity between electrodes A and

B is negligibly small. At 25 C the capacity just commences to rise, reaching 0.05pF at 30°C. This gradual rise in capacity continues up to 35° C (0.15pF) after which the increase per degree Centigrade becomes suddenly very much greater. At 37° C the capacity is 0.25pF, at 40°C the capacity is 1pF, and at 45° C the capacity is 1.45pF. After 45° C the rate of increase in capacity drops, the curve becoming almost completely levelled off above 55° C, this representing the temperature at which the column has passed completely through electrode B and has carried on for some further distance.

The curve of Fig. 2 illustrates that the required dramatic change in capacity for electronic operation exists and that it appears at a small range just below 40° C; and the writer decided that the two points X and Y represented suitable points for further theoretical consideration. Point X corresponds to a capacity of 0.25pF and a temperature of 37° C, and point Y to a capacity of 1pF and a temperature of 40° C. The capacity variation given between these two temperatures is of the order of 1:4, a ratio which should be more than adequate for operating an electronic switching circuit. If employed as a thermostat such a circuit should then be able to switch off the appropriate heaters at 40° C and switch them on again at 37° C. A further point was that, since the device should be capable of centring at 38.5° C when the lower-temperature edge of electrode B was set to 40° C, other centre temperatures could be selected by the simple process of setting the lower-temperature edge of electrode B 1.5° C higher than that required.

The Switching Circuit

A switching circuit which should, theoretically, be capable of operating from the capacity changes given between electrodes A and B is shown in Fig. 3. This has been especially prepared to ensure economy of components, and a very simple description of how it operates is as follows.

An oscillator V_1, whose output amplitude is controlled by variable resistor R_2, works in a tuned anode circuit. The anode tuned circuit consists of coil L_1 shunted by the capacity of the screened (coaxial) cable connected to its anode end. Coil L_2 is a feedback winding. Both the oscillator and its output lead are screened, this being done to prevent direct pick-up by the switching circuits around V_2.

The r.f. voltage appearing at the anode of V_1 is applied to electrode A of the thermometer. Electrode B connects to the grid of V_2. The two electrodes may, in consequence, be considered as the two plates of a variable condenser, the r.f. voltage passed via this condenser being detected by the grid and cathode of V_2. When the r.f. voltage becomes sufficiently high, due to the mercury column entering electrode B, the relay in the anode circuit de-energises. Similarly, when the r.f. voltage is low, due to the mercury column leaving electrode B, the relay energises. The relay contact arrangement shown in Fig. 3 is that needed when the device is intended to operate as a thermostat. Other contact arrangements can, of course, be employed for alternative applications.

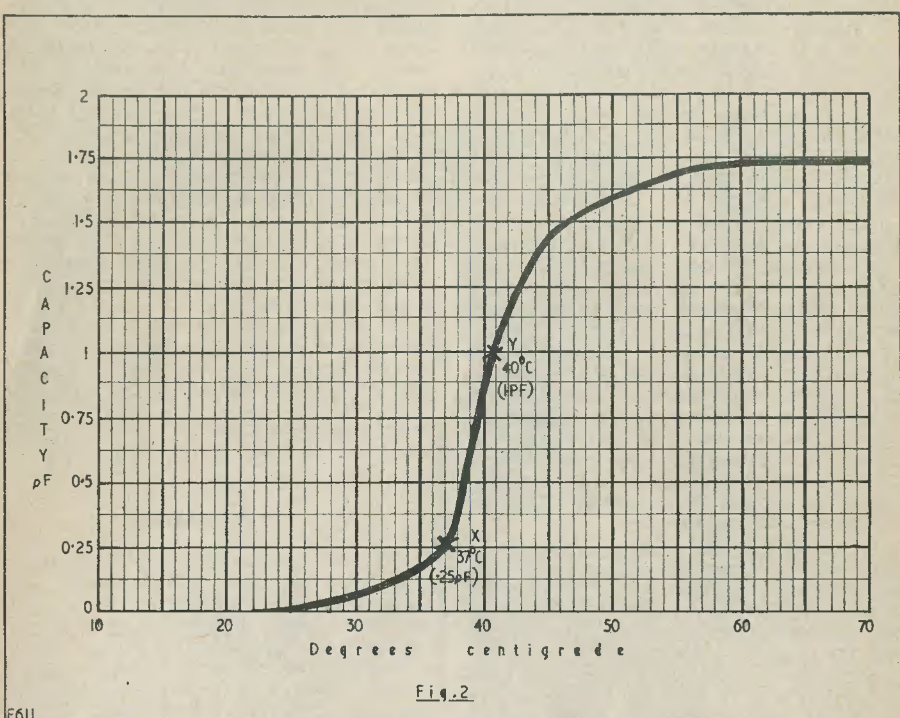


Fig. 2. Curve showing the capacity between electrodes A and B for bulb temperatures between 10 *and* 70 *C*

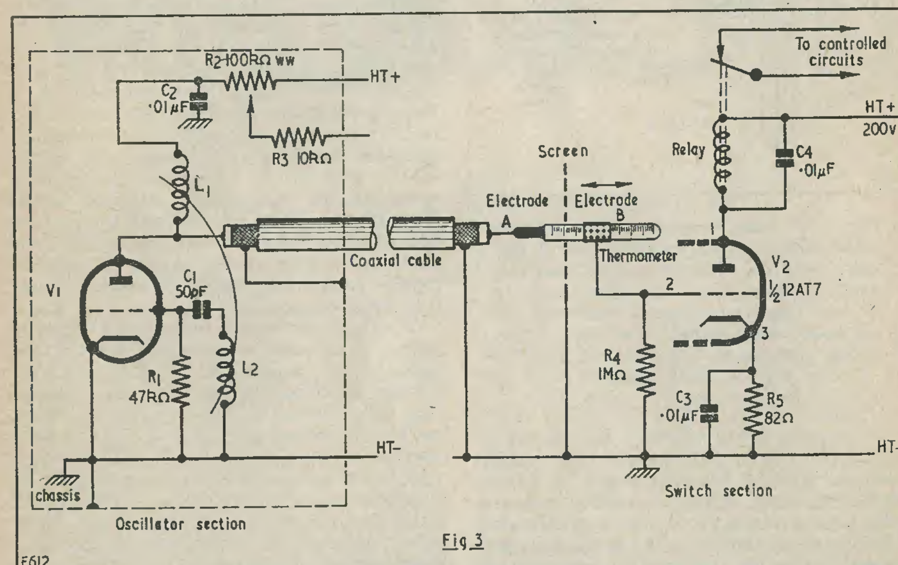


Fig. 3. A suggested circuit wherein the thermometer may operate a relay at predetermined temperatures

Operating Conditions

The description of operation just given may sound deceptively simple but such is not really the case, as the circuit of Fig. 3 takes into account a considerable number of factors. These will now be dealt with.

One of the first points to consider is that since the capacity between electrodes A and B is, in actual fact, the series condenser of a leaky grid detector it is necessary for the time constant of the condenser and the associated grid leak, R_4, to be long compared with one cycle of the r.f. from the oscillator. A sensible value for R_4 would be 1MΩ, whereupon the time constant given by this resistor with 0.25pF (point X of the curve of Fig. 2) is 0.25μs, and with 1pF (point Y) is 1μs. A suitable oscillator frequency for these time constants would then be of the order of 20 Mc/s, each cycle of which would have a length of 0.05μs. L_1, L_2 should, in consequence, be a coil capable of oscillating at this frequency. In practice, L_1, L_2 could be any normal short wave coil (such as the Teletron HFA3) having a top frequency around 20 Mc/s, the tuned coil being connected in the L_1 position instead of, as is usually the case, in the grid circuit. The valve employed in the V_1 stage may be any triode of the 6J5 class, whereupon the values shown for R_1 and C_1 should cope comfortably enough. There is no necessity, incidentally, to take any precautions against frequency drift, as the small shifts in frequency which would normally result from warm-up will not affect the operation of the device.

We may now transfer our attention to V_2. A valve having a short grid base is needed here, and the writer has calculated component values around one triode of a 12AT7 the remaining triode being unused.[2] The input capacity of one triode of a 12AT7 is 2.5pF with the result that, when the capacity between electrodes A and B is 1pF (point Y of the curve) 1/3.5 of the r.f. voltage applied to electrode A appears between V_2 grid and chassis. When the capacity between the electrodes is 0.25pF (point X of the curve), 1/11 of the r.f. voltage applied to electrode A appears between V_2 grid and chassis.

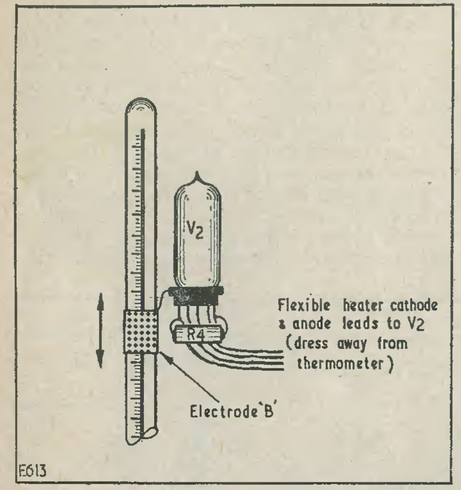


Fig. 4. In order to ensure a short connection between V_2 grid and electrode B, this valve may be mounted to the electrode itself, as shown here. The valve should be on the "high-temperature side" of the electrode. There should be no necessity to fit any components other than R_4 directly to the valveholder

A limiting factor imposed by the use of ½-12AT7 is that the maximum permissible cathode current for this valve is 15mA. Assuming zero voltage between grid and chassis, a standing current of approximately 12mA (safely within the maximum permissible) may be obtained by inserting an 82 ohm resistor in the cathode. This resistor will then drop approximately 1 volt. Having proceeded so far we now have the situation where the triode is operating under safe conditions and, when the grid is at chassis potential, has a cathode voltage of 1 volt positive with respect to chassis.

This positive voltage will act as a delay, with the result that the diode formed by the grid and cathode will not rectify for peak voltages of 1 volt or less. We require the switch to operate between points X and Y of the curve of Fig. 2, so let us now assume that, at point X, 1 volt peak of r.f. appears at electrode B of the thermometer. We have already seen that at point X, where the capacity is 0.25pF, 1/11 of the voltage on electrode A is applied to the grid of V_2, so our requirements will now be met if the r.f. voltage on electrode A has a value of 11 volts peak. Such a voltage is well within the capabilities of the V_1 oscillator circuit, and it may be obtained by suitable adjustment of resistor R_2.

Briefly summing up, we currently have the condition that, with 11 volts peak r.f. on electrode A, 1 volt peak r.f. appears between grid and cathode of V_2 when the temperature is at point X of the curve of Fig. 2. Due to the delay introduced by cathode bias resistor R_5 the grid and cathode of V_2 do not rectify, and the anode current of this valve is 12mA.

We must next increase the temperature applied to the thermometer such that the capacity between electrodes A and B rises to 1pF (as occurs at point Y of Fig. 2). We will now find that 1/3.5 of the 11 volts applied to electrode A appears between V_2 grid and chassis. This voltage is approximately 3.15. Being greater than the delay provided by R_5, rectification will take place and a negative potential with respect to chassis will appear at the grid of V_2. Due to this negative potential, the bias voltage dropped across R_5 will become less as, also, will the positive delay voltage on the cathode. The final result will be an anode current of approximately 2mA, with a drop of approximately 0.16 volts across R_5.

We therefore have a second case wherein, when the capacity between electrodes A and B is 1pF, the anode current of V_2 is 2mA.[3] Finally, summing up and using the temperature figures given in Fig. 2, valve V_2 passes an anode current of 12mA at 37° C, and a current of 2mA at 40° C. It will be noted that the anode current changes in V_2 are of a large order, viz. 12 to 2mA. Such currents are, of course, passed through the coil of the relay of Fig. 3, whereupon it becomes energised or de-energised accordingly. In practice, most relays will have an energising to de-energising current ratio which is markedly lower than the 6:1 ratio provided in the above calculations. As a result, the switching tolerance should become significantly tighter than the arbitrary ±1.5° C on which the calculations were based.

Practical Points

Little needs to be said about practica points as these are of a fairly simple nature and should be capable of solution by any constructor with average experience. One important fact is that the lead between electrode B and the grid of V_2 should be short and should have a low capacity to chassis. Indeed V_2, with R_4, could be mounted on electrode B itself, and could be moved up and down with this electrode when the latter is set to the temperature required. If this method of mounting is adopted the valve should be positioned as illustrated in the suggested layout of Fig. 4, where it does not approach the column of mercury below the electrode.

Another point of practical importance is that the two electrodes A and B should make good surface contact with the glass of the thermometer. The reason for this is that full advantage of the dielectric constant of the glass will then be taken, this constant being some 4 to 7 times that of air.

[2] Unfortunately, the second triode cannot be employed in the V_1 position owing to the risk of pick-up by V_2 electrodes of r.f. from the oscillator.

[3] The valve current figures given in this and the preceding case are taken from published I_a–V_a curves.

SERVICING

This month Smithy the Serviceman explains some of the mysteries of timebases to his assistant, Dick.

"DRAT THE BLASTED THING," SAID DICK, angrily.

Smithy the Serviceman turned round, to see his assistant glaring malevolently at the television receiver he had just finished servicing.

"Swearing at it won't make it any better," remarked the Serviceman mildly. "What's the trouble?"

"It's this tarnation frame hold," replied Dick. "I've just spent three-quarters of an hour fixing up a fault in the i.f. strip of this set. I get the darned chassis working beautifully, put it back in the cabinet, and then find that the frame timebase has gone for a burton."

Smithy walked over to the receiver and adjusted the frame hold control. He could not lock the picture at any position of the control, although he noted that the frame timebase was running only slightly out of lock at the extreme clockwise end of the track.

"There you are, you see," said Dick, disgruntledly. "If only there were a little more track in the pot you'd make it!"

Grid Base

Smithy grinned a little and, leaving the frame hold control at the extreme clockwise end of its track, switched off the receiver.

"Did you check the range of the frame hold control when you had the chassis unboxed?" he asked Dick.

"As a matter of fact," his assistant admitted, "I rather forgot to do that."

"Not to worry," said the Serviceman. "We all overlook things now and again. Nevertheless, it's always a good plan to check that frame and line hold are both well within the range of the controls when you have a chassis out of its box, in order to save yourself future frustrating experiences like that we have just now. Ideally, you should be able to go out of lock in both directions with both controls, but this requirement isn't essential provided you get lock over a reasonably large range of the control concerned."

He turned back to the receiver and switched it on again.

"I've left the frame hold control hard over in the position in which it nearly locks," he remarked to the somewhat mystified Dick. "Let's see what happens as the set warms up."

After some moments a picture appeared on the tube.

"Why, the frame has locked in now," said the surprised Dick. "What have you done, Smithy?"

"Nothing," said the Serviceman, "except probably repeat the circumstances under which you yourself tested the set. Starting up from cold with the control hard over, the frame may lock in and stay locked in. However, give the control a bit of a waggle, as you doubtless did when you put the cabinet on, and you'll almost certainly lose lock and won't be able to get it back again."

Whereupon Smithy turned the frame hold control. The set behaved exactly as he had predicted. With a satisfied expression on his face he then wandered back to his own bench.

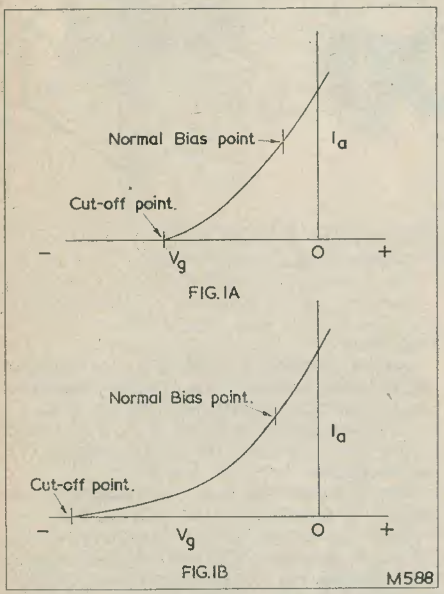


Fig. 1. *Illustrating how two valves, which may behave exactly the same as amplifiers under normal biasing conditions, can have quite dissimilar cut-off potentials. The cut-off voltage in* (*b*) *is markedly further negative than that in* (*a*)

"Hey, Smithy," called Dick, "don't leave me in the lurch! Don't tell me I've got to get the cabinet off again and start going through the frame timebase circuit."

"Only if you're unlucky," replied the Serviceman over his shoulder. "So far as I remember, that particular species of receiver employs the triode of a triode-pentode as the frame oscillator. It also has the same triode-pentode in several other positions on the chassis. If you swap the frame oscillator valve with one of the other triode-pentodes you should be able to clear the fault on, at worst, your second or third attempt."

Dick did as he was bid. The very first valve he tried in the frame timebase circuit cleared the trouble and frame hold was such that he could lose lock in both directions of the control.

"Well, swapping valves has cleared the trouble, Smithy," Dick called out, pleased. "But do you think it's safe to leave the duffy valve in another stage of the receiver?"

"If the set's working O.K. I shouldn't bother," replied the Serviceman, somewhat indifferently.

Dick found that he could get no further information from the Serviceman, who had now become completely engrossed in his own work. He decided to renew the attack later on in the morning. His opportunity appeared around eleven o'clock, as he and the Serviceman sipped their tea together.

"Smithy," said Dick. "I'm still bursting with questions about that frame oscillator bottle. I don't understand how you could be so certain that another valve would work O.K. in its place. Also, I don't see why the first valve should still be O.K. in another position."

"I must admit," said Smithy in reply, "that I took a slight risk in several directions when I advised you to swap the valves over. I assumed first of all that something serious hadn't gone wrong with the frame timebase. Secondly, I assumed that the grid base of the existing frame oscillator had shifted slightly, but that its mutual conductance was still good enough for it to be employed elsewhere."

"Grid base?"

"The grid base of a valve," explained Smithy, "defines the range in grid bias voltage between zero and cut-off. Perhaps you can understand this better if I draw a few curves."

Smithy pulled a ball-pen from his pocket and scribbled on some paper lying beside him."

"Now here," he said, "we have a normal common-or-garden I_a–V_g curve, such as any member of the public whose spare time reading includes valve manuals is likely to meet. As you can see (Fig. 1 (*a*)), it has the usual straightish section around the place you normally bias it, and the curve tails off as you approach cut-off. Another valve curve is like this (Fig. 1 (*b*)). This is identical to the first one around the normal biasing point. But the cut-off voltage occurs at a point which is quite a lot further from zero bias. The two curves I've drawn could quite easily be those for two valves having the same type number, and you wouldn't notice that they had different grid bases if you operated them under normal bias conditions. But if you tried to work the two valves in a circuit where cut-off voltage was important you would soon know the difference."

"I think I'm beginning to see what you're driving at," remarked Dick slowly. "I presume I'm correct in thinking that grid base is important in a timebase, and that is why swapping the two valves over made the frame timebase work properly again. At the same time, what I described as a duffy valve was then quite O.K. in a position where it just had to amplify in normal manner."

"That's right."

"Ah," said Dick. "Well, the next thing that occurs to me is that somebody had had a dig in that set before we got it in for repair; that someone having put a valve with the wrong grid base in the frame timebase."

"Not necessarily," commented Smithy. "As valves grow older their cut-off potentials are liable to creep around a little, and this may have happened to the particular valve in your set. So far as I know, the creeping effect is due to changes in cathode emissive surface, and so on. It may even happen that a few molecules of that mixture of smog and diesel fumes which we laughingly call air find their way into the evelope. Incidentally, we shouldn't forget that with timebases, there is always the risk that a slight amount of leakiness in a condenser or across a tag-strip or valveholder has altered the running frequency so that, by putting in a new valve, we are really counteracting a defect elsewhere in the circuit. However, if the new valve obviously clears the trouble I don't think we're justified in looking for such faults just on the off-chance. I might add that with a few television receivers it is almost a recognised fact that you have to select valves to get one or other of the timebases running at correct frequency. Fortunately, the requirements of most timebase circuits aren't very critical in this respect."

"What I still don't quite understand," said Dick, "is why the cut-off voltage is so important."

"That's an easy one," chuckled the Serviceman, "and to give you an explanation I'll start off by drawing you the circuit of a simple blocking oscillator (Fig. 2). This is how it works. When you first of all apply h.t. to the blocking oscillator, the anode of the valve commences to draw current through the primary of the transformer, causing a magnetic field to build up. This increasing field causes a voltage to be induced in the secondary winding. The secondary is connected to the valve such that in the presence of an increasing field the grid goes positive via the series grid condenser. The fact that the grid goes positive assists the flow of anode current through the primary of the transformer, and this continues to increase until either the valve or the transformer saturates. As soon as saturation point is reached no further increase in anode current takes place and the field in the transformer ceases to increase. In consequence no voltage is now induced in its secondary, and the positive voltage on the grid commences to leak away via the grid leak. The slight decrease in positive grid voltage at this instant causes a slight reduction in anode current, with the result that the transformer field next commences to collapse. Being now a collapsing instead of an expanding field, it induces in the secondary a voltage which is opposite in polarity to that previously given. The grid, therefore, goes further negative, there is a further reduction in anode current, and the collapse of the transformer field becomes assisted. The final result is that the grid is driven highly negative—well past cut-off—and anode current ceases completely. The grid then stays beyond cut-off until the series grid condenser has discharged sufficiently into the grid leak for anode current to commence once more. Whereupon we get the commencement of another expanding field in the transformer and we start off on another cycle.

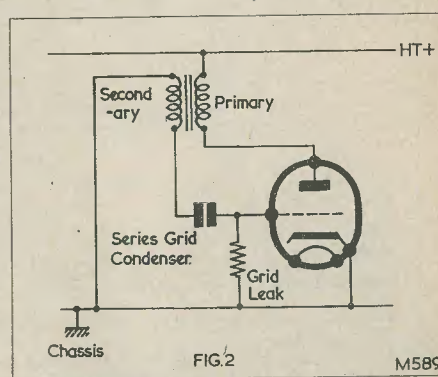


Fig. 2. A simple blocking oscillator. A control of frequency is possible by making the grid leak a variable component. Positive-going sync pulses may be applied to the grid, a possible method consisting of inserting a low value resistor between secondary and chassis, and applying the pulses to the junction of the resistor and the secondary

"These waveforms," continued Smithy, scribbling again, "help to show the general principle. If you look at the anode and grid voltages during the cycle (Figs. 3 (*a*) and (*b*)) you can, in fact, see the whole story. Point A on both waveforms is where you switch on h.t. and anode current commences to flow. Point B marks the spot where saturation occurs. Here you see that anode voltage is at a minimum (because anode current is at a maximum) and the grid has gone to its most positive condition. After point B you get the collapse of the field, the most interesting effect of which is the negative excursion of the grid to point C. From point C to point D what you mainly have is the exponential curve given by the series grid condenser discharging into the grid leak. Immediately this curve hits the cut-off line your valve commences to pass anode current and off you go on your next cycle. You will, of course, note that the distance from C to D is a lot longer than that from A to C. So C to D corresponds to the scanning period, and A to C corresponds to the flyback, or retrace, period."

"Fair enough," said Dick, who had been following Smithy's explanation closely. "I'm beginning to see now why the cut-off voltage is so important. If I draw another cut-off line on your diagram (Fig. 3 (*c*)), this being only a wee bit further out from zero than your original one, I reduce the scanning period by what is, proportionately, a very large amount. The reason being, so far as I can see, that the exponential curve is nearly flat when it

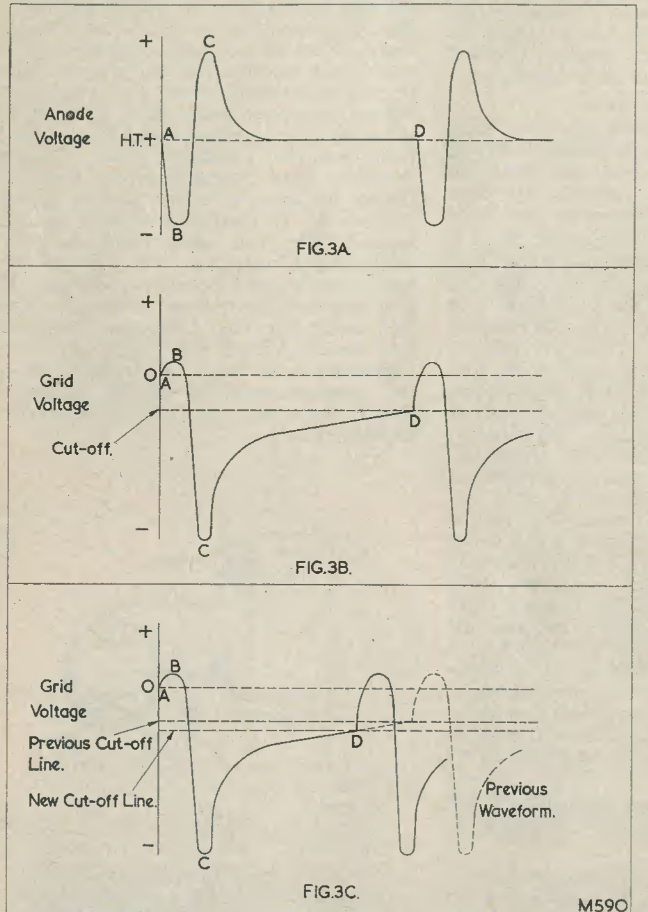


Fig. 3 (a) The anode voltage waveform of a typical blocking oscillator. (b) A blocking oscillator grid voltage waveform corresponding to the anode waveform of (a). (c) If the grid cut-off line is moved slightly, the length of the period from C to D, and hence the frequency of the oscillator, is considerably modified

approaches the cut-off line."

"That's right," confirmed Smithy. "A small change in cut-off voltage can cause a very large change in the scanning period. I've used a blocking oscillator in my circuit because its operation is easy to explain, but the same principle applies to other television timebases using hard valves. In a multivibrator the effect is slightly more complicated. A change in cut-off voltage in one of the valves causes the scanning period to be altered, whilst a change in cut-off voltage in the other valve causes the length of the retrace period to be altered."

"It must be a bit of a headache to timebase designers," remarked Dick, "having to put up with varying grid bases."

"I don't suppose it's all that difficult," replied Smithy, "they just have to put enough range in their hold controls to accommodate the spread they can expect in the valves they specify."

Synchronising

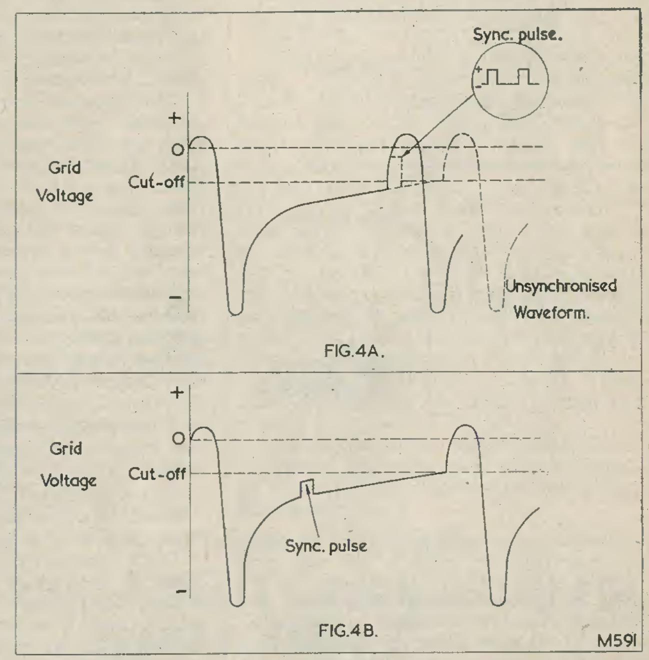
"How about syncing your blocking oscillator?"

"The blocking oscillator is very simple to synchronise," said Smithy. "The usual method consisting of putting positive-going sync pulses into the grid circuit. (See Fig. 2.) These then cause the grid to go over the cut-off line, like this (Fig. 4 (*a*), whereupon they start off the next cycle a little before its proper time. If, however, the sync pulses arrive too late they can't do anything because the timebase has already started its next cycle. That is why you can never sync in a blocking oscillator that's running at too high a frequency. At the same time, if your sync pulses arrive too early they won't sync the timebase because they don't cause the grid to go over the cut-off line. (Fig. 4 (*b*)). Mind you, you *could* cause them to sync the timebase if you made them large enough to force the grid past the cut-off line. This is one of the reasons why frame timebase adjustment is usually more critical than line timebase adjustment. In most cases you can pump in a king-size sync pulse into the line timebase of a receiver and get a wide range of hold control as a result. On the other hand, you can usually only apply a relatively small sync pulse to the frame circuits and they become more critical to set up."

"Why must the frame sync pulse be small?"

"Because," replied Smithy, "the frame timebase is liable to fire rather too readily on interference. Sync separator circuits which

Fig. 4 (a) When a positive-going sync pulse is applied to the grid of a blocking oscillator, its leading edge causes the grid to pass the cut-off line and initiate the next cycle before its natural time. (b) If the sync pulse arrives too early, as happens here, the grid voltage does not pass the cut-off line, and the oscillator continues to run at its natural frequency



allowed a large frame sync pulse to be passed to the frame timebase would also pass interference pulses with too high an amplitude. There are other snags as well, these having to do with interlacing, but we haven't the time to go into these now."

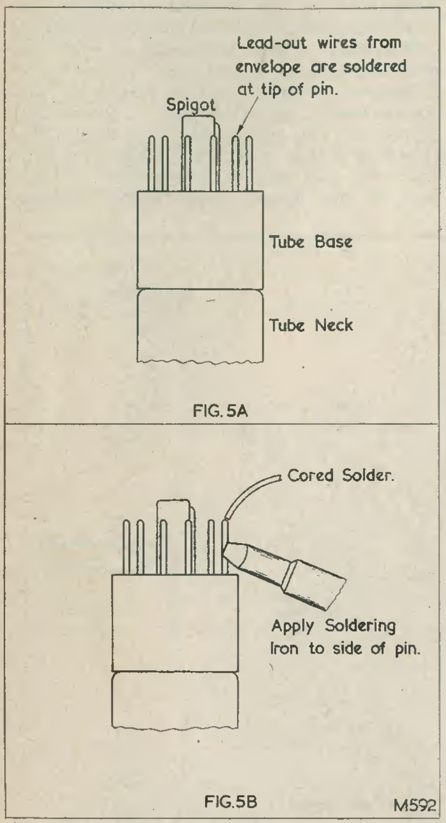


Fig. 5 (a) Open-circuit connections to cathode ray tube elements occasionally occur at the point where the lead-out wire from the envelope is soldered to the pin. (b) Where such open-circuits occur they may frequently be cleared by applying a little active, but non-corrosive, flux to the tip of the pin, carefully laying the soldering iron along its side, and allowing a little cored solder to melt and run down the inside of the pin

"Well, thanks for the gen," said Dick. "Things are a bit clearer to me now."

"O.K.," said Smithy, equably, "now let's get back to the grind."

Open-Circuit Tube

Dick obediently went back to his bench and peace descended on the Workshop once more. It was short-lived, however.

"Smithy," Dick's voice called across the Workshop. "I've got another queer snag here."

"What's up?"

"I've got a c.r.t. whose screen won't light up."

"Perhaps it's blocked up with dead cowboys," suggested Smithy.

"No, do be serious," protested Dick. "The heater is O.K. and all the electrodes are getting their proper potentials. And there aren't any shorts between electrodes."

"Could it have completely lost its emission?"

"I shouldn't think so," said Dick, "it's a very new set."

"How about an open-circuit cathode?"

"Ah, I hadn't thought of that," replied Dick. "How do I check for it?"

"Let the tube warm up for a while," said Smithy, "then remove the socket and check with an ohmmeter across cathode and grid pins. If you get a resistance reading with the leads applied one way but none the other, then grid and cathode are O.K. because they're acting as the anode and cathode of a diode. If you get readings both ways then you've got a leak or a short between the two. If you get no reading either way then one of the two electrodes is open-circuit. An open-circuit grid will give you uncontrollable brilliance, and an open-circuit cathode will give you no picture at all. Fair enough?"

"Sure," replied Dick. "I'll try it out."

Dick tried Smithy's suggestion and gave his report—delivered in the usual manner across the breadth of the Workshop.

"You were right, Smithy," he called out. "It was an open-circuit cathode. What does that mean now, a new tube?"

"Not necessarily," replied the Serviceman, walking over, once more, to Dick's bench. "In all fairness to the customer I think we ought to see if we can repair the present one. Quite often an open-circuit of this nature occurs at the point where the lead-out wire from the glass is soldered to the pin."

Smithy indicated the point with his finger. (Fig. 5 (*a*).)

"Sometimes the joint here isn't as good as it might be and it finally gives way in service. So what I would suggest is that you put the tube on its face with the pins pointing upwards and attempt re-soldering the connection. First of all, apply a little active, but non-corrosive, flux to the suspect pin. Then lay your soldering iron bit against the side of the pin near the top so that the heat gets into the pin itself. (Fig. 5 (*b*).) Next apply a good quality cored solder to the tip of the pin and allow a little of this to melt and run down inside. Finally, take your iron away carefully and allow the solder to cool and solidify in its own good time, without touching or bumping the tube in any way. Don't forget that what is very often described as a cold joint is really the result of the joint being jolted slightly at the instant of the solder solidifying."

"And re-soldering should cure the trouble?"

"Only," said the Serviceman, "if the fault is at the pin. The idea being that, if the tube is otherwise dud, any guesswork repairs of this nature are worth while provided they don't take too long. I would even suggest, if the procedure I've just described gives no cure, that you give the neck of the tube some light thumps. You don't have to use sledge-hammer tactics here, of course. If you're lucky you may make an internal intermittent connection become good again and you can then return the set to the customer stating that the tube may pack in at an early date or that it may carry on for years. I've done this with one or two customers, and they've all been prepared to take a gamble rather than pay for a new tube."

"I see," replied Dick. "Incidentally, talking about soldering, I've got another query. What sort of solder is the best for mains dropper tags?"

"That's rather a problem," replied Smithy. "The trouble here is that mains dropper tags are liable to get very hot in service, hot enough even to melt the solder. The usual practice is to use 20/80 solder instead of the normal 60/40 alloy."

"Which is 60% of tin and 40% of lead?"

"That's right."

"I suppose the 20/80 solder has a higher melting point," remarked Dick.

"Not exactly," replied the Serviceman. "Except for one particular combination all tin/lead alloys go through what is called a 'pasty' stage before they finally become fluid. For percentages above 15% tin they all enter this 'pasty' stage at 183° C, after which they become completely fluid at a higher temperature. A 63/37 alloy has practically no 'pasty' stage at all, it becoming fluid almost immediately after 183° C. The further you go away from the 63/37 alloy, in either direction, the higher the temperature at which the 'pasty' state changes to the fluid state. For 20/80 the fluid state is reached at approximately 275° C."

"After what you've told me," remarked Dick, "I can't see the point of using 20/80. I've seen solder in the 'pasty' state before now and, whilst it doesn't exactly flow, I have certainly been able to push it around very easily. What's the advantage of using 20/80?"

"There isn't much," admitted the Serviceman. "The basic fault here lies in designs which allow droppers to get so hot that their tags exceed 183° C. When I have to wire up mains droppers myself I usually make sure that connecting wires are well twisted around the tags before I solder. If the tag has a hole I thread the wire through this as well. The idea behind all this is that, if all else fails, you still have a fairly good mechanical joint. I then use 20/80 solder, but only to give myself the comforting feeling that the solder will remain on the tags for temperatures above 183° C, and that it won't drop off and cause shorts elsewhere, as 60/40 would."

"Thanks, Smithy," said Dick. "Well, I think that's given me all the information I require."

Whereupon, to the complete astonishment of Smithy, Dick turned round, concentrated on his work, and asked no further questions whatsoever.

PHILIPS HIGH-FIDELITY PICK-UP HEAD

Type AG. 3016

An entirely new high-fidelity crystal pick-up head for microgroove and 78 r.p.m. record reproduction—type AG.3016—is now being offered by Philips Electrical Ltd. at 22s. (tax paid).

Improved design giving a wide frequency response with a minimum of "needle talk" are special features, and the high output system is protected against humid conditions by a special material contained in the sealed head shell.

The two easily replaceable sapphire styli are fitted in an independent holder, the styli being connected to the armature by elastic couplers. The system is mechanically stable and has a high degree of compliance.

The AG.3016 will eventually supersede types AG.3010/3012/3013 and can be used on all equipment fitted with those types.

Technical Specification

Output voltage: 100mV per cm/sec. at 400 c/s.
Average output approximately ½ volt.
Frequency response: 30–15,000 c/s.
Load resistance: 220,000 to 470,000 ohms.
Lateral compliance: 2.3 x 10–6 cm/dyne.
Playing weight: 7–10 gms.

UNDERSTANDING TELEVISION

PART 13

By W. G. MORLEY

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

In this month's contribution we conclude our discussion on the tuner section of the television receiver by considering the function of the mixer valve and describing the means by which alignment may be carried out with the aid of a frequency modulated signal generator.

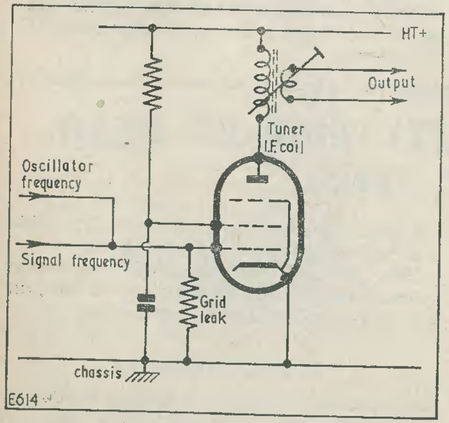


Fig. 69. The basic television tuner mixer circuit. Both signal and oscillator frequencies are fed to the common control grid

The Mixer

The mixer performs an important function in the television tuner, its purpose being to cause the difference frequency between the oscillator and input signal frequencies to be presented to the i.f. amplifier of the associated televisor. The oscillator is, of course, tuned such that the difference frequency is equal to the intermediate frequency.

The type of mixer encountered in television tuners differs from those employed for normal broadcast band and short-wave reception insofar that both the signal and the oscillator frequencies are fed to a common control grid, instead of to two separate grids in a common electron stream. The mixer valve employed in television tuners is almost always a pentode, whereupon it constitutes one-half of a triode-pentode, the complementary triode functioning as oscillator. Typical of triode-pentodes employed in current tuners are valves type PCF80, LZ319, 8A8 and 30C1 (all of different manufacture and all directly interchangeable).

The basic mixer circuit arrangement is illustrated in Fig. 69. In this diagram we see the pentode connected up such that its anode feeds into an i.f. coil, its screen grid is supplied via a conventional resistor and decoupling condenser, and its control grid receives both signal and oscillator frequencies. The cathode of the mixer in Fig. 69 connects directly to chassis.

Let us now examine the circuit arrangements which allow the signal and oscillator frequencies to be fed to the single control grid. We have already seen[1] that it is common practice to arrange the secondary part of the bandpass circuit such that optimum matching is obtained between the secondary coil and the input impedance of the mixer. This is an essential point of tuner design: the secondary of the bandpass tuned circuit must allow maximum signal frequency voltage to be applied to the mixer grid. The amplitude of oscillator voltage fed to the grid does not, on the other hand, require to be at a maximum. Instead, it has to be maintained close to a particular value (dependent upon the mixer circuit and valve type) which enables maximum *conversion conductance* to be obtained.[2] Fig. 70 illustrates a conversion conductance/oscillator voltage curve for a typical mixer valve. As may be seen, conversion conductance drops if the oscillator input voltage increases above an optimum value in just the same way as it is liable to drop if oscillator input voltage decreases below that value. Due to the fact that the mixer grid of Fig. 69 is connected to chassis via a high-value resistor, a leaky-grid detector action takes place between grid and cathode. The mixer valve, in consequence, receives a bias which is close to the peak value of the oscillator voltage.

Methods of coupling the oscillator to the mixer input circuit vary for different designs of tuner, but they are always based on capacitive coupling, inductive coupling, or a combination of the two. Fig. 71 (*a*) illustrates an instance where the coupling is intended to be almost entirely capacitive, inductive coupling being reduced to a low value by mounting the oscillator coil at right angles to the bandpass tuned coils. This arrangement is typical of turrent practice, wherein each coil segment may contain an oscillator coil fitted at right-angles to the bandpass coils. Also typical of turret tuner practice is the arrangement of Fig. 71 (*b*), in which all three coils are fitted in line to the one former.[3] In this case oscillator coupling is intended to be almost entirely inductive, the only capacitive coupling being provided by "stray" capacities between wiring and coils. Tuners in which intentional inductive coupling is augmented by intentional capacitive coupling are also frequently encountered.

The I.F. Coil

The i.f. coil illustrated in the basic arrangement of Fig. 69 consisted of a tuned circuit having a secondary winding. In practical tuners employing this type of i.f. coil it is usual to find that the circuit of Fig. 72 (*a*) is used, this diagram illustrating also the input tuned circuit of the i.f. amplifier, or "strip." The secondary winding of the turret i.f. coil usually has the requisite number of turns needed to match the primary to 75 ohms, whereupon 75 ohm coaxial cable may be employed to couple the tuner output to the first i.f. coil on the receiver chassis proper. An equivalent circuit is illustrated in Fig. 72 (*b*), wherein it may be seen that the tuner and i.f. tuned coils constitute a bandpass pair.

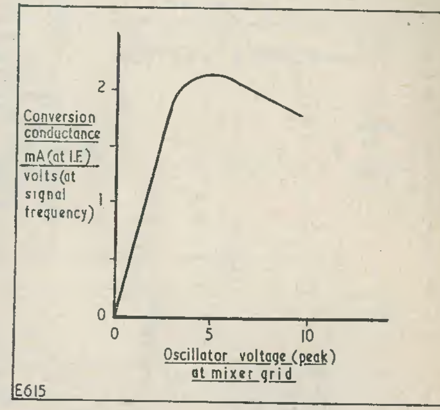


Fig. 70. A curve showing conversion conductance against oscillator voltage applied to the grid of the mixer

An alternative type of i.f. output tuned circuit is illustrated in Fig. 72 (*c*). In this case the coil in the tuner has one winding only. This coil is frequently connected into the i.f. strip as illustrated. The overall arrangement then resulting is that shown in Fig. 72 (*d*), in which we have a bandpass circuit once more. For correct bandpass operation it is necessary that the common condenser of Fig. 72 (*d*), sometimes called the "bottom-end condenser," has the requisite capacity. A variation on the arrangement of Fig. 72 (*c*) consists of fitting a low-value inductance in place of the common capacity whereupon, given the requisite inductance values, a bandpass effect is again obtained. Yet a further variation consists of having both capacity and inductance in parallel at the chassis ends of the tuned coils.

All conventional tuners have an i.f. coil of

[1] Understanding Television, part 11, Fig. 67 and text on page 273, *The Radio Constructor*, November 1958.

[2] Conversion conductance defines the change in intermediate frequency anode current produced by unit change in signal frequency voltage at the grid.

[3] Fig. 50, Understanding Television, part 9, *The Radio Constructor*, September 1958, shows examples of turret coil segments.

one of the two types just discussed mounted on the chassis of the tuner itself. This practice is extremely desirable because it enables a very short connection to be provided between the anode of the mixer valve and the i.f. tuned circuit, thereby ensuring minimum lead length and minimum undesirable "stray" capacity to chassis.

The circuit of Fig. 72 (*a*), employing the double winding i.f. coil, has been very popular in the past. In currently made tuners, however, it is being largely superseded by the single winding arragement of Fig. 72 (*c*). The single winding arrangement is particularly advantageous in miniaturised tuners, where space is at a premium.

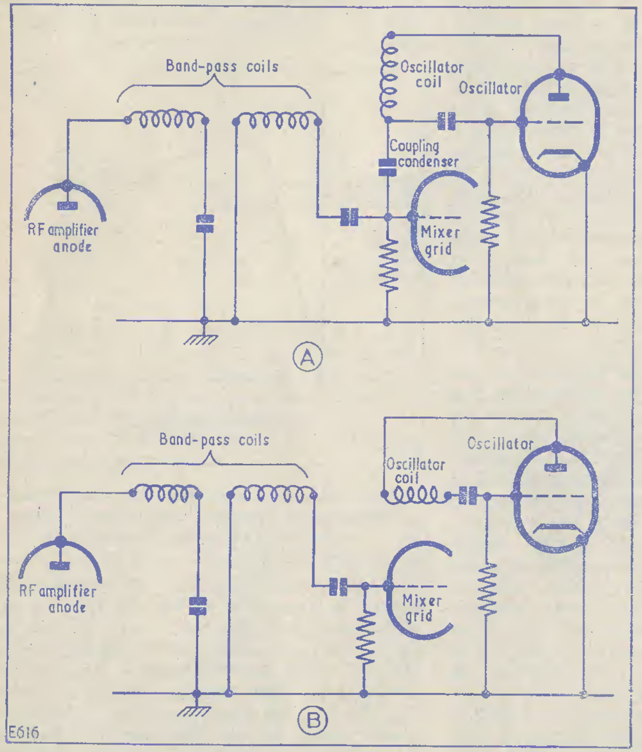


Fig. 71 (a) The oscillator voltage is frequently applied to the mixer grid via a coupling condenser, as shown here. The value of the coupling condenser usually lies between 1 and 3pF. (b) An alternative type of coupling. In this case the oscillator coil is mounted in line with the bandpass coils to obtain an inductive coupling

Mixer Variations

It frequently happens that tuners employ variations on the basic mixer circuit of Fig. 69. A typical example is illustrated in Fig. 73 (*a*), the variation here being that the cathode of the mixer is returned to chassis via a resistor and decoupling condenser rather than by a direct connection. The advantage of the resistor and condenser is that the resultant cathode bias provided ensures that the conversion conductance/oscillator voltage curve becomes flatter, as in Fig. 73 (*b*), than that of Fig. 70. In consequence, reductions in gain given by oscillator voltages increasing above the optimum value are not so marked, and an easement in oscillator and coupling requirements becomes possible.

Another common manufacturing device consists of inserting a low-value choke in series with the screen-grid of the mixer, as in Fig. 73 (*c*). The presence of this choke enables a regenerative effect to occur at Band 3 frequencies, and it is stated that Band 3 gain is enhanced in consequence. When employed, the screen grid choke consists of several turns of wire only.

Noise

A most important requirement of a television tuner is that its locally generated noise level must be kept as low as possible. Locally generated noise in television tuner stages is normally the result of three factors: random movement of electrons in resistors (thermal agitation noise), random variations in the numbers of electrons arriving at the anode of a valve (shot noise), and induced currents in the grid wires of a valve by random variations in the anode current (induced grid noise).[4] These three effects add together to cause a total noise voltage to appear in the anode circuit of the valve under consideration. It is usual, when discussing noise in valve stages, to assume that the noise is generated between grid and cathode even if this is not entirely true.

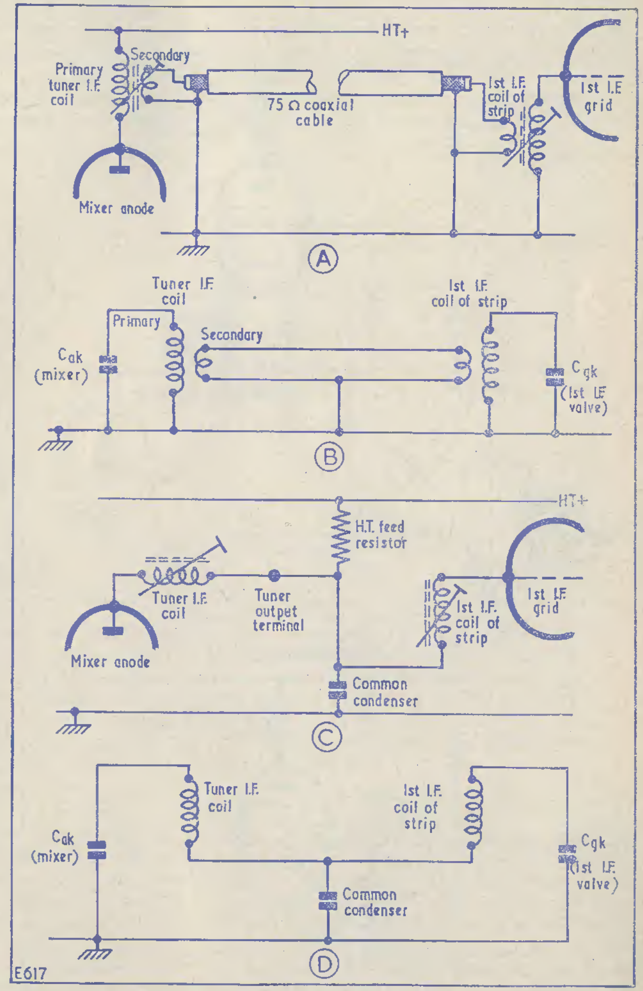


Fig. 72 (a) When a two-winding i.f. coil is employed in the tuner, connection to the main i.f. amplifier, or "strip," is often obtained via 75Ω coaxial cable. (b) The circuit of (a) forms a bandpass arrangement, the tuner i.f. coil being tuned by the capacity between mixer anode and cathode, and the first i.f. coil being tuned by the capacity between grid and cathode of the first i.f. valve. (c) A single-winding tuner i.f. coil may be connected up as shown here. The h.t. feed resistor normally has a value which is sufficiently high to prevent any effects on the tuned circuits. (d) The circuit of (c) may, once again, be shown as being a bandpass arrangement

In a sound receiver, internally generated noise makes itself evident as a hiss. In a television receiver noise makes itself evident as a speckled background to the picture, the effect often being described as "snow." If a television tuner is to operate efficiently with weak signals it is necessary that it should have a low noise level, so that snow is kept to a minimum. With modern high-gain television receivers it is, indeed, the noise level of the tuner which ultimately defines the useful sensitivity of the receiver.

The noise generated in the mixer stage of a tuner is normally considerably greater than

[4] F. Langford-Smith, *Radio Designer's Handbook*, 4th edition, Iliffe & Sons, page 939.

that generated in the grid circuit of a straightforward r.f. amplifier. Television tuner designs always employ an r.f. amplifier before the mixer, with the result that the amplified signal passed to the grid of the mixer is sufficiently large in amplitude, when compared with the mixer grid noise level, to override the latter. The noise factor which then limits the useful sensitivity of the tuner is that appearing in the grid circuit of the r.f. amplifier.

vary the gain of the r.f. amplifier by varying its grid bias. When this is done care has to be taken to ensure that r.f. amplifier gain is never reduced to so low a value that noise at the mixer grid becomes prominent on the signal passed to the i.f. strip.

The Wobbulator

In order to align the tuned circuits of tuner units it is customary to employ a frequency modulated signal generator (or wobbulator)

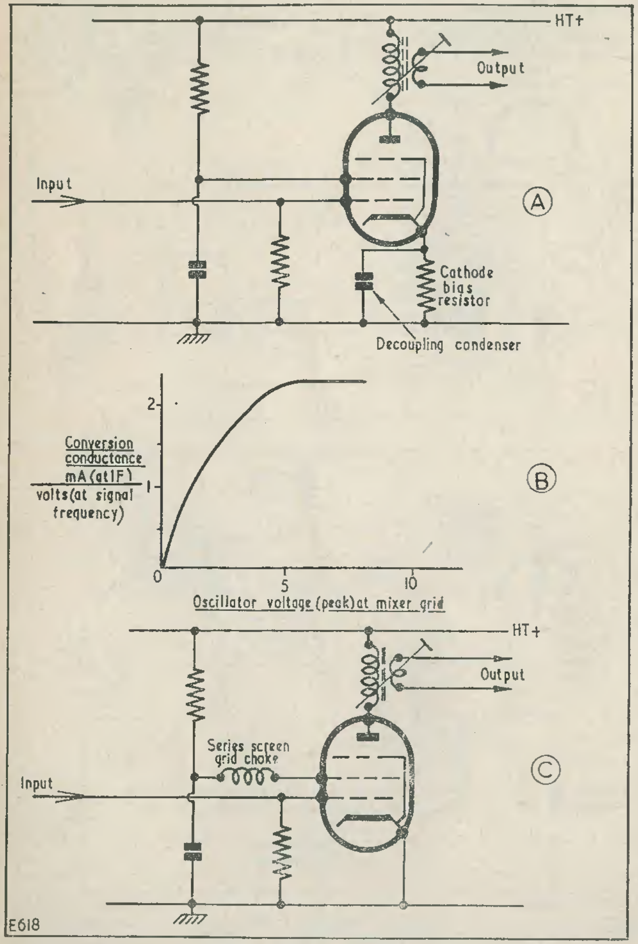


Fig. 73 (a) In many tuners, the cathode of the mixer is not connected direct to chassis. Instead, a bias resistor and decoupling condenser are inserted in series. (b) The presence of the cathode bias resistor causes a flattening of the conversion conductance/oscillator volts curve, thereby easing oscillator voltage and coupling requirements. This diagram should be compared with Fig. 70. (c) Band 3 gain can sometimes be enhanced by inserting a small-value choke between the screen-grid of the mixer and its decoupling condenser

In practical tuners, attention is always paid in initial design to keep internally generated noise level at the r.f. amplifier grid to as low a level as possible. In many receivers, contrast and automatic gain control[5] circuits

and an oscilloscope. It is possible with the aid of these two instruments to obtain a visual presentation of the response curve of the tuner.

Fig. 74 illustrates a typical wobbulator and oscilloscope set-up. The wobbulator output

[5] To be discussed in a later article.

is connected to an amplifier incorporating a number of tuned circuits; the output of the amplifier connects to a detector; and the output of the detector connects (via an amplifier in the oscilloscope) to the Y plates of the oscilloscope cathode ray tube. The wobbulator output is modulated in frequency at a constant rate. In applications of the type we are considering here the modulating source is usually the sine wave a.c. mains voltage, suitably stepped down. The same modulating potential is also applied to the X plates of the oscilloscope. In consequence, the electron beam in the oscilloscope cathode ray tube moves from left to right at the same time as the frequency of the wobbulator moves from one end of its range to the other.

the oscilloscope cathode ray tube. At the left hand side of the display the wobbulator output is at 80 Mc/s and the amplifier, providing little gain at this frequency, causes little output to be passed to the Y plates of the oscilloscope. In consequence the beam suffers negligible upward deflection. As the wobbulator output approaches 100 Mc/s the gain of the amplifier increases, and more and more output voltage is passed to the Y plates of the oscilloscope cathode ray tube. Because of this the beam, as it travels to the right, becomes more and more deflected upwards. After 100 Mc/s the gain of the amplifier commences to fall and, as a result, the upward deflection of the oscilloscope cathode ray tube beam becomes less also. At 120

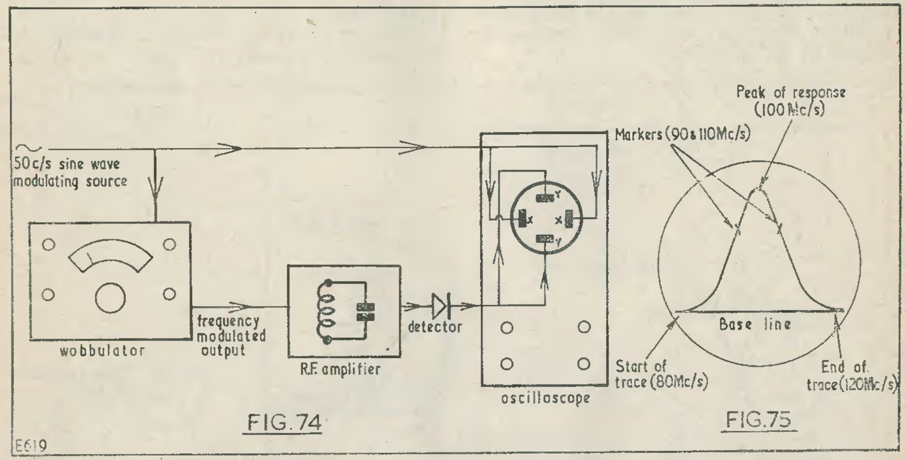


Fig. 74. A wobbulator and oscilloscope set-up. In practice, the output from the detector passes through an amplifier before application to the Y plates. Fig. 75. A typical r.f. amplifier response, as given by a wobbulator and oscilloscope. As described in the text, the cathode ray tube beam, in travelling from left to right, traces out the response curve. In returning from right to left it traces out the base line. (In practice, the response can just as readily be traced out from right to left, and the base line from left to right.)

To take an example let us assume that the tuned circuits in the amplifier of Fig. 74 are aligned to 100 Mc/s and that they provide a sharp rise in gain at that frequency. In order to examine the frequency response of the amplifier we could then adjust the wobbulator such that its output is modulated over the range 80 to 120 Mc/s. The change from 80 to 120 Mc/s will occur during one half cycle of the 50 c/s modulating potential. We also adjust the oscilloscope such that the electron beam in its cathode ray tube moves from left to right during the same modulating half cycle. Turning to Fig. 75 we can now see the result which appears on the screen of

Mc/s, where amplifier gain is low again, the beam suffers negligible upward deflection. As will have been gathered, because the wobbulator output has traversed the range 80 to 120 Mc/s, and because the oscilloscope electron beam has moved from left to right in sympathy, the display traced out by the electron beam spot on the screen of the oscilloscope cathode ray tube is a copy of the actual response curve of the amplifier.

There are several points which require a little further enlargement if the process we have just considered is to be fully understood. One of these is that, since the wobbulator frequency and oscilloscope X plates are controlled by the sine wave 50 c/s a.c. mains, the electron beam will similarly trace out the response curve of the amplifier as it returns from right to left during the second half cycle of the modulating potential. In practice this effect is a nuisance, this being due to the fact that it is a little difficult to make the two displays (one given by the beam moving from left to right and the other by the beam returning from right to left) exactly coincident. In consequence, it is usual to cut off the connection between the detector and the oscilloscope during the second half cycle, with the result that a *base line*, corresponding to zero output from the amplifier, appears on the oscilloscope display. The process of cutting off the connection to the oscilloscope Y plates is, in practice, normally carried out by cutting off one of the valves in the Y plate amplifier, this process being sometimes referred to as "blanking."

than those appearing in conventional a.f. circuits.

In order to obtain visual indication on the oscilloscope screen of "spot" frequencies, it is usual to insert *markers* into the wobbulator system. These markers are obtained from oscillators or signal generators whose frequencies are known. Fixed frequencies from either of these two sources are fed into the wobbulator or amplifier circuits at any convenient point before the output detector. When the wobbulator frequency passes an injected frequency the two beat together, causing a marker to appear on the display. More than one marker may be injected in this manner. In Fig. 75 there are two markers, one at 90 and one at 110 Mc/s.

Test Points

In order to enable external connections to be made to a tuner, it is usual to provide

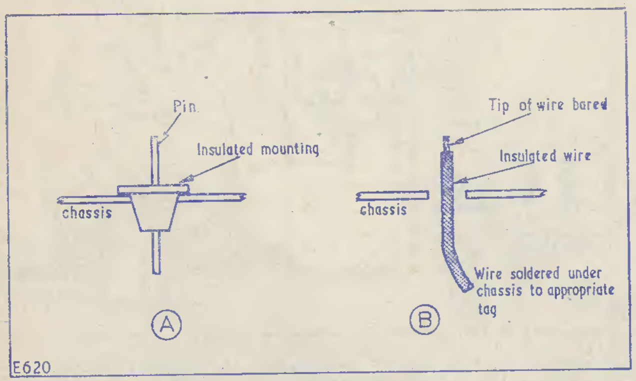


Fig. 76. Two typical test points

Another important point is concerned with the detector following the amplifier. The output of the amplifier, being at r.f., is not suitable for direct connection to the Y plates of the oscilloscope cathode ray tube. After detection, however, a voltage is obtained which is proportional to the amplifier r.f. output and this is quite suitable for application to the Y plates. It should be noted that the detector has to be connected correct way round to obtain the desired presentation. If reversed, the display on the oscilloscope cathode ray tube will become upside-down. The voltage provided by the detector varies during the modulating cycle. In consequence it may be treated as an audio frequency (having, however, somewhat low basic frequency components). Furthermore, it can be amplified by reasonably normal a.f. techniques, it being necessary only to use coupling condensers which are larger in value

what are described as "test points." These test points offer points where external connections may be made to the tuner circuits for purposes of alignment or test.

Test points usually take up one of two forms. One form consists of a solid pin which passes through the chassis via an insulated mounting (see Fig. 76 (*a*)), whilst the other consists of an insulated wire passing through a hole in the chassis (Fig. 76 (*b*)). In both instances care is taken to keep the capacity between the test point and chassis to a minimum.

What is referred to as a "grid test point" appears in all conventional tuners. This test point is usually connected direct to the grid of the mixer valve, and it can be employed for two processes: first, an oscilloscope Y amplifier may be connected to it, enabling alignment or test of the tuner circuits to be carried out with the aid of a wobbulator;

second, a signal generator, or wobbulator, may be connected to it so that the i.f. coil in the mixer anode circuit and subsequent i.f. coils may be aligned or tested.

Dealing with the first purpose of the grid test point (in which we are, in the present context, more interested) it is possible, with its aid, to obtain the wobbulator and oscilloscope set-up shown in Fig. 77 (*a*). The wobbulator output is connected to the aerial terminals of the tuner, whereupon a display showing the combined response of the aerial and bandpass tuned circuits appears on the screen of the oscilloscope cathode ray tube. We have already seen[6] typical tuner bandpass

tuned coil, whereupon the bandpass circuits may be initially aligned. The aerial tuned circuit may then be brought back into use, by removing the resistor, whereupon it can be adjusted for optimum overall response.

It was pointed out earlier in this article that a detector is necessary in a wobbulator set-up, so that the output of an r.f. amplifier may be presented in suitable form to the oscilloscope Y plates. When the mixer cathode is connected direct to chassis, as in Fig. 77 (*a*), an external detector is not necessary. This is because the grid and cathode of the mixer form a diode, and consequently enable a detected signal to be

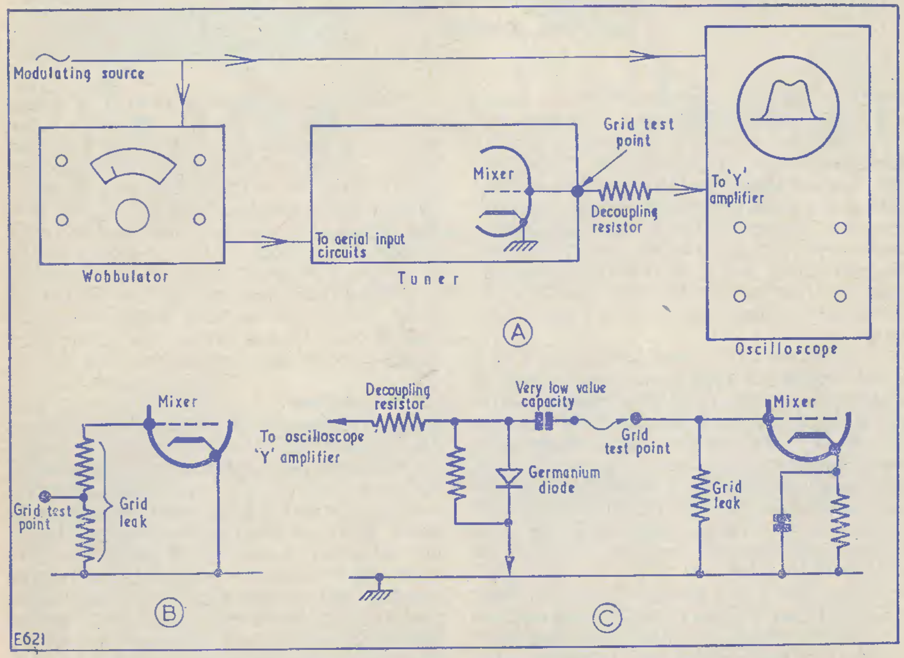


Fig. 77 (a) Employing a wobbulator and oscillator to examine the response curve of a television tuner. Since, in this case, the mixer cathode is connected direct to chassis no external detector is required. The decoupling resistor should be mounted very close to the grid test point. (b) A method of connecting the grid test point encountered in some tuners. (c) When a resistor is inserted in the cathode circuit of the mixer, an external detector is needed for wobbulator alignment. The very low value capacity shown here may, in practice, consist of the capacity between two insulated wires held close together. The resistor across the diode should have a value between 100 *and* 500 $k\Omega$

and overall responses. During practical alignment it is usual to put the aerial tuned circuit out of use by such methods as connecting a low value resistor across the

[6] Fig. 66, Understanding Television, part 11, *The Radio Constructor*, November, 1958.

immediately available at the grid test point.[7]

[7] Actually, this detector action occurs only during the periods in the oscilloscope cycles when the grid is not made more negative with respect to cathode than the peak value of the applied signal frequency.

continued on page 439

An Easy SUPERHET

By F. G. RAYER

The average superhet often seems somewhat difficult for a constructor who has previously confined himself to straightforward t.r.f. receivers. However, some circuit simplification is possible without losing the main advantages of the superhet, and this reduces the components and wiring necessary. Very good results can nevertheless be maintained, and there is the added advantage that further circuits (such as that for automatic volume control) can be added later.

A circuit which has been found to give very good results is shown in Fig. 1, and is employed in the receiver described here. A M.W. frame aerial, with L.W. loading coil, is used, with separate oscillator coils for each waveband. However, a ready-made coil pack was found to be satisfactory, as was the use of aerial coils instead of the frame and loading coil. Coils of any make will also function satisfactorily, and can therefore be used if to hand.

A common 15kΩ resistor is used for both f.c. (frequency changer) and i.f. (intermediate frequency) stages, including the oscillator anode, and both valves have common cathode bias. This eliminates several resistors and condensers. The elimination of a.v.c. and the use of a double-diode, instead of the usual double-diode-triode, further simplifies construction. In all, these changes almost reduce to one-half the number of small resistors and condensers required.

The 2kΩ potentiometer provides volume control. If a 5kΩ control is to hand, it will be satisfactory. A signal of very good quality is, of course, available from the double-diode, and the output valve is triode connected to take advantage of this. Such an arrangement gives very satisfactory reproduction. If the extra gain is wanted, the screen grid may be wired to the h.t.+ line instead, without any other circuit changes.

Though simplification is in view, a mains transformer is used for h.t. as well as valve heaters, as this isolates the receiver from the mains. Good results can be obtained with a 6.3V transformer for heaters only, a metal rectifier being employed instead of the 5Z4. *But the usual precautions must then be taken against mains shocks: receiver chassis should go to the "Neutral" main, a non-reversible plug being desirable, and the set should be fitted in a wooden or other insulated cabinet, with chassis holding screws and knob grub screws recessed and covered with hard wax.*

Chassis and Baffle

Fig. 2 shows the layout above the chassis. The speaker baffle is of 3-ply, approximately 9in x 8in, and is mounted ¾in in advance of the front runner of the chassis, thereby leaving clearance for the small epicyclic ball-drive fitted to the tuning condenser. A bracket supports one end of the baffle. The other end is bolted to the mains transformer, which is in turn bolted to the chassis. This can only be done with a transformer having flanges for vertical and horizontal mounting. With other transformers, a second bracket may be necessary. An alternative is to screw the baffle inside the receiver cabinet, leaving sufficient flex for the receiver to be withdrawn. However, the set is more convenient to handle, as a single unit, when the speaker is fitted to the receiver.

Any pair of 465 kc/s transformers will be satisfactory, but it must be checked that there is sufficient space for them near the speaker, and that the adjusting cores can be reached. For these reasons, miniature transformers are best, though larger types can be accommodated. Some transformers have a lead issuing from the top for i.f. valve grid cap. With others, the connection has to be taken through the chassis from below.

The baffle has a round aperture to suit the

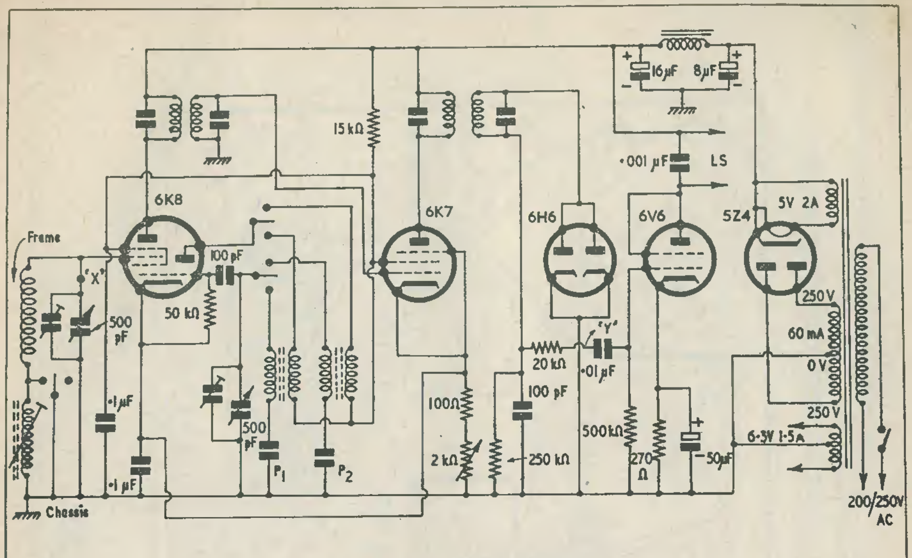


FIG. 1. THEORETICAL CIRCUIT

Component List

Five octal valveholders.
Two 465 kc/s i.f.t.'s
M.W. frame aerial; L.W. loading coil (see text)
M.W. and L.W. oscillator coils with padders (Osmor, etc.)
3-pole 2-way switch
2-gang 500pF tuning condenser with trimmers. (Small type)
Ball drive and 3 knobs
Fixed condensers: two 0.1μF, two 100pF, 0.001μF, 0.01μF, 8μF 350V, 16μF 350V, 50μF, 50V.

Resistors: 100 ohm ½ watt, 270 ohm 1 watt, 15kΩ2 watts, 20kΩ ½ watt, 50kΩ ½ watt, 250kΩ ½ watt, 500 kΩ ½ watt, 2kΩ potentiometer

Mains transformer secondaries: 5V, 2A; 250–0–250V, 60–70mA; 6.3V, 1.5A

60–70mA smoothing choke

6K8, 6K7, 6H6, 6V6 and 5Z4 valves, G or GT types

P.M. speaker with transformer, primary 5,000Ω, 50mA

diameter of the speaker cone. A 6in or 7in speaker is suitable. In view of the weight of this item, it can best be left off until most of the wiring has been completed.

Under the Chassis

Fig. 3 shows connections and components under the chassis. A small 2-gang tuning condenser is required, and it is bolted to the front runner. The average chassis will not be quite deep enough to allow the condenser to open, and four plywood "feet" are therefore bolted to rear and front runners, so that the moving plates of the condenser can open without fouling the bottom of the cabinet, when the receiver is resting in the usual position. If a chassis is bent up from aluminium, the runners can be high enough to allow the condenser to open. The projecting lug of the ball-drive must be secured against rotation by means of a long bolt and sleeve.

The volume control is a type without switch, as it was more convenient to use a lead-through type of switch in the mains flex. A potentiometer with switch can be used instead if preferred, the switch being wired between transformer primary and mains plug.

A spare tag on the 5Z4 holder is used for the h.t.+ line and speaker flex, the speaker transformer being mounted on the speaker itself.

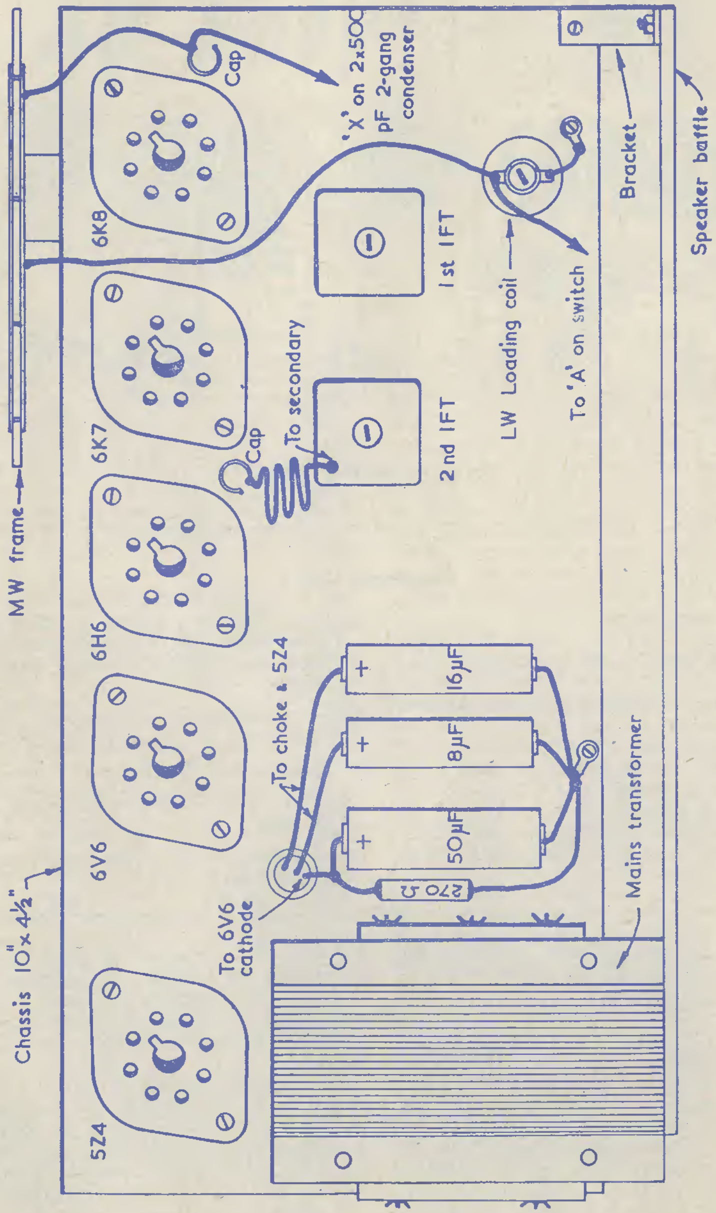


FIG. 2. TOP VIEW OF CHASSIS

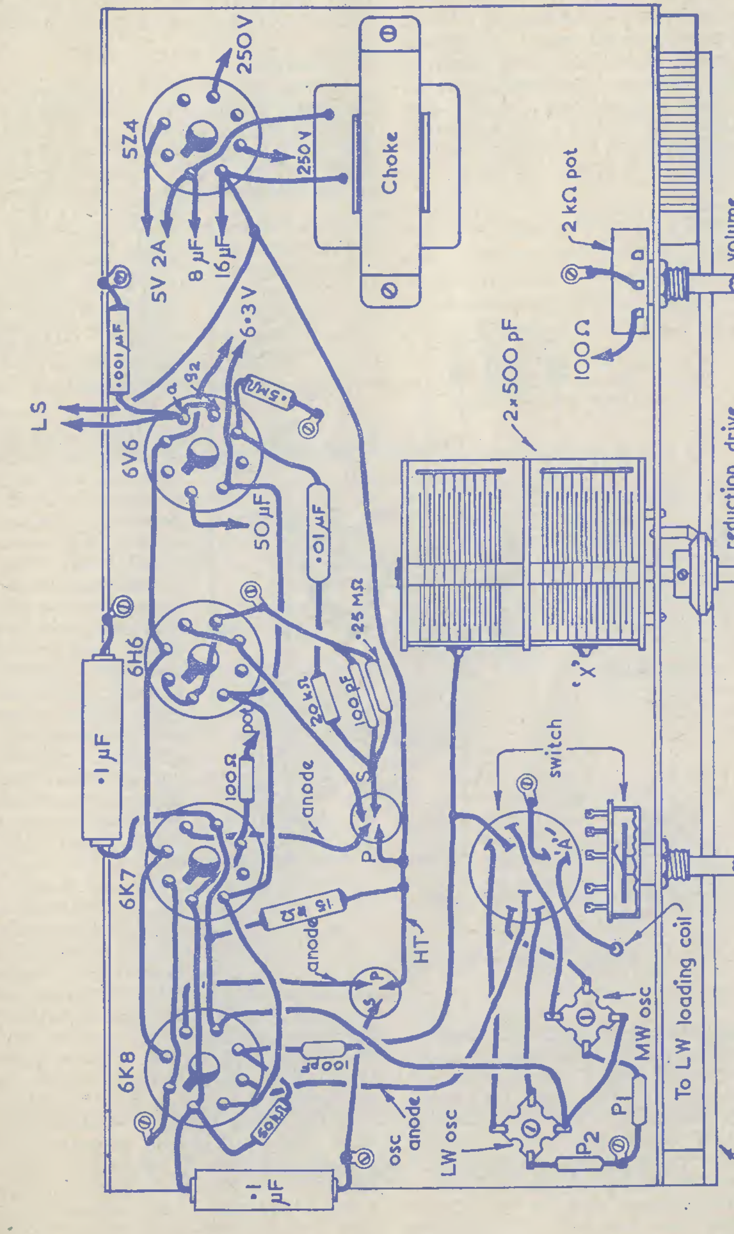


FIG. 3. UNDERSIDE OF CHASSIS SHOWING WIRING

In Fig. 3, "P" denotes primary connections for the i.f. transformers, and "S" indicates secondary connections. Some transformers have coloured leads; other have tags or stout wires. In all cases, the maker's instructions have to be followed, as no standard method of indicating connections exists. If tags are marked "Anode" and "H.T." these are wired up as shown. With the first transformer, the secondary may be marked "Grid" and "A.V.C." If so, the "A.V.C." tag is taken to chassis. The remaining transformer secondary is taken to diode and diode load components.

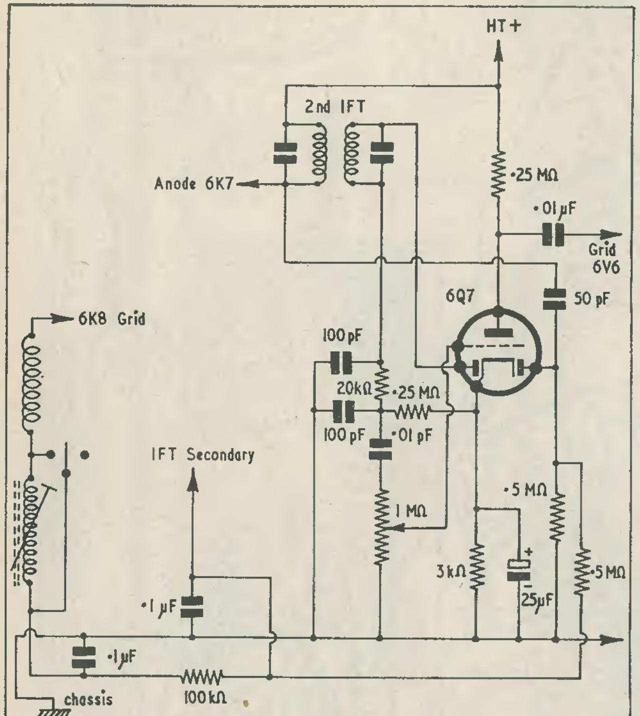


FIG. 4. D.D.T WITH A.V.C

The letters "M.C." denote "metal chassis" and connections so marked are taken to solder tags suitably fixed to the chassis.

Coil connections in Fig. 3 are for Osmor coils, which also require a M.W. oscillator padder (P_1) of 500pF, and a L.W. padder (P_2) of 150pF. Other coils will operate satisfactorily, but the maker's tag connecting data must be followed, and the appropriate padder values are essential, and may be different from those used with the Osmor coils. When the switch is in the M.W. position the L.W. loading coil (above chassis) is shorted out of circuit.

If the gang condenser is not fitted with trimmers, two separate 50pF pre-sets can be used, each being wired from chassis to one section of fixed plates on the gang condenser.

Adjustments

Correct alignment is very necessary for optimum results, and adjustments can be made by ear, though the use of a meter will give more accurate indications. If a meter is used, positive is taken to chassis, and negative to the junction of 20kΩ resistor and 0.01µF condenser ("Y"). A 1mA meter with 20kΩ series resistor, or 0.1mA meter with 200kΩ series resistor, will suffice; or a voltmeter (preferably of 10,000 ohms-per-volt rating) set to the 10V or 25V range.

If a signal generator is available, inject 465 kc/s at the f.c. anode, and align i.f.t.'s. for maximum response. Failing a generator, tune in a local station, and adjust the transformers. No core, or trimmer, should come at the limit of its travel. If it does, re-adjust the other cores until this is overcome. With pre-aligned i.f.t.'s. only a very slight adjustment will be necessary. Final aligning of the f.c. anode circuit should be done with a station, or signal injected at the f.c. valve signal grid (top cap).

The i.f.t.'s can then be left, as no further adjustment of them is required. The set is then tuned to a fairly low wavelength (high frequency) on the M.W. band, and the gang condenser trimmers are adjusted for maximum results. A station of fairly high wavelength on this band is then tuned in, and the oscillator coil core is adjusted, in conjunction with the tuning knob, for best results. (If a M.W. aerial coil is used, instead of the fixed inductance frame, its core is adjusted for best results.) The procedure should be repeated a few times (trim at low wavelength, adjust core at high wavelength) until no further improvement is possible. If a particular station is required at maximum volume, adjustment can be made with this station tuned in. (For example, trimming on 208 metres.)

After completing adjustment on the M.W. band, switch to Long waves and adjust the loading coil core for maximum volume. No separate L.W. trimmers are fitted as they did not seem to be justified.

All adjustments should be made with a fully insulated tool. Only approximate alignment is possible with a metal blade. A suitable trimming tool can be made from a length of ebonite rod or the handle of an old toothbrush, filed to shape.

The presence of the meter will cause some loss in volume, so it should be disconnected when alignment is completed. As mentioned, the 6V6 screen grid (g_2, Fig. 3) can be taken to h.t. positive, if extra amplification is required. The anode bypass condenser may then be increased to 0.05µF, if desired.

Using A.V.C.

The sensitivity of the receiver can easily be increased at a later date, by replacing the double-diode by means of a double-diode-triode. A suitable circuit for this purpose appears in Fig. 4.

The 2kΩ volume control is replaced by a 1MΩ potentiometer, wired as in Fig. 4. The first i.f. transformer secondary is transferred from chassis to a.v.c. line. Connection to the loading coil is similarly modified, together with this section of the switching. (If this is overlooked, the a.v.c. will be shorted out on the M.W. band.) If desired, alignment may now be accomplished with the aid of a 10mA or similar meter, with 0.01uF condenser in parallel, wired in series from 2nd primary to h.t.+, adjustments being for minimum deflection on this meter.

Understanding Television

continued from page 433

In tuners employing this circuit all that is then necessary is to make the connection to the oscilloscope via a decoupling resistor of some 50 to 200kΩ, this resistor being fitted very close to the test point. The purpose of the resistor is to prevent the self-capacity of the leads to the oscilloscope upsetting conditions at the mixer grid.

In some tuners the mixer grid leak takes up the form shown in Fig. 77 (*b*). This is usually done to ensure that even the low self-capacity to chassis of the test point is not directly applied between grid and chassis. Alternatively layout difficulties may prevent a direct connection between the mixer grid and the test point. Connections from the oscilloscope to the grid test point may in this case be made directly to the test point, the upper half of the grid leak functioning as a decoupling resistor. (In practice, however, the use of an additional external decoupling resistor, as in Fig. 77 (*a*), is a wise precaution.) A disadvantage of the arrangement of Fig. 77 (*b*) is that it is difficult to inject signals *into* the mixer grid for alignment of i.f. coils, the upper half of the grid leak offering considerable series impedance. In some tuners this difficulty is overcome by temporarily connecting direct to the internal grid wiring by some form of special adaptor.

When the mixer employs cathode bias, as in Fig. 73 (*a*), the grid and cathode do not form a diode and an external detector is necessary. A typical detector circuit is shown in Fig. 77 (*c*), this being connected directly to the test point via a very low value capacity (around 1pF) to avoid upsetting mixer grid operating conditions. Frequently, it is possible to obtain sufficient coupling by holding an insulated wire from the detector close to the test point.

A second test point commonly encountered in television tuners is the anode test point. This is connected direct to the anode of the mixer and offers a convenient connection by means of which the anode i.f. coil in the tuner may be put out of use with a low value resistor during factory or service alignment of the first coil in the i.f. strip. We shall examine the technique employed here when we deal with i.f. tuned circuits.

Next Month

This concludes our discussion of the television tuner unit. Next month, we shall carry on to the i.f. strip.

MS4 Silicone Compound

In the December issue (page 343), it was stated that the above compound was to be obtained from Holiday & Hemmerdinger Ltd. We have now been informed by this company that they are only able to supply industrial users and radio retailers. Readers may obtain supplies from component retailers at 7s. 6d. per one ounce tube.

A TRANSISTOR C-R BRIDGE

by B. Shaw

THE APPARATUS DESCRIBED HERE WAS designed to meet the need for a small portable instrument which could be carried in the pocket. Resistors and capacitors may therefore be checked when purchased, and it should prove useful to the serviceman when checking apparatus away from his workshop. No claim to great accuracy is made, but this should be sufficient for most purposes. Power requirements are very small, about 4.5mA at 3V. The two U16 Penlight cells should last almost as long as their shelf life, the unit only being switched on while a reading is being taken.

The circuit is shown in Fig. 1, and it will be seen that TR_1 and TR_2 operate as a multivibrator and generate a square waveform of about 2.5V peak-to-peak at a frequency of about 5kc/s. This signal is coupled through C_9 to the bridge circuit consisting of R_7 and the standards, which latter are selected by the switch S_2 and the correct choice of test leads. The frequency may be lowered by increasing R_3 and R_4, or raised by reducing C_1 and C_2—but a fairly high frequency gives a better balance point, especially when testing small capacitors. The output from the bridge is passed through the high impedance winding of a miniature output transformer T_1, which is the type used in battery portables with a ratio of 60 : 1, and the low impedance winding feeds the signal into the base of TR_3 via C_3.

This transistor is stabilised by the feed-back resistors R_5 and R_6, C_4 being necessary to prevent negative feed-back which would otherwise greatly reduce the gain of this stage. The bridge is balanced by adjusting R_7 to obtain minimum signal in the earphone. The latter is a single low-impedance earphone of the balanced armature type, in the writer's case—about 30Ω d.c. resistance—these being readily available on the surplus market. A pair of 4000Ω impedance 'phones was tried, but there was little improvement in the performance. A deaf aid insert earpiece could also be used.

It is usually recommended that the potentiometer of a bridge circuit be of fairly large diameter, but since the object of this design was compactness, the size has to be limited. In the writer's case, R_7 is a linear wirewound type of 5kΩ resistance, made by Radiospares, and it is of just under 1⅜in. dia. This is the largest size which may be accommodated on the tag board, but slightly smaller diameter potentiometers would be satisfactory.

The switch S_2 is a Yaxley type 1-pole 12-way, with the stops bent up so as to limit the rotation to eight positions. C_3, C_4 and C_9 are 25μF 25V wkg. electrolytic capacitors. Lower capacities would no doubt be quite suitable, but 25μF are readily obtainable.

The standards used were high stability 1% or 2% resistors and 1% silver mica capacitors for the 100 pF and 1000 pF ranges. For the 0.01μF and 0.1μF ranges it is either necessary to obtain a 0.01μF of about 2% tolerance, or to get someone to check a number of ordinary capacitors and to select an accurate one. This having been done, a series of 0.1μF capacitors can be checked on the 0.01μF range and an accurate one selected. Note that the 100pF standard is not fitted until the bridge is almost completed. All resistors may be of the lowest wattage available. The transistors used in the original were Mullard OC71 as these were to hand, but any equivalent type should be quite satisfactory.

Constructional Notes

The complete bridge is built on a 7in long tag-board about 2in wide, containing 36 tags 15 of which are removed. Owing to slight variations which may occur between components, it is advisable to start construction by laying out the main components on the tag side of the board commencing with T_1 on the left (Fig. 2). C_4, S_1, C_3, S_2 and R_7 are then added with the minimum of space between them. The space on the right end of the board is then used for wiring the

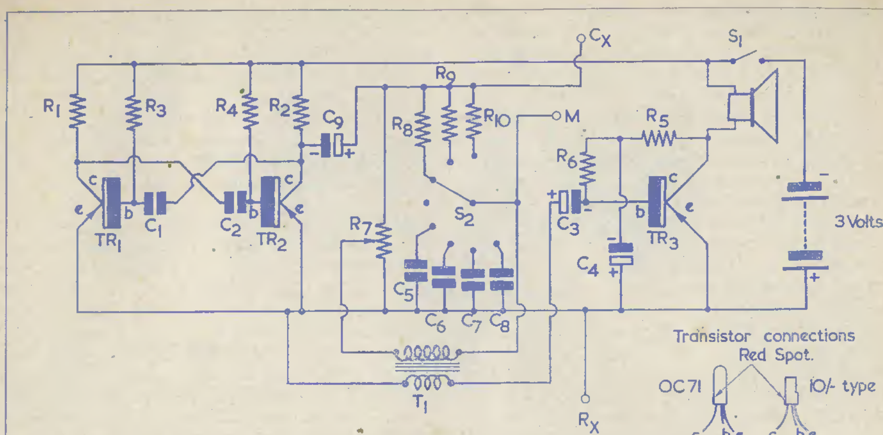
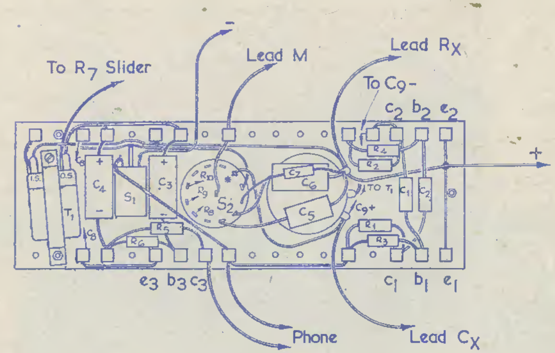


FIG.1.



N.B. C_8 C_9 R_8 R_9 R_{10} omitted for clarity - see text.

* Contact of S_2 used as tag for common ends of R_8-R_9-R_{10}.

FIG.2.

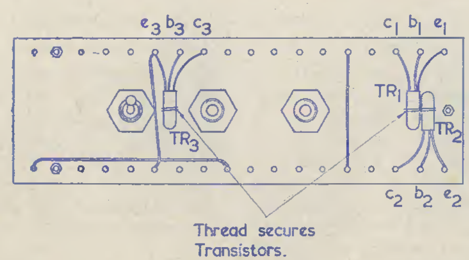


FIG.3.

M528

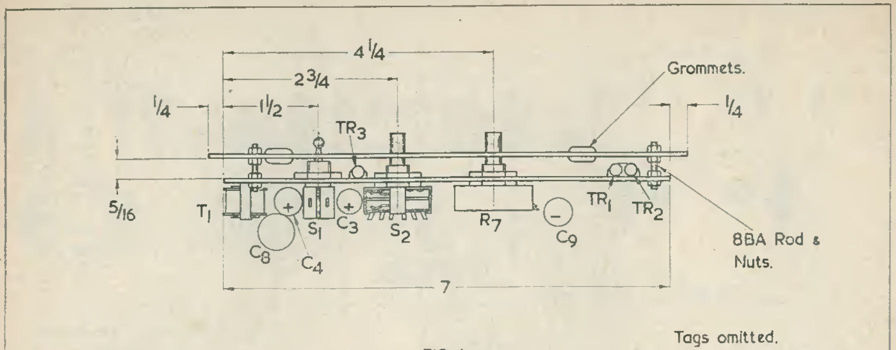


FIG.4.

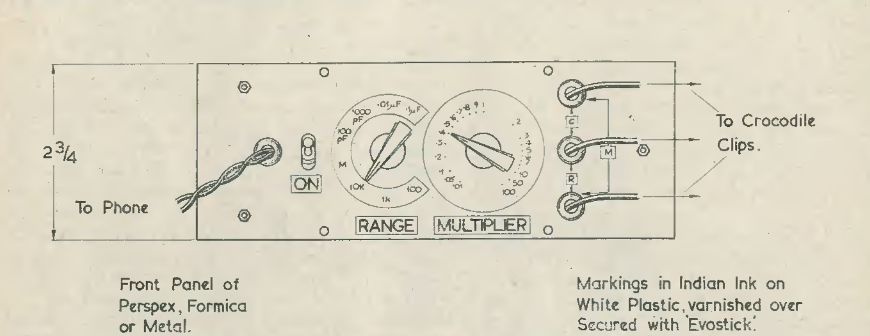


FIG.5.

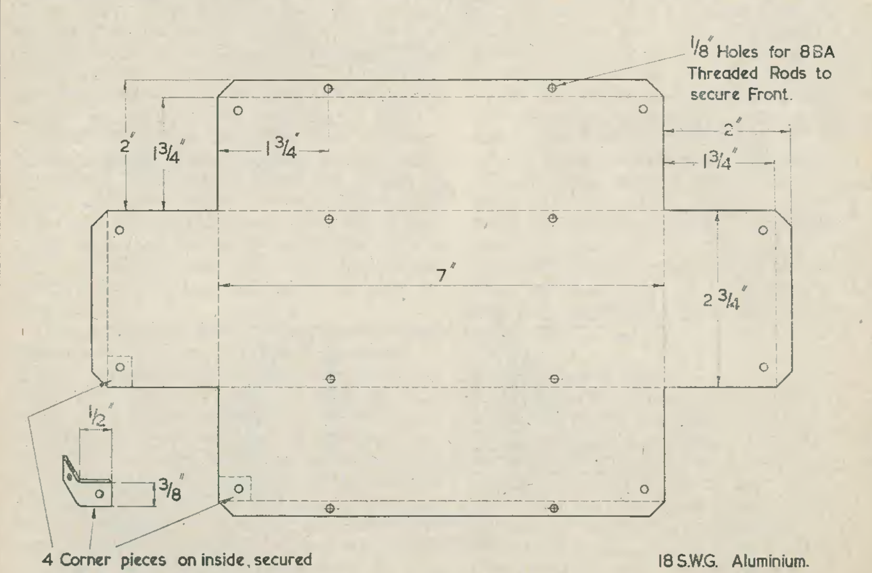


FIG.6.

oscillator. Do not be tempted to space things out more, thinking that the oscillator components do not take up much room, because the battery is placed beneath this section. Next drill the holes for S_1, S_2 and R_7, and fix these components in position, and drill the holes for the 4 grommets and insert them. The three wires on the top of the tag-board as shown in Fig. 3 are now soldered in position.

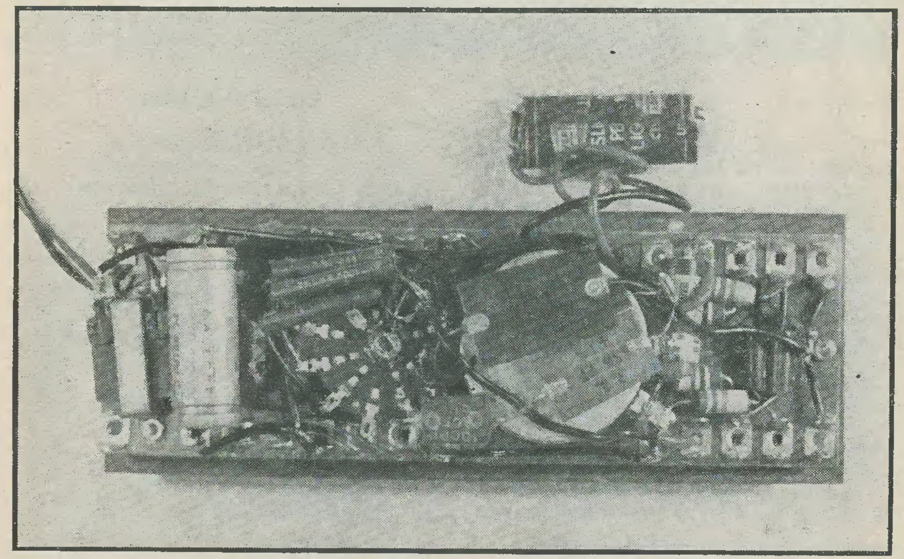
The oscillator components are then wired to the board. C_9 (which is omitted from Fig. 2 for clarity) is then wired from the lower tag of R_7 to the collector tag of TR_2, the positive lead being to the potentiometer R_7. Next connect C_4, C_3, R_5 and R_6 in position, and take the transformer leads to their appropriate tags. All the remaining wiring may now be added, including the standard resistors and the standard capacitors C_6 and C_7 (if a close tolerance component is available for C_7).

carefully checked, as faults could prove expensive in transistors. On switching on, a whistle should be heard in the earphone, and the current should be about 4.5mA, although this will vary with the transistors.

The front panel may now be made and fitted (Fig. 5), and the multiplier dial glued in place. The scale must now be calibrated by means of external standards. If an accurate resistance box is available this is an easy matter; if not, a set of six 1% tolerance resistors of the following values may be used: 1kΩ, 2kΩ, 3kΩ, 4kΩ, 100Ω and 500Ω.

These resistors will give calibration points on the scale from 1 to 10 when using the 1kΩ range, and from 1 to 0.1 when using the 10kΩ range. The 100Ω and 500Ω resistors give the 0.01 and 0.05 marks on the 10kΩ range, and 5kΩ and 10kΩ give the 50 and 100 marks on the 100Ω range, the worst error possible being 4%.

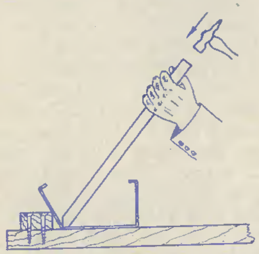
The next step is to select a "standard" for



Below-chassis view of Transistor C-R bridge

The test leads should be of flexible p.v.c. covered wire, red for the outer leads and black for the centre one, these being terminated with crocodile clips. The transistors are now soldered in position, using pointed-nosed pliers as a heat shunt to prevent heat travelling up the leads and damaging the transistors which are secured to the tag-board by thread. The earphone may now be soldered into the circuit, and the bridge connected to a 3V battery with a milliammeter in one lead. The wiring should now be

the 100pF range, and to do this it is first necessary to place a 100pF 1% capacitor across the capacitor test leads, and a 100pF trimmer in the position of C_5. Obtain the balance point, and adjust the trimmer to get this to occur at unity on the scale. It may be necessary to place a small capacitor across this trimmer to increase its value. If there is room, this trimmer may be left in the circuit; if there is not, one or more fixed capacitors must be put in its place to obtain the correct value. In the writer's case this was a 100pF in series with a 365pF. The effect of stray capacities on the other ranges may be neglected. It will be seen from Fig. 2 that C_7 was a miniature component, this having been matched with the rather large component which was 2% tolerance.



Stick sharpened to a right angled edge, when hammered into partly formed box, bends sides up vertically.

FIG.7. M530

The multiplier scale, as were all the other markings, was marked in indian ink on white plastic, and then given a coat of clear varnish.

The case was constructed from 18 s.w.g. aluminium, as shown in Fig. 6. For a case of this size, a neater job is obtained not by folding the corners over, but by joining them edge to edge, and retaining them at the corners by a single screwed or riveted angle piece, and then closing the edges together with light taps of a hammer. The sides are first bent up as far as possible in a vice, and then forced into the final position with a wooden block as shown in Fig. 7. The box is then given a coat of black or grey undercoat and finally a coat of black crackle paint.

The two pen cells are bound together at the ends with Sellotape and held to the side of the case, beneath the oscillator, by a small Terry clip which fits round one cell. The battery leads should be about 6in long, and of flexible wire to facilitate battery replacement.

If the above work is carefully carried out, the reader should possess a very useful piece of equipment, and will probably wonder how he managed without a bridge before. All resistors and capacitors should be checked before inclusion in any apparatus, as even new components have been found to be faulty on occasions, and early discovery may save hours of fault finding.

The balance point will probably be indistinct for resistors above about 100kΩ, and this is the highest value that can be checked with accuracy. Even the smallest capacitors give quite a sharp balance point.

Finally, a useful source of a.f. signal is available between the outer test leads, and this might prove handy for testing amplifiers and the a.f. stages of radio sets; but for these uses, make sure that there is no possibility of either a direct connection to a live point in the apparatus, or of a voltage surge which would destroy the transistors.

List of Components

Capacitors
C_1, C_2 0.01μF Hunts miniature.
C_3, C_4, C_9 25μF 25V Electrolytic
C_5, C_6, C_7, C_8 Standards (see text).

Resistors
R_1, R_2 1kΩ ¼W
R_3, R_4 22kΩ ¼W
R_5, R_6 33kΩ ¼W
R_8, R_9, R_{10} Standards 1kΩ, 10kΩ, 100kΩ, 1 or 2%
R_7 5kΩ wirewound potentiometer, Radiospares.

Miscellaneous
T_1 Miniature output transformer, 60 : 1
TR_1, TR_2, TR_3 OC71, Mullard
36-tag tag-board
S_1 1-pole on/off switch
S_2 1-pole 12-way Yaxley type
3 crocodile clips

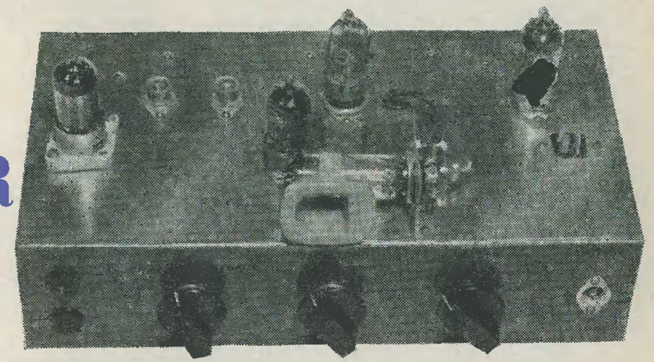
NEW MULLARD PAMPHLET

Mullard Ltd., Mullard House, Torrington Place, London, W.C.1, now have available to readers, free and post free, an 8-page pamphlet entitled "Valves and Semi-conductors for the Radio Amateur." Attractively produced on heavy art paper, it lists the essential data on the following types of valves, voltage amplifying pentodes, output pentodes, triodes and double triodes, rectifiers, frequency changers and the EB91 double diode. The semi-conductor data covers the various types of both germanium diodes and germanium junction transistors. A valve equivalents table and a transmitting valve section, together with a most useful transmitting valve chart, is also included. The latter chart has been compiled to acquaint amateurs with the range and scope of transmitting valves available for communication purposes, and to facilitate the selection of suitable types for given applications.

PRICE CORRECTION

In the advertisement of Messrs T.R.S. Radio Component Specialists, on page 393 of the December issue, we inadvertently published the price of the BAND III TV CONVERTER as **£13.19.6.** This should, of course, have read **£3.19.6.**

The MULLARD TAPE AMPLIFIER "Type C"



PART 3

Described by R. WEBB

The H.F. Oscillator Stage ($V_{5a, b}$, *Type ECC82*)

Tagboard No. 4 should be assembled, the following components being fitted as shown in Fig. 13: C_{19} (0.005μF), R_{26} (4.7kΩ), C_{20} (0.005μF), R_{28} (4.7kΩ), R_{23} (27kΩ), C_{15} (47pF), R_{21} (56kΩ), C_{16} (100pF), R_{22} (56kΩ), C_{17} (47pF).

The completed tagboard should be bolted to the chassis in the position indicated in Fig. 16. The record/playback and erase co-axial sockets should be connected to the record/playback switch SA, care being taken when soldering to avoid overheating the plastic insulant. The record/playback socket should be joined to position 5 of the section SA_4 and the erase socket should be wired to position 8 on SA_5.

When you come to fit the type WF1388 transformer, you will probably find that any ready punched chassis you buy will have a single hole ⅞in diam. drilled for the transformer type used on the earlier versions. It will then be necessary to drill the two (6BA clearance) fixing holes for the WF1388. They are spaced 1⅜in apart and can be placed equidistantly either side of the existing ⅞in hole. A two-way tagboard can conveniently be mounted on one side to which can be anchored the orange lead and the bias lead required.

On wafer 3 of the record/playback switch SA, position 6 should be connected to position 2 and the connection continued to position 9. Position 9 should be earthed at the tag (the second direct connection to the chassis) at the erase head socket.

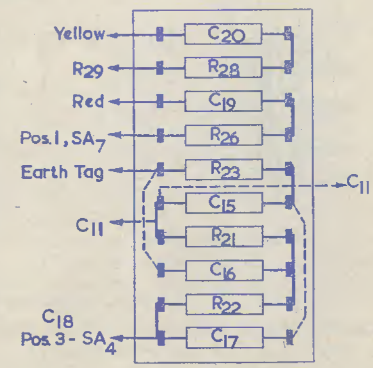


FIG.13. Tagboard No.4. M570

The end of C_{15} (47pF) on tagboard No. 4 nearer to the erase head socket should be connected along the path shown in Fig. 16 to the end of C_{11} (0.1μF) on tagboard No. 3 furthermost from the V_3 valveholder. The junction of C_{17} (47pF) and R_{22} (56kΩ) on tagboard No. 4 should be connected to position 3 of switch section SA_4. From position 1 of switch section SA_7 run a lead to the nearest, or free, end of R_{26} (4.7kΩ).

in C_{28} (2,200pF), shown in Fig. 13 (*a*) but omitted from Fig. 2 in the November issue, between pins 1 and 6 on valveholder V_5. Also wire C_{29} (0.5μF 350V) capacitor between the tagboard for the orange lead and the earth tag. This capacitor also was omitted from the circuit diagram and the component list.

From the earth tag near the erase socket, wire in R_{29} (22kΩ) to nearest end of R_{28}.

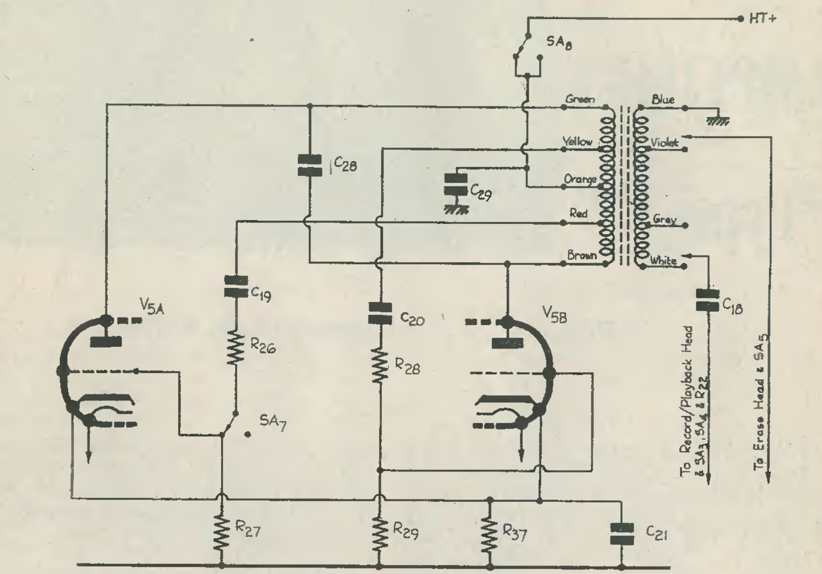


FIG. 13A
The complete Bias Oscillator Circuit

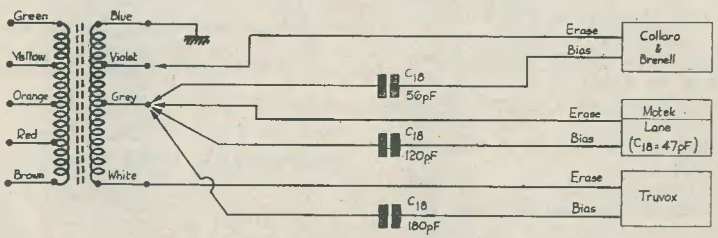


FIG 13B
The arrangements for obtaining the various Erase and Bias Currents.

M571

Connect R_{27} (22kΩ) between position 11 of SA_7 and the earth tag. Run on lead from the junction of R_{23} C_{16} to the earth tag.

On valveholder V_5 link pins 3 and 8 together and also pins 4 and 5 together. Wire

Connect a wire between Pin 2 of V_5 and the junction of R_{28}, (4.7kΩ) and R_{29} (22kΩ) and one between pin 7 of V_5 and position 11 on SA_7.

From pin 8 on V_5 fix R_{37} (680Ω, 1 watt)

and C_{21} (0.1μF) to the earth tag used for R_{27} and R_{29}.

The H.F. Transformer Connections

Run the brown lead on the h.f. transformer to pin 1 on V_5.

Run the red lead to the free end of C_{19} (0.005μF).

Join positions 7 and 8 on switch wafer SA_8 and continue lead to the orange lead which should be secured to one tag of the 2-way tagboard.

Join the yellow lead to the free end of C_{20} (0.005μF).

Join the green lead to pin 6 on V_5.

and the grey lead. This can best be accomplished by running a lead from the junction of R_{22} (56kΩ), C_{17} (47pF) to a stand-off insulator placed near the WF1388 transformer. C_{18} (56pF) can then be fixed between the insulator and the lead required on the transformer at the tagboard. A lead should then be run from the junction of C_{18} and the bias lead to the erase socket.

(ii) *Truvox.*—For this high impedance head connect a lead from the white lead to position 8 on switch SA_5.

TABLE I

	Point of Measurement	Voltages (V) (*a*) SA in Record position	(*b*) SA in Playback position	D.C. Range of Avometer* (V)
	C_4	163	163	1,000
	C_7	190	190	1,000
	C_{12}	250	250	1,000
	C_{100}	<350	<350	1,000
	C_{101}	300	300	1,000
V_1 (EF86)	Anode	50	50	1,000
	Screen grid	60	60	1,000
	Cathode	1.4	1.4	10
V_2 (EF86)	Anode	60	60	1,000
	Screen grid	90	90	1,000
	Cathode	1.5	1.5	10
V_3 (EF86)	Anode	110	110	1,000
	Screen grid	140	140	1,000
	Cathode	2.6	2.6	10
V_4 (EM81)	Anode	40	0	1,000
	Target	145	0	1,000
V_5 (ECC82)	(*a*) Anode	290	290	1,000
	Cathode	14	12	100
	(*b*) Anode	290	290	1,000

* Resistance of Avometer:
1,000V-range, resistance = 20MΩ;
100V-range, resistance = 2MΩ;
10V-range, resistance = 200kΩ.

Run the blue lead to position 9 on switch wafer SA_5.

The remaining leads, violet, grey and white are selected for the various playback and erase heads as follows:—

(i) *Collaro and Brenell.*—For the low impedance heads connect a lead from violet to position 8 on switch SA_5. C_{18} (56pF) is connected between the junction of R_{22} (56kΩ) and C_{17} (47pF)

C_{18} becomes in this case 180pF and is connected from the grey lead as (i) above.

(iii) *Motek.*—For this head both erase and record are connected to the grey lead but C_{18}, this time 120pF, is in series with the record head.

(iv) *Lane.*—This head uses the same arrangement as in (iii) above but C_{18} becomes 47pF.

Fig. 13 (*b*) illustrates the several arrangements pictorially.

TABLE II Playback Sensitivity (Signal frequency=5 kc/s)		
Tape speed (in./sec)	Input (mV)	Output (mV)
15	5.5	300
7½	2.4	300
3¾	1.0	300

The H.F. Oscillator Coil

The instructions included in the ECC82 stage for wiring in the h.f. oscillator coil apply to the Mullard Ferrox-cored transformer type WF1388. Whereas the complete circuit diagram given in Part 1 shows three secondary terminations the final version includes extra tappings in order to accommodate certain tape heads. This was the coil used in the prototype amplifier and was found suitable for the heads fitted to the following tape decks: i.e. Collaro, Brenell, Motek, Lane and Truvox.

Fig. 13 (*a*) shows the various secondary tappings available.

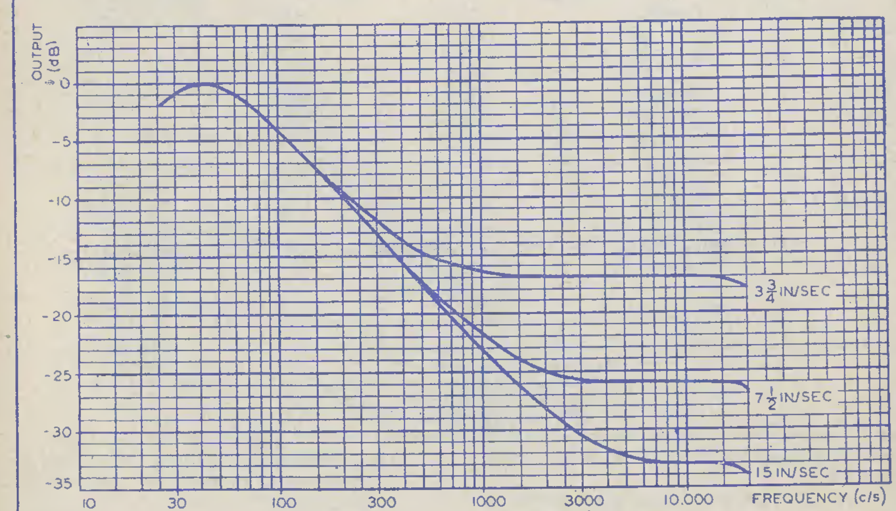


FIG. 14

The EM81 Stage

The resistor R_{25} (150kΩ) should be connected between pin 9 of the EM81 valveholder and the stand-off insulator close to the valveholder. R_{24} (560kΩ) should be joined between pin 7 of the holder and the stand-off insulator. A lead should be taken from the insulator through the rubber grommet, under the internal screen c to position 3 of switch SA_6.

TABLE III Bass Boost Signal frequency=40 c/s (Output voltage for 5 kc/s=50mV)		
Tape speed (in/sec)	Voltmeter reading (V)	Output boost (dB)
15	2.3	33
7½	1.0	26
3¾	0.36	17

Test Instructions and Performance Characteristics

The four tests outlined below are intended as simple, yet quite effective, checks for the combined record/playback amplifier.

The values given in the various tables and figures were obtained from the prototype amplifier, using Collaro record/playback and erase heads. The bias current used throughout was 1.0mA at a frequency of 60 kc/s, and the erase head voltage was about 25V, again at a frequency of 60 kc/s.

Test I—D.C. Voltages

The d.c. voltages at points in the equipment should be tested with reference to Table I. The results shown in this table were obtained using an Avometer, Model No. 8.

Test II—Amplifier on Playback

Two pieces of equipment are required for this test:

(1) A signal generator covering a frequency range from 20 c/s to 20 kc/s;
(2) A valve voltmeter covering a frequency range from 20 c/s to 20 kc/s.

The record/playback switch SA should be in the playback position. A signal from the generator, having a frequency of 5 kc/s, should be applied to the record/playback socket (which normally accommodates the connection plug from the record/playback head). The consequent output signal should be measured on the voltmeter at the output socket.

The input voltage should be adjusted to give an output voltage at the output socket of 300mV for each tape speed, and the input required for this output should be noted. The voltage readings that should be obtained are given in Table II.

For operation at such high sensitivities, great care should be taken to ensure that the signal measured is not composed mostly of hum. It is advisable, therefore (*a*) to use screening cans on the three EF86s, (*b*) to screw on firmly the base of the amplifier, and (*c*) to use coaxial cables for the connections to the measuring equipment.

TABLE IV Treble Boost (Output voltage for 1 kc/s=15mV)			
Tape speed (in/sec)	Signal frequency (kc/s)	Voltmeter reading (mV)	Output boost (dB)
15	17	84	15
7½	12	150	20
3¾	5.5	100	16.8

The input voltage at 5 kc/s should be varied until the output voltage drops to 50mV. The frequency of the signal should then be reduced to 40 c/s and the values of boost listed in Table III should be observed at the output socket.

The bass boost characteristics for the three tape speeds are shown in Fig. 14.

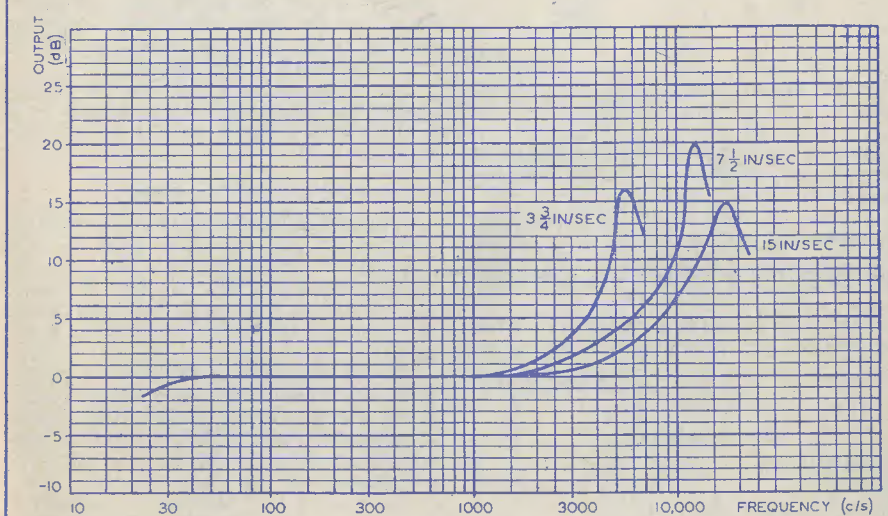


FIG. 15

Test III—Amplifier on Record

The instruments required for this test are:

(1) A signal generator covering a frequency

range from 20 c/s to 20 kc/s;

(2) A valve voltmeter* covering a frequency range from 20 c/s to 20 kc/s.

The record/playback and erase heads should be connected to the appropriate

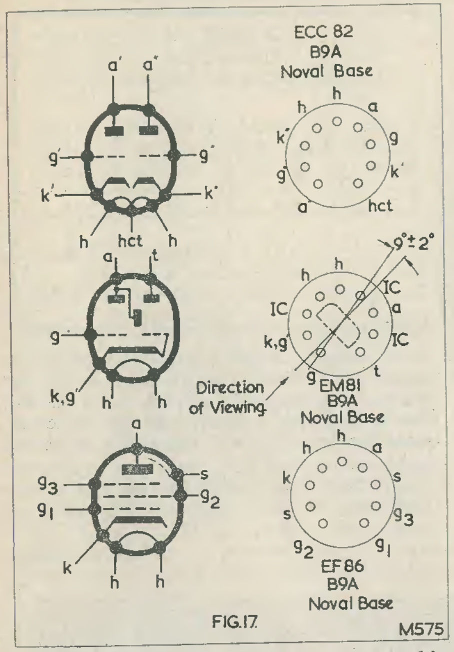


FIG.17

(*Note:* Fig. 16 was given in last month's issue.)

sockets in the amplifier, and the equipment should be switched to the recording condition.

A signal at 1 kc/s should be applied from the generator to the radio input socket. The magnitude of this signal should be such that an output of 15mV is obtained at the output socket.

The boost indicated in Table IV should be obtained at the appropriate tape speed when the signal frequency is altered to the value shown in the table.

TABLE V

Recording Sensitivity

Signal frequency	=1 kc/s;
Tape speed	=15, 7½ or 3¾in/sec;
Voltage at anode of V_3	=15V;
Microphone input	=0.5mV;
Radio input	=65mV.

The treble boost characteristics for the three tape speeds are shown in Fig. 15.

Values for the recording sensitivity for an output voltage measured at the anode of V_3 (EF86) are given in Table V. A test of the recording level indicators should show that the EM81 "closes" for each speed with approximately 15V at the anode of V_3.

An alternative method of checking the recording amplifier is possible: for each tape speed, the voltage developed across a 50Ω resistor connected in series with the recording head can be observed for the full range of signal frequencies. The response figures so obtained should agree with the values obtained with the prototype amplifier under the section "Performance Characteristics." For these observations, it will be necessary to disconnect one end of resistors R_{26}, R_{28}, otherwise only the bias signal will be measured.

Test IV—Bias Level

For this test, two pieces of equipment are required:

(1) A valve voltmeter which will indicate accurately at frequencies of up to 70 kc/s;

(2) A resistor of 50Ω.

The resistor should be soldered in series with the earthy end of the record/playback head, and the voltage developed across the resistor, with no input signal, should be measured with the voltmeter.

The voltage developed across the resistor should be 50mV, which corresponds to a bias current of 1.0mA flowing in the 50Ω-resistor.

Power Pack Circuit Description

The Circuit Diagram for a Power Unit suitable for use with the Type C tape amplifier is given in Fig. 18. The requirements of the unit are that it should provide (i) a d.c. voltage of 300V at a current of 50mA, and (ii) an a.c. voltage of 6.3V at a current of 2A.

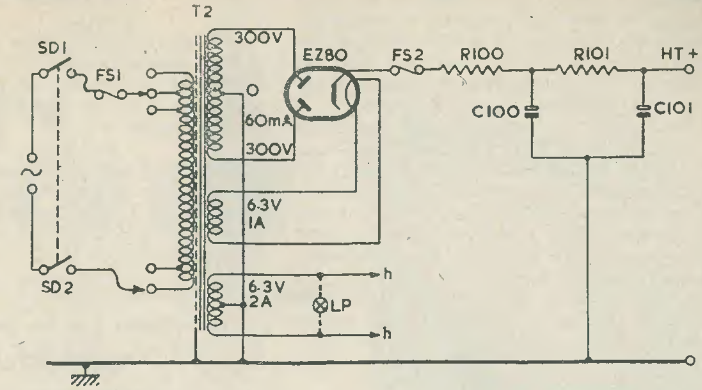
Any of the mains transformers suggested for use either with the "low-loading" version of the Mullard 5-valve 10-watt High Quality Amplifier, or with the Mullard "3–3" Quality Amplifier will be suitable for this unit. The specification for this transformer is:

	Voltage tappings	Current rating
Primary	10–0–200–220–240	
Secondaries	300–0–300	60mA
	3.15–0–3.15	2A
	0–6.3	1A

The choice of rectifier will depend on the tape deck used. Normally, the Mullard full-wave rectifier, type EZ80, will be suitable.

* For accurate results, two separate pieces of p.v.c. covered wire are recommended for the connections to the valve voltmeter. A coaxial cable may result in considerable errors in the measurments because of the parallel capacitance which is introduced.

Fig. 18—POWER UNIT CIRCUIT



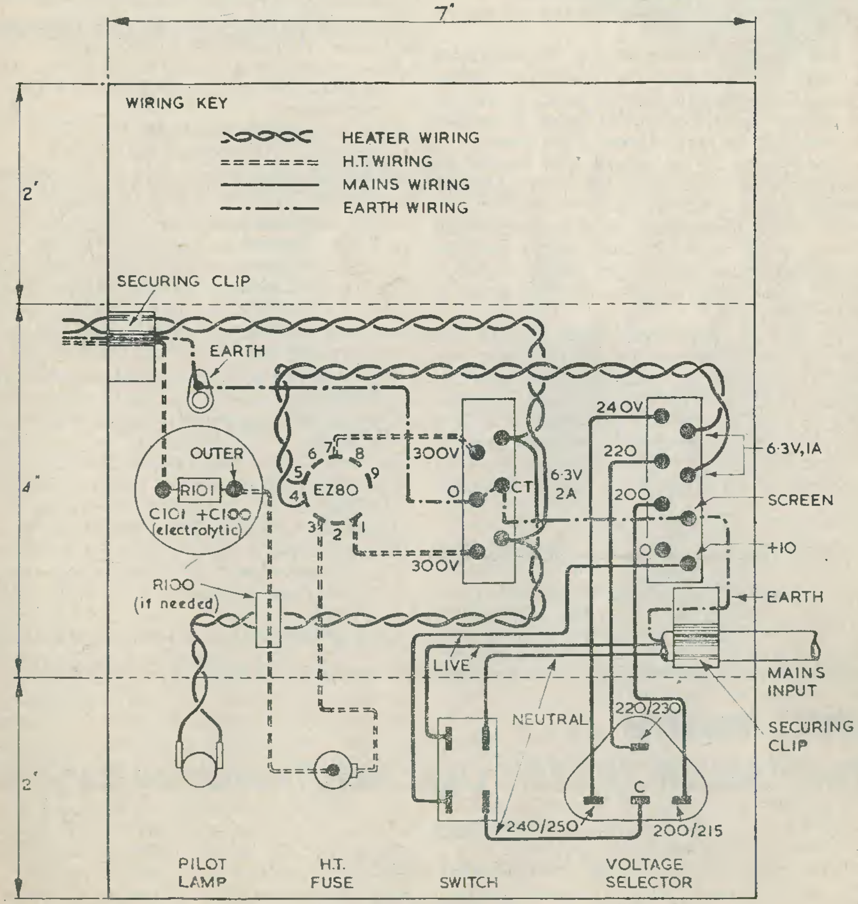


Fig. 19—POWER UNIT ASSEMBLY AND WIRING DETAILS

However, with tape decks that use electrical braking for the tape transport system—the Truvox, for example—it is essential that the Mullard type EZ81 be used, so that the current of 150mA which is required for the short braking periods can be supplied.

If the EZ80 is used, the series resistance in each anode circuit of the rectifier must be at least 215Ω; if the EZ81 is used, the minimum series resistance is 200Ω for each anode. Very few transformers meeting the specification given above will have a total winding resistance less than these minimum requirements, but should it be lower, a series resistance large enough to make up the minimum should be added to each anode circuit.

Chassis Assembly and Wiring Details

The chassis consists of one piece of 16 s.w.g. aluminium sheet to dimensions shown in Fig. 19.

The drawing shown in Fig. 19 illustrates a mains transformer of the inverted mounting type. If a different type is used, it will be necessary to drill grommet holes to enable the leads to be taken through the chassis.

The wiring of the power unit should be accomplished quite easily by referring to the wiring diagram of Fig. 19.

To avoid unnecessary expense, input and output plugs have not been used: securing clips suffice to anchor the mains and h.t. leads. The pilot lamp is also an optional component.

It is very important when wiring the electrolytic capacitor to ensure that the correct section is used as the reservoir capacitor C_{100}. The section which is identified as the "outer," or else marked with a red spot, should be used for this component.

The amount of series resistance R_t contributed at each anode by the transformer is:

$$R_t = R_s + n^2 R_p,$$

where R_s = the resistance of half the secondary,
R_p = the resistance of the primary,
and n = the ratio of the number of turns on half the secondary to the number of turns on the primary.

If R_{min} is the minimum resistance needed in each anode circuit (215Ω or 200Ω for the EZ80 or EZ81 respectively), the value of the resistance R that it may be necessary to add to each circuit is:

$$R = R_{min} - R_t.$$

The values of the dropper resistors R_{100} and R_{101} should be chosen to give a potential of less than 350V across the reservoir capacitor C_{100} and a potential of 300V across C_{101} respectively. It may be found that the resistor R_{100} is not needed in the power unit.

Components List for the Power Unit

C_{100} and C_{101}, 50+50μF electrolytic capacitor.
Working voltage rating =350V d.c.
Min. ripple current rating=100mA.
R_{100}. Value to give less than 350V h.t. across C_{100}. (Unnecessary in prototype.)
R_{101}, value to give 300V h.t. across C_{101}. (820Ω, 3W, wire-wound resistor used in prototype.)
B9A valveholder McMurdo BM9/U.
Rectifier, Mullard type EZ80 (EZ81).
T2 Mains transformer. One of the following commercial types would be suitable:

Manufacturer	*Type No.*
Elstone	MT/3M
Gilson	WO839
Hinchley	1442
Parmeko	P2631
Partridge	H300/60
Wynall	W.1547

Input securing clip. Hellerman P clip, 3180/5B.
Output securing clip. Hellerman P clip, 3180/3B.
Mains switch. Bulgin 2-way, S300.
Fused voltage selector. Clix VSP393/0, P62/1.
Fuseholder. Belling Lee Minifuse L575.
FS_1, 1A Fuse
FS_2, 200mA Fuse
LP, pilot lamp (optional), 6.3V, 0.3A. Bulgin D180/Red
Chassis 4in x 7in x 2in deep. (2 or 4 sided)

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The "*SOLAR THREE*" Light Cell Transistor Receiver

★ *Small and compact*
★ *Ferrite rod aerial*
★ *Portable*
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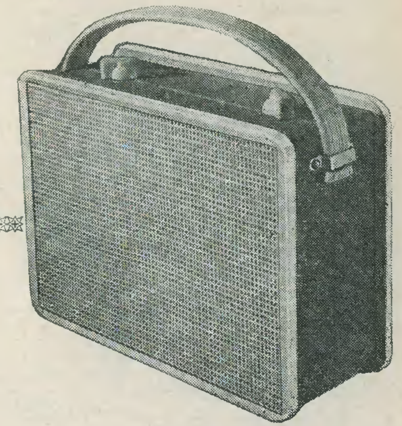

A 7-TRANSISTOR RECEIVER FOR THE HOME CONSTRUCTOR

PART I

described by JAMES S. KENT

Most home constructors who have dabbled with transistor circuits, especially the simple two- and three-transistor receivers, sooner or later aspire to build the more complex superhet circuit, several designs of which are currently offered on the market. The one about to be described has been specially prepared to allow of easy construction in four distinct and simple-to-follow stages. This allows those with no great experience of radio construction, and only a few simple tools, to successfully complete the receiver with a minimum expenditure of time and trouble.

From the photograph of the completed receiver, shown herewith, it will be seen that the whole forms a very compact assembly, and the attractively designed case gives the appearance of a professional receiver.

Circuit

This is shown in Fig. 1, from which it will be noted that a slab-type Ferrite rod aerial is incorporated in the design, this being the Repanco type FS2. The receiver is switched-tuned to 3 preset Medium wave frequencies and one on the Long wave band. On the preset Medium wave positions, the values of the capacitors C_{15}, C_{16}, C_{17} and C_{18} respectively, as given in the component list, will give the MW1 position a coverage from 200 to 280 metres (*Note:* Not all r.f. transistors will operate down to 200 metres), the MW2 position of the switch will give a coverage of from 290 to 350 metres, and the MW3 position covers from 410 to 450 metres. Should the desired station be outside the wavelength ranges given above, the following table gives the values of capacitors for all sections of the Medium wave band.

C_{15}, C_{16}	C_{17}, C_{18}	*Coverage*
65pF	65pF	290 to 350 metres
75pF	75pF	320 to 380 metres
150pF	150pF	410 to 450 metres
200pF	150pF	435 to 480 metres

The values given for C_1 and C_4 are for the Light Programme on the Long wave band.

The frequency changer transistor TR_1 should be a type designed for this position, though a selected white spot equivalent may be used where so desired. The Repanco combined oscillator and 1st i.f. transformer type OT1 has been specially designed to function with all types of r.f. transistors and, in order to achieve this, R_{17} has been included as a stopper to regulate the amplitude of the local oscillator. The final value of this resistor, however, should be determined by experiment when the receiver has been completed, thus allowing for the individual characteristics of the transistor used in the first stage. The value of R_{17} which is given in the component list as 56Ω is an average one. In some cases it may be necessary to short the resistor out altogether and again, in others, it may be required to increase the value to as much as 120Ω. The optimum value should produce the maximum output without spurious oscillations being present.

The values given for R_{19}, R_{20} and R_{21} respectively are again the average values. The final values should be determined

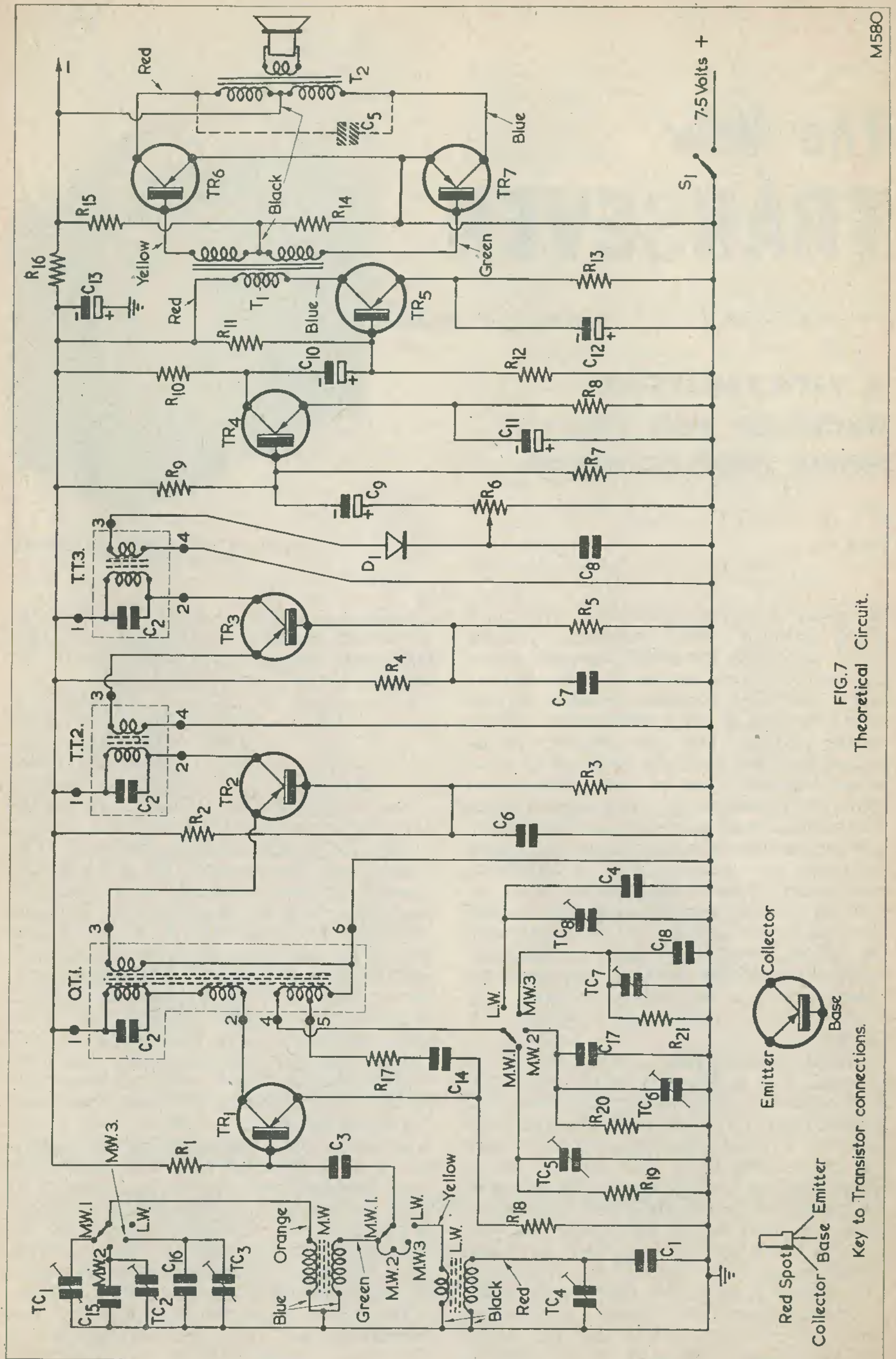

FIG.7 Theoretical Circuit.

Key to Transistor connections.

experimentally as with R_{17} above. With some r.f. transistors, these resistors may be as low as 2kΩ, while with other transistors they may not be needed at all.

The output of the frequency changer is applied to the first i.f. transformer and from there to the remainder of the i.f. strip. The transistors TR_2 and TR_3 are Mullard OC71 types, or alternatively red spot equivalents may be used. Both of the i.f. transistors are operating in the earthed base mode—thereby providing more stable operation at the intermediate frequency of 315 kc/s than would be possible in the earthed emitter mode.

Output from the final i.f. transformer, TT3, feeds into the crystal diode D_1, the potentiometer R_6 being the diode load, and also acting as the volume control. The signal passes via C_9 to the first a.f. amplifier, TR_4. The output of this stage is applied, via C_{10}, to the driver transistor TR_5. Both of these latter transistors operate as earthed emitter amplifiers. The output of TR_5 is fed into the primary winding of the a.f. driver transformer, T_1. The centre-tapped secondary winding of this transformer is coupled into the bases of the two push-pull output transistors operating in class B, the resultant output of these (TR_6 and TR_7) being fed via an output transformer T_2 to the voice coil of the speaker.

TR_4 and TR_5 transistors are Mullard type OC71 or the red spot equivalents. TR_6 and TR_7 may either be a matched pair of Mullard type OC72 for 200 milliwatts output or a pair of OC71s (red spot) for 100 milliwatts output.

Assembly and Construction

This is quite simple. Reference to Fig. 2, where both stages one and two are shown in point-to-point form, will considerably assist in the easy construction of this part of the receiver.

Stage 1

Fit the driver transformer type TT4 and the output transformer type TT5 to the paxolin group board using 6BA screws and nuts through the fitting holes A and B (see Fig. 2), so that the driver transformer is mounted underneath. A solder tag should be fitted with each holding screw on the underneath side, i.e. on the output transformer side. The fly leads of both transformers should be located towards the middle of the group board.

Thread the blue lead of the driver transformer through hole 16 to eyelet 12 and solder. Solder the yellow lead of this transformer to eyelet 18, the black lead to eyelet 15, the green lead to eyelet 14 and the red lead to eyelet 29.

Connect R_{15} (6.8kΩ) from eyelet 13 to eyelet 15, and follow this by soldering R_{14} (220Ω) from eyelet 15 to eyelet 17—continuing the wire end of R_{14} through to the solder tag on the fixing screw at A and soldering.

Having completed the above, solder R_{11} (15kΩ) from eyelet 29 to eyelet 11; R_{12} (10kΩ) from eyelet 11 to eyelet 23 and R_{13} (1kΩ) from eyelet 10 to 23.

Fit the i.f. transformers type TT2 and TT3 so that the slot in the tag ring is in the position shown on the stage one point-to-point diagram, 8BA screws and nuts being used for fitting purposes.

Resistors (all miniature)

R_1	1MΩ
R_2	82kΩ
R_3	4.7kΩ
R_4	1MΩ
R_5	47kΩ
R_6	10kΩ pot. w/switch
R_7	10kΩ
R_8	1kΩ
R_9	47kΩ
R_{10}	3.3kΩ
R_{11}	15kΩ
R_{12}	10kΩ
R_{13}	1kΩ
R_{14}	220Ω
R_{15}	6.8kΩ
R_{16}	1kΩ
R_{17}	56Ω (see text)
R_{18}	3.3kΩ
R_{19}	6.8kΩ (see text)
R_{20}	6.8kΩ (see text)
R_{21}	6.8kΩ (see text)

Capacitors

C_1	200pF (see text)
C_2	Fitted in I.F.T.s
C_3	0.01µF, Moldseal
C_4	800pF (see text)
C_5	0.01µF, about (optional)
C_6	0.1µF, Moldseal
C_7	0.1µF, Moldseal
C_8	0.01µF, Moldseal
C_9	25µF, electrolytic
C_{10}	25µF, electrolytic
C_{11}	25µF, electrolytic
C_{12}	25µF, electrolytic
C_{13}	25µF, electrolytic
C_{14}	0.01µF, Moldseal
C_{15}	65pF (see text)
C_{16}	150pF (see text)
C_{17}	65pF (see text)
C_{18}	150pF (see text)

Miscellaneous

Ferrite slab aerial type FS2 (Repanco Ltd.)
TR_1 F.C. junction, or white spot (see text)
$TR_{2, 3, 4, 5}$—Mullard OC71 or red spot
$TR_{6, 7}$—Mullard OC72 (200 milliwatts) OC71 (or red spot) (100 milliwatts)
$TC_{1, 2, 3, 4}$ 4 x 60pF trimmers
$TC_{5, 6, 7, 8}$ 4 x 60pF trimmers
Group board and brackets (Repanco Ltd.)
IFT type OT1, TT2, TT3 (Repanco Ltd.)
T_1, Driver transformer type TT4 (Repanco Ltd.)
T_2, Push-pull o.p. transformer type TT5 (Repanco Ltd.)
7½V battery
3-pole, 4-way midget rotary switch
Crystal diode
7in x 4in elliptical speaker, 3Ω, Elac

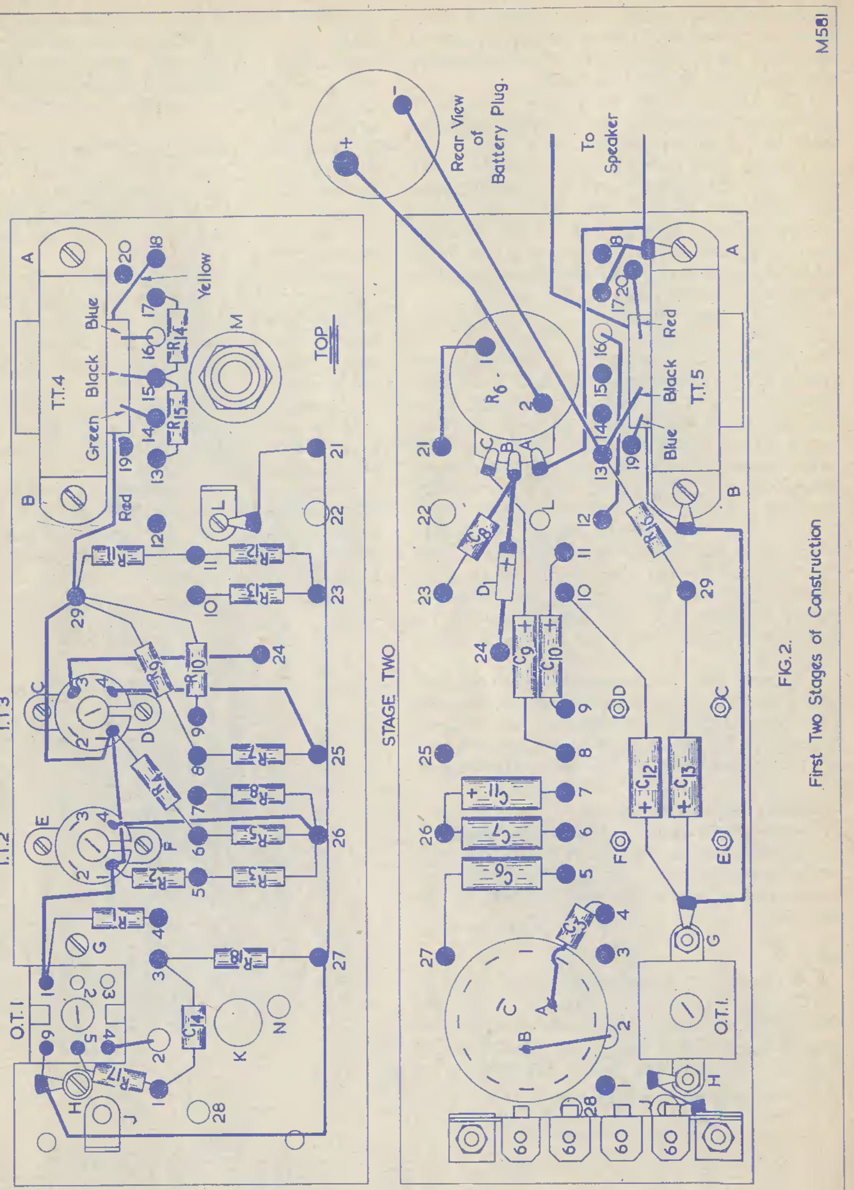

FIG. 2. First Two Stages of Construction

Next, join tag 3 of the TT3 to eyelet 24, following this by joining tag 1 of the TT3 to eyelet 29. Join tag 1 of the TT2 to tag 1 of the TT3.

Solder R_9 (47kΩ) from eyelet 29 to eyelet 8; R_{10} (3.3kΩ) from eyelet 29 to 9; R_7 (10kΩ) from eyelet 8 to 25; R_8 (1kΩ) from eyelet 7 to 26; R_5 (47kΩ) from eyelet 6 to 26; R_3 (4.7kΩ) from eyelet 5 to 26; R_4 (1MΩ) from eyelet 6 to tag 1 of the TT3; R_2 (82kΩ) from eyelet 5 to tag 1 of the TT2 and finally, R_{18} (3.3kΩ) from eyelet 3 to eyelet 27.

Next, fit the combined oscillator and first i.f. coil (OT1) to the group board using 6BA screws and nuts through the fixing holes G and H, making sure at the same time that the pins are in the exact position as shown in the stage one diagram (Fig. 2). To the screw inserted through G, fit a solder tag on the underneath side, and to that inserted through hole H, fit two solder tags, one on top and one underneath the group board.

Having proceeded thus far, solder the resistor R_1 (1MΩ) from pin 1 of the OT1 to eyelet 4. Join pin 6 of the OT1 to the solder tag at H, following this by joining pin 1 to tag 1 of the TT2. Solder R_{17} (56Ω) from pin 5 of the OT1 to eyelet 1. (*Note*: The value of R_{17} is experimental in each model.) Connect C_{14} (0.01μF) from eyelet 1 to eyelet 3. Join tag 4 of the TT2 to eyelet 26; tag 4 of the TT3 to eyelet 25 and join together the eyelets 21, 23, 25, 26 and 27.

With approximately three inches of connecting wire, solder one end to pin 4 of the OT1 and thread the free end through hole 2. Solder eyelet 27 to the solder tag on the screw at H.

Follow this by fitting the ferrite slab angle fixing brackets at holes J and L, fitting a solder tag on the underneath side of the 6BA screw at J and one on the top side of the screw at L. Join the solder tag at L to the eyelet 21. This completes stage one and the constructor should now check his wiring, etc., with the point-to-point diagram of the appropriate stage shown in Fig. 2, before commencing with the wiring of the following step.

Stage 2

Commence by cleaning the output lead of the TT5 nearest to the fixing screw at B, removing both the enamel and tin, and solder the end of this lead to the solder tag on that screw. Solder the red lead of TT5 to eyelet 20; the black lead to eyelet 13 and the blue lead to eyelet 19.

Fit the miniature potentiometer R_6 (10kΩ) through the hole marked M. Connect point A of R_6 to the solder tag on screw A, following this by soldering the switch contact 1 of R_6 to eyelet 21.

Fit the 3-pole, 4-way switch through the hole K with the locating pin through the hole marked N.

Solder R_{16} (1kΩ) from eyelet 29 to eyelet 13 and C_{13} (25μF) from eyelet 29 to the solder tag on screw G, ensuring that the positive end (+) is fitted to the solder tag. Join the solder tag of screw G to the solder tag on screw B. Connect C_{12} (25μF) from eyelet 10 to the solder tag on screw G, with the positive end (+) soldered to the solder tag.

Connect C_{10} (25μF) from eyelet 11 to eyelet 9, with the positive end to 11. Solder into position D_1 (crystal diode) from eyelet 24 to tag B of R_6, with the cathode (red end) to tag B.

Solder one end of C_8 (0.01μF) to tag B of R_6, the other end to eyelet 23. Fit C_9 (25μF) from eyelet 8 to tag C of R_6, with the positive end to tag C of R_6. Next, connect C_{11} (25μF) from eyelet 7 to eyelet 26, with the positive end to 26. Solder C_3 (0.01μF) from eyelet 4 to pole A of the wavechange switch.

Next, connect the lead from pin 4 of the OT1 (fitted in stage 1) to pole B of the wavechange switch. Solder C_6 (0.1μF) from eyelet 5 to eyelet 27 and C_7 (0.1μF) from eyelet 6 to 26. Join the solder tags of screws H and J together.

Solder the positive battery lead (red p.v.c. connecting wire) from switch contact 2 of R_6 to the larger pin of the battery plug. Connect the negative (black) battery lead from eyelet 13 to the smaller pin of the battery plug. Next, connect approximately 6in of connecting wire to the solder tag on screw A; this lead, together with the other lead (enamelled) from TT5, are the output leads to the speaker.

Mount the two banks of 4 x 60pF trimmers on to the fitting brackets, using 6BA screws and nuts, and fix these to the group board. Note that the "60" markings face upwards on the top bank and face downwards on the bottom bank of trimmers. This completes stage 2 of the instructions. A further check of these connections should now be made before proceeding further. *To be continued*

LONDON U.H.F. GROUP

The annual dinner of the London U.H.F. Group will again be held at the Bedford Corner Hotel, Tottenham Court Road, W.1, on Saturday, 31st January, 1959, at 7 p.m. Tickets 12s. 6d. each, obtainable from:

P. A. Thorogood, G4KD, 35 Gibbs Green, Edgware, Middlesex.

RADIO *Miscellany*

RECENTLY THERE HAS BEEN A LOT OF discussion, chiefly among radio servicemen, on the merits and drawbacks of printed circuits. The great majority seem to be against. Over ten years ago I wrote a lengthy article on printed circuit processes and possibilities while they were still comparatively in their infancy. Hence I feel I have a prophetic interest in the question. More recently I drew attention to the advertisements of an American manufacturer who proudly proclaims that printed circuitry finds no place in his receivers. As far as I can check there is now only one British manufacturer who does not use a certain amount of printed circuitry in current t.v. models, although, of course, there may be more—but not many!

When printed circuits were first extensively introduced into modern t.v. receiver production, smart advertising alecs saw in them an opportunity of scoring a sales point. Consequently they were presented to the great British public as being the latest and best innovation for years. Many ordinary viewers swallowed the bait, hook, line and sinker. Quite proudly they will tell you "It has the latest plated circuits, y'know."

Actually, of course, it was a step to automation and was adopted by the manufacturers not because it was better, but because it was cheaper. The saving in labour costs alone is pretty considerable. Incidentally, the basis of the idea goes a long way back. In 1921, I and a good many other amateurs were using pencil line grid leaks; and in the days of breadboard construction, plywood coated with metallic paint carried the earth return leads and negative connections.

No one who has any understanding of the technicalities involved would expect a printed conductive line with tagged joints to be as good as solid wire with properly soldered connections. It is cheaper, and manufacturers believe it is good enough for the small current carrying demands made of it. Theoretically, of course, a reasonable deposit of printed conductive material should be ample, but if they fail in service a whole section may have to be discarded—which may not be a particularly tricky job from the serviceman's point of view. It is, however, liable to be expensive from the customer's point of view, make on-the-spot repairs in the viewer's home no longer possible and require more prolonged testing after a repair job is done. The risk of the bugbear of all servicing is likely to occur more frequently and be more difficult to trace. I mean, of course, the intermittent fault. Such a fault in a printed sub-assembly where the suspected connection or component is completely inaccessible will prove even more maddening. Servicemen who have run into a succession of such faults naturally feel that the use of printed circuitry is a retrogressive step, although personally I haven't yet had direct experience of it. However, I have recently come to suspect the stability of many modern t.v. sets. A week or two back I went to a rental showroom where a double row of receivers were all tuned to the same programme for demonstration purposes. Most of the well-known makes were represented but on every model the linearity left a lot to be desired. I couldn't be sure whether no one had bothered to adjust them, whether there was no further adjustment possible or whether the circuits just didn't "hold."

Oddly enough, prospective hirers don't seem to be very critical. At least, the chap in charge said no one had complained and admitted that he himself didn't see much wrong with them! Seemingly many viewers are satisfied if they get a picture of some sort. When visiting friends no doubt you, too, have been told "Well, it isn't so good tonight as it is most evenings."

Perhaps at this point a repetition of an old warning might be appropriate. Don't dare adjust it for them. As sure as God made little apples, when the set breaks down in a couple of months time they will be firmly convinced that it was "something" *you* did to it.

That Empty Space

There has recently been a renewal of controversy about the vacant channels in the t.v. wavebands and how they should be used. Both the B.B.C. and I.T.V. strenuously press their claims. Unimaginatively both appear to intend to use it for the same purpose—as a mere duplication of the same dreary pattern of programme which both Authorities already dish up. Could not something constructive be done about it while there is still time?

Its fate lies in the hands of politicians, and I have a sneaking fear that their decision might too easily be swayed by political consideration—whichever party is in power. If the present government hand it over to I.T.V. the Left-wingers will attempt to make capital by alleging they are dominated by Big Business. And they are not likely to parcel it out to I.T.V. themselves. If either Party give it to the B.B.C. they will risk popularity as it can only result in a considerable increase of the licence fee, and few viewers pay their £4 ungrudgingly as it is. TV overheads are extremely high and my guess is that the licence fee will need to be raised by 50%; and it must not be overlooked that B.B.C. audiences are invariably in the minority.

Alternatives

It could well be used for higher definition. British manufacturers could mass-produce sets using the Continental 625 line definition instead of the 405 line we have clung to since 1936. This would also simplify Eurovision. As 405 line receivers grow out-of-date, viewers would replace them with the higher definition sets and everyone would make the changeover without hardship. This seems basically an excellent idea, but what of the claims of colour t.v?

Alternatively, an excellent case can be made out for a third Authority to present programmes arranged by the universities and similar bodies. This could be financed partly from licence fees and partly from advertising revenue.

Many of our readers, I should imagine, being themselves technically minded, are likely to strongly favour the idea of developing colour t.v. on the vacant channels. Unfortunately this will prove to be a mighty expensive business. The recent Political and Economic Planning Report gave some enlightening figures. The cost of transmitters and linking was estimated at £10 million, to which a further £6 million must be added for studios and equipment. Spread over *all* viewers this would be at least a couple of pounds each. To try to divide it among colour viewers only would put them all in the workhouse; that is, if the cost of the set hadn't already put them there! Present costs of a colour receiver would be at least £300 and intensive mass-production at the best could only bring it down to the £200 mark. Tube replacements would be in the region of £70 to £80.

There is, of course, still another alternative—stereovision. 3-D programmes also would be mighty expensive, and how many viewers would cheerfully pay increased licence fees and have to buy more expensive sets for the sake of another dimension?

Centre Tap talks about items of general interest

Finally we come to a possibility this column has, in the course of the last few years, frequently touched upon. I refer to satellite-borne t.v. transmitters. These would give enormous coverage with comparatively small power. Experimental work has already been done, particularly in the United States where, for domestic reasons, they have every interest in its early development. I am beginning to wonder if the political leaders of the freedom-loving countries are fully alive to the importance of being first in the field with international t.v. radiated from space-borne carriers. Steam radio as a means of mass-suggestion has already been exploited—and proven. The power of t.v. is infinitely greater. The effects of mass-suggestion on educated populations can be startling—the impact on the semi-literate masses of Asia or Africa could easily be devastating. Indeed, it could well decide whether Western or Russian political influence will be the decisive factor in world history, or even whether English or Russian will become the world's leading language. All of which simply leaves me wondering whether we can afford to leave such a decision in the hands of a group of politicians, whatever party they represent?

Tongues of Men

From the early days of broadcast radio, international friendship enthusiasts have seen in our hobby an opportunity to introduce, even if only as pen-pals, hobbyists of varying nationalities. Between the wars there were a number of organisations with important-sounding names, but membership seemed to be more of gesture with but vague probability of successfully promoting permanent friendship and mutual understanding. I am afraid these organisations consisting of chiefly "registered" sympathisers achieved little and many responsible-minded hobbyists feared that a few well-intentioned, but tactless, individuals might easily undo all the good that sprang as a natural growth from the common basis our hobby provided. A few, too, were suspected of being politically inspired.

Much more practical results have come from links formed by transmitting amateurs, and a number of highly successful parties have visited the Continent. Good work in this connection is recognised annually by the award of the R.S.G.B. Calcutta key. Last year it went to Dr. Arthur Gee (G2UK) with whose unofficial efforts in this respect I myself have had some small connection. This year it was awarded to George Partridge (G3CED) the founder and hon. sec. of the Ham Hop Club, which I recently warmly commended to readers interested in strengthening international understanding. Most of the introductions from which personal meetings may result will be, of course, with those from Western European countries. As many of us may well live to see the birth of a United States of Europe, this factor is likely to assume still greater significance, quite apart from the impending European Common Market.

Older readers will remember that from time to time I have related my own personal experiences among European radio enthusiasts. Even if I have failed to achieve anything much in the way of improving international relationships, I have at least made a number of firm friendships. Perhaps the one claim I can truly stake for having achieved some little good was the occasion, shortly after the war when British prestige on the Continent was at its highest, in Holland. There was to be a gathering of the clans throughout a wide region to mark the rapid progress amateur radio was making following its war-time hiatus. Tickets went well, and it became almost national—and then international as amateurs from two other countries besides myself were to attend. This made me a sort of official visitor: to represent British amateurs. Hence I was invited to say a few words. I felt I should at least say two or three sentences in Dutch if only to shatter any remaining traces of prejudice that Britishers are aloof. With the patient help of a Dutch friend I manfully struggled with a few simple sentences. At the dinner I blundered painfully through my carefully rehearsed passage with beads of perspiration oozing from me and, I am sure, a beetroot-coloured face. Everybody applauded delightedly, although I am sure it was only out of kindness and sympathy for me with perhaps a little well-at-least-he-tried admiration. Then both the other "foreigners" spoke in what seemed to me to be fluent Dutch. Was I thankful that, despite the torture of my careful rehearsing and the agony of those two or three minutes, I had struck a blow to dispel ideas of British smugness.

Since then I have attended one or two national gatherings in Europe, but to my dismay the invited representative from Britain did not bother to learn a single phrase of the language of the host country. Yet I remember the German representative once made a full speech in Danish which, I was told, he learned especially for the occasion. I wonder how we should feel at an Amateur Radio dinner in London if the invited French guest spoke only in French without as much as "Good evening" or "Thank you" in English?

Several times this column has urged those visiting overseas, when they expect to meet families, to learn a few words of the language. I have already told one or two stories against myself in this respect, but mistakes made over language difficulties always end up with a good laugh all round. Perhaps because I am a trier I get more entangled than most in this way. In Austria, early after the war, a pre-war amateur, then a "pirate," invited me to his house to see his transmitter. None of the family or friends who gathered round could speak any English. His good wife rushed to make a cup of tea—a gracious compliment as it was not only scarce but enormously expensive. Was it not the national beverage of the visitor? It wasn't very good tea and I don't believe the water boiled, but I said I would like another cup. The good *hausfrau* looked quite shocked, stared at the cup I passed back and went off to fetch another. Only then did I realise I had once again blundered. I had asked for "another cup" (andere tasse), not a re-fill of the same cup (noch eine tasse). I got more confused than ever in trying to explain it was my bad German (a literal translation from the English) and not the cup that was wrong. As it dawned on them they all started to explain it to one another. This made it seem even funnier and before long we were all laughing—even me—despite my confusion. There is nothing like a good laugh to break the ice, and the atmosphere which had previously been rather strained was markedly easier. It finished by my staying to supper (they insisted despite the shortages) and cordial invitations to call again. So don't be afraid of making a few mistakes.

More about the ... "MINI-7"

The appearance of the constructional articles on the pocket transistor set appropriately called the "Mini-7" in the May-June 1958 issues of *The Radio Constructor* sent the writer hot foot to the nearest dealer to obtain a kit of parts. On the principle that "only the best is good enough" the cost of the set was increased by insisting on being supplied with standard, not surplus, transistors. The reason for indulging in this seeming luxury was that it had been previously shown that it was important to use transistors which had passed a satisfactory noise-level test. This is, of course, sometimes a fault with the cheaper or surplus transistors although they must not be condemned completely on these lines. After all, if they could pass tests to a tighter specification it is a reasonable assumption that they would merit a higher price. It is fairer to refer to the surplus transistor as "sub-standard" rather than as "rejects." The "sub-standard" audio transistor can still be sold as usable even though its wide "spread" of characteristics can be somewhat of a nuisance when trying to obtain the maximum gain from a particular standard arrangement. This difficulty is likely to be more apparent, of course, when "sub-standard" r.f. transistors are used, in that the associated circuitry has to be designed to comparatively tight limits in order to secure reasonable results. The conditions governing whether the mixer will oscillate, for example, are very dependent on the inductance values in conjunction with the base or emitter currents available. Generally speaking, it is very difficult for a circuit designer to lay down a set of specific values for his transistor circuit which will be wholly satisfactory for the wide variations which exist between certain transistors among those which are available today. In other words, to obtain the best results the constructor should be prepared to carry out a few additional experiments when he has assembled all the bits, even if it does work first time. It will be seen that the recommendation was given in the original instructions for building the "Mini-7" that R_4 might have to be determined by trial and error. The writer realised that there might be more in this than met the eye, especially as the circuit had been carefully designed for a particular series of transistors.

The "Mini-7" worked straightaway after the prescribed lining-up instructions had been carried out with R_4 at the suggested value. Substituting a variable resistance of 0–500Ω soon uncovered the correct value for the Mullard OC44 which gave the most reasonable gain with the designer's circuit. There was a distinct tendency for the i.f. stages to be unstable due to the greater gain of the OC45s used as i.f. amplifiers, and after repeating the R_4 procedure with R_5 and R_7 to determine the most suitable values (using appropriate values of variable resistance) it was found necessary to slightly off-tune the first i.f. transformer. A certain amount of "pulling" on the oscillator circuit was apparent, this being caused by the aerial inductance. Initially, an improvement was obtained by removing the link between "black" and "blue" and linking the "red" or top end of the primary to the "blue" or "earthy" end of the secondary. The "black" was then used as the top-end connection to the rotor of C_1. This arrangement appeared to give a suitably degenerative effect. Eventually, a Jackson's Type 00 ganged capacitor with a screen between the two sets of vanes was fitted which helped considerably to reduce the effect.

Coming down to the audio end, the recommended modification to the volume control of changing it to 25kΩ and taking the slider to the positive end of C_9 was found to be desirable, although an even higher value could still be used without loss. The top end of the volume control then goes to the junction of C_8, R_8 and the positive end of D_1.

TR_4 and TR_5 were OC70 and OC71 respectively, although OC71 in both cases would serve, where changes of value for R_{13} and R_{14} were found desirable in order to adjust the drive to the output stage. The two output transistors supplied for use were two OC71 and were not matched. The variable resistance technique was again adopted, this time on R_{17} in order to apply the correct bias current. If the quiescent current of the push-pull pair is allowed to fall too low, what is called "crossover" distortion will be apparent. This might happen when the battery is running down and will be obvious to the ear. In the excellent and informative Mullard publication "Transistors for the Experimenter," among a wealth of transistor information a circuit is given which uses a pair of OC72s and which advises the use of a capacitor of approximately 0.1μF in value, connected across the two outer ends of the primary of the output transformer in order to minimise this effect. This seems to be a worthwhile precaution to add.

By the time that this stage was reached, the experimenting and day-to-day usage had brought the two batteries to a low ebb and the high resistance which builds up within the cells as the voltage drops had made itself apparent. It seems to be the practice to offset this effect by putting a 50μF electrolytic across the battery. Making sure that the polarity of the condenser agrees with that of the battery, it is best fixed on the "circuit" side of the on/off switch which is positive and the centre tap on the output transformer which is negative. Most miniature electrolytics of this capacity have a working voltage in excess of the battery voltage, so that it is only necessary to ensure that the physical size is such that it can be tucked into the case satisfactorily. The main advantage of this additional capacity is that each battery can be used for a longer period before being discarded.

If you find the two individual cell arrangements as specified are not to your liking, an alternative arrangement can be used which utilises the Ever-Ready PP3 Type battery of 9 volts. With very little disturbance of components this battery can be fixed in place of the original battery clips and clip-on connections facilitate easy renewal. The press-stud connections terminate in new leads which are fitted from the centre-tap of the output transformer and the switch. They are manufactured especially for this type of battery by Carr Fasteners Ltd. and the three pieces required are referenced Nos. 78/174, 175 and 176. It must not be thought that changing to the 9-volt battery is all one has to do, but again the change is well worth it, resulting in a decided increase in overall performance when certain adjustments have been made. The existing clips have to be removed.

The first point to verify is the working voltage of any capacitor subjected to the higher voltage. Check the new 50μF across the battery which was mentioned above, and then C_{12} (100μF). Capacitors of that value but of higher working voltage are to be obtained and are usually of the same diameter but slightly longer. Instability may occur until R_{16} is increased to a suitable value to drop the battery volts to the first five stages. Further adjustment of R_4 may be necessary as well. With the extra voltage available for the push-pull stage it is now possible to use OC72s instead of OC71s, which will result in a greatly increased output. Do not forget the bias re-adjustment for the OC72s which is effected with R_{17}.

In conclusion, it should be made clear that the above notes are given for guidance to show the principles to use in this particular search for improvement. No definite new values of resistor, for example, have been given as it is felt that with the possibility that each individual constructor may have his own preferences in regard to a choice of transistors, that this would introduce sufficient variations as to require separate and distinct treatment anyway on the lines described.

Elsewhere, other than in this article, will be found plenty of tips on the correct way to handle transistors in so far as use must be made of a heat conductor, or "sink" as it is known, in order to minimise the amount of heat which can reach the transistor during the soldering process. For the same reason do not attempt to shorten the leads provided to less than $\frac{3}{8}$in. The soldering iron itself should, of course, be of the low-wattage type which if only for convenience should be of small size.

It might be as well to add to these usual warnings the fact that resistance measurement of other components should not be undertaken without first isolating the transistors and that for current measurement the battery supply must be switched off before inserting the milliameter and again when removing the meter. It must be accepted that transistors do not agree with any open circuit conditions for any of their "limbs" and are liable to be damaged if this point is not observed. Equally so is the fact that reversed battery connections are harmful and can, in fact, end the useful life of the transistor. Another important point is that when adopting the variable substitute resistance method the base of the transistor must never be subjected to the full negative voltage at any time. Reference should, in fact, be made to the transistor manufacturer's published data and variations kept within the prescribed limits.

The writer found that only by such an exercise can one really gain knowledge of transistors and remove that feeling that they are to be avoided at all costs on account of their being easily damaged. The "Mini-7" has proved to be an admirable "bread-board" type of design on which to work. At the same time it gives such worthwhile results that it is seldom left at home these days, accompanying the writer everywhere.

A CONSTRUCTOR'S IMPRESSIONS OF

THE RADIO HOBBIES EXHIBITION, 1958

THE SECOND R.S.G.B. RADIO HOBBIES EXHIBITION, which was held at the Royal Horticultural Old Hall from Wednesday to Saturday 26th to 29th November, was notable on this occasion for several trends fast becoming apparent in the radio hobbyist world. Not the least of these was the record attendance, this being some 10,000 as against last year's figure of 7,000. So great was the interest in this year's event that at one time a considerable queue of enthusiasts stretched along the front of the building waiting to gain admission. It was certain that each hoped to win the Racall RA17HF £400 communications receiver, and it was equally certain that each and every one had come to see a good show—in the latter they were not to be disappointed!

Within the hall were displayed many and varied items of equipment, receivers, transmitters, test equipment, aerials, components and workshop accessories, etc., both home-constructed and professional. Of the trends mentioned above, the most important to the writer's mind was the great increase of various equipments offered in kit form. The kit has many advantages to offer the home constructor; it is professionally designed and styled, complete from one supplier—down to the last length of solder; results are virtually guaranteed; and service after sales is usually available.

For the transmitting fraternity, the K.W. Electronics Ltd. "Vanguard" transmitter, available in kit form (or wired and tested), covers from 10 to 80 or from 10 to 160 metres. These transmitters employ modern T.V.I.-proofing techniques with full screening, h.t. and mains filtering, pi-output and harmonic trap, etc. The Minimitter Company Ltd. featured for the transmitting amateur the well-known "Mercury" Tx, and in addition offered the new mobile range—a compact under-dash transmitter for 1.7, 3.5 and 7.0 Mc/s, companion shortened whip aerials and an all-transistor power supply. Daystrom Ltd. (Heathkits) had on view, for the first time in this country, the famous DX100 and

DX40 transmitters, these being very popular in the States. Racall Engineering Ltd. placed on show their new TRA55 SSB 60-watts Radiotelephone.

For the receiving enthusiast, which of course also includes all those interested in amateur communication, much that was new was featured on many of the stands. K.W. Electronics Ltd. featured the Geloso G209 double conversion receiver for A.M., C.W. and S.S.B.; the G209 front-end coil unit and parts, together with the well-known G8KW multi-band dipole. For those wishing to learn the morse code, practice kits, together with gramophone records reproducing code exercises, were offered by the British National Radio School. The new MR38 communications receiver covering all amateur bands plus general coverage in eight wave-bands, with modern refinements, was to be seen and inspected on the Minimitter Co. Ltd. stand. The MC8 All-Band Converter was also of great interest here. A very great interest was shown in the Racall RA17HF communications receiver—and not only because this was the star prize of the show! This receiver, which the writer had great difficulty in approaching, owing to the almost perpetual crowd of interested enthusiasts, covers the range 0.5 to 30 Mc/s without bandswitching! It has an overall stability, after a short warm-up period, of within 50 c/s. This receiver, the draw for which the writer entered—as did most others—was won by a Mr. K. R. Rogers of Hitchin—lucky man!

Test equipment abounded and included all types and prices. The new Heathkit type V-7A valve voltmeter and the 0-12 oscilloscope attracted some considerable attention. The Trecoscope, a modern high efficiency oscilloscope, was demonstrated on the Range Electronics Co. stand, these including methods of visual alignment of both i.f. and discriminator circuits in f.m. receivers. The Jason Motor & Electronic Sales Co. featured, in addition to their well-known f.m. receivers and amplifiers, a simple oscilloscope which produces a good performance from the minimum of components. A wobbulator, audio generator and a multi-range valve voltmeter were also to be inspected. Home Radio of Mitcham Ltd. arranged an attractive display of Eddystone communications receivers, radio components and Panda transmitters, etc.

For the first time at an exhibition in this country, colour television was seen both by enthusiasts and the general public. Both B.B.C. experimental and amateur transmissions were on display. During the exhibition, a B.B.C. colour film was featured and hundreds of visitors packed the stand thoroughly enjoying the show.

The R.S.G.B. stand was, of course, the mecca of all radio amateurs. From here operated the exhibition station GB3RS/A, many contacts being made on the amateur bands. A very interesting display of equipment, home-built and designed, was entered by Society members for the Home Constructors Competition. Some of this equipment was so well devised and completed that the writer found it more attractive than many commercially made counterparts. During the course of the exhibition, the R.S.G.B. enrolled over 200 new members. The I.G.Y. (International Geophysical Year) Group of the Society had a stand of their own at which typical examples of the types of signal reports collected of the telemetry signals from the Russian earth satellites were shown. Tape recordings of radio signals, including those from the satellites, were to be heard.

In the short space allotted here it is impossible, of course, to mention each and every stand or item of equipment. The latter varied over the whole range of radio and electronic units, from the comparatively simple 3-transistor receiver shown by the Teletron Co. Ltd., to the stereo amplifiers featured by Jason Motor & Electronic Sales Co. Ltd.

The exhibition was an undoubted success both from the point of view of the final attendance figures and from the varied equipment shown. I, for one, am looking forward to next year's show.

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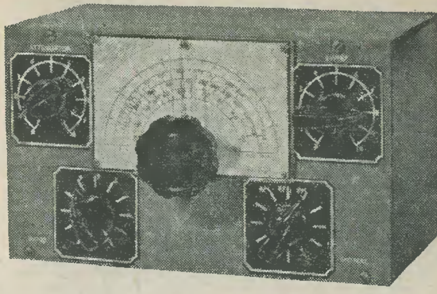

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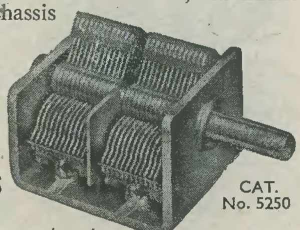

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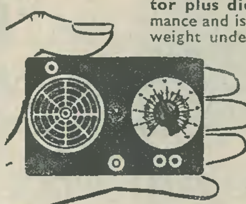

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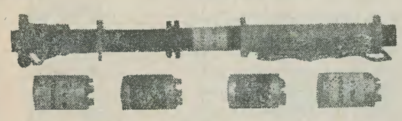

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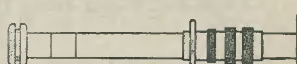

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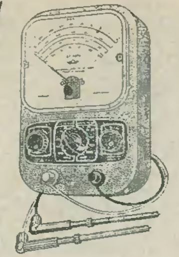

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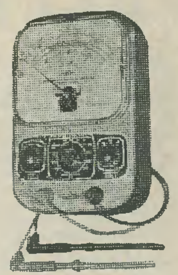

Undoubtedly a most useful instrument by a firm long famous for fine instruments. Entirely re-designed, it has a square movement with diacon plastic cover; this makes for a brighter, more readable scale, extra scale length and wider angle of vision. With the test set is included a pair of combined test prods and crocodile clips also a stand for inclining the meter at the best reading position. Ranges: a.c. volts: 0-10, 0-25, 0-100, 0-250, 0-500, 0-1,000; ditto d.c. A.C. current: 0-100mA; d.c. current: 0-2.5, 0-10, 0-100, 0-500 mA. Resistance: 0-1M and 0-10kΩ. **Price £12.7.6** plus 5/–carr. and ins. or £1 deposit and 24 fortnightly payments of **10/–**. **FREE GIFT.**—All purchasers this month will receive a Series 100 range extender scale and data, which adds capacity 2pf–0.1μF in two ranges, inductance, E.H.T., and many others.

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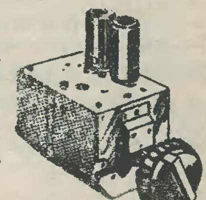

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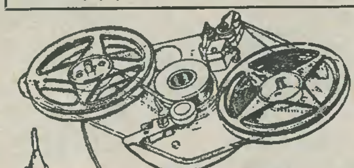

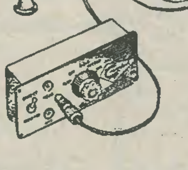

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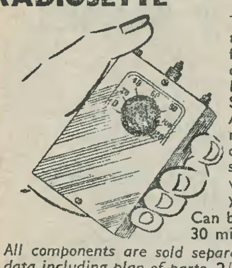

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Can be built in 30 minutes **30/-**

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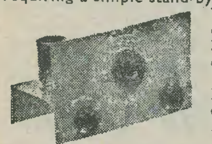

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Highest Quality Cable, low-loss Polythene Aeraxial, semi-air spaced, feeder losses cut 50%. Standard ¼" dia. Stranded core. Famous make.

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3" ...	175ft	... 7/–	250ft	... 9/–
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5¾" ...	850ft	... 24/6	1,200ft	... 31/6
7" ...	1,200ft	... 30/–	1,800ft	... 45/–

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Terms: C.W.O. or C.O.D. Post and packing up to ½lb 7d., 1lb 1/1, 3lb 1/6, 5lb 2/–, 10lb 2/9

The TRANSIDYNE RECEIVER

(Page 119 Sept. issue)

We guarantee all components to be exactly as **specified by designer & approved by Messrs. Teletron**

Drilled case, printed circuit, battery holder, dial, nuts, screws	£1.5.0
Complete coil and aerial kit	£2.2.0
Resistor kit (with circuit refs.)	6/-
Cond. kit (with circuit refs.)	£1.5.0
Rola speaker (tax paid)	£1.8.2
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Transistors—
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Green/Yellow (audio) 9/6 each

COMPLETE KIT **WITH TRANSISTORS** AT THE **SPECIAL REDUCED PRICE OF £11.19.6**

FREE—Special 'printed circuit' solder with each kit

Full constructional details, **9d.**
S.A.E. Price List

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(by Bulgin)

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Plug **2/6** *Socket* **3/-** See p. 376

Sub-miniature type ⅜" x ½" panel space. ½" behind panel, ⅝" projection.
Plug **1/3** *Socket* **9d.**

TRANSISTOR KITS. **Companion £5.9.0.** Leaflet 6d. **'Mini-7', £12.** Envelope 1/6. **Radiosette £2.3.0** (with phones)
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CONNECTING WIRE. p.v.c. 50ft coil, 5 colours, **1/9. Sleeving,** 15ft, asstd. colours and thicknesses, **8d. Tinned Copper Wire** 24 s.w.g., 15ft **8d. Combined pack** (3 above items) **2/9**

TRANSISTORS—*CHEAPER STILL*

Yellow/Red R.F.	15/-
White Spot R.F.	14/-
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HI GAIN BAND 3 PRE-AMPLIFIER
(See page 568 March)

Resistor Set, 1/6; Capacitor Set (with clip), **8/9; Valve ECC84, 17/-; Rectifier** (50mA), **7/6; Transformer, 13/-; Coil Set** (L_1–L_5) **9/-; Chassis** (punched for coils, space for Power Pack), **3/9; Coax Sockets, V/holder, Tag Strip, Nuts, Bolts, 5/6.**
COMPLETE KIT AS ABOVE £3 . 3 . 0

QUOTATIONS gladly given (S.A.E. please) **R. FAGELSTON** (MAIL ORDER) *Please add Postage to above prices*

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1R5	7/6	6X4	7/6	DK91	7/6	EF92	5/6
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1T4	6/-	12AH8	9/6	DK96	9/-	EL84	9/-
3S4	7/6	12AT7	7/6	DL92	7/6	EL91	7/6
3V4	8/-	12AU7	7/6	DL94	8/-	EY51	10/6
5U4G	6/-	12AX7	9/-	DL96	9/-	EZ35	8/-
5Z4G	9/-	12K8GT	13/6	EB91	5/6	EZ40	8/-
6AM6	6/9	12K7GT	8/6	EBC41	8/-	EZ80	8/-
6AL5	5/6	12Q7GT	7/-	EBF80	9/6	EZ81	8/6
6AT6	7/6	25A6G	10/6	ECC81	7/6	KT33C	9/6
6BA6	8/6	25L6GT	7/6	ECC82	7/6	PCF82	11/-
6BE6	7/6	35Z4GT	8/6	ECC83	7/6	PL82	10/6
6BR7	10/6	35L6GT	9/6	ECC84	8/6	PY81	8/-
6BW6	8/6	53KU	11/6	ECF82	11/-	PCC84	9/-
6J5G	5/6	807	6/9	ECH81	10/6	PCF80	9/6
6J7GT	8/6	5763	10/6	ECH42	10/-	U76	8/6
6K7G	2/6	DAF91	7/6	ECL80	12/6	UBC41	10/-
6K8G	7/6	DAF96	9/-	EF36	7/6	UCH42	9/-
6Q7GT	8/6	DF91	7/6	EF39	5/6	UF41	10/-
6SL7GT	8/-	DF96	9/-	EF41	9/-	UL41	9/6
6SN7GT	8/6	DH76	8/6	EF80	8/-	UY41	8/-
6V6G	7/6	DH77	7/6	EF91	6/9	W76	8/6

Matched Pairs EL84, **23/-**; 6V6G, **17/-**; 6BW6, **18/-**; KT33C, **19/6**; KT66, **27/6**; 807 **14/6** pair

1R5, 1S5, 1T4, 3S4, 3V4, DAF91, DF91, DK91, DK92, DL92, DL94, any four, **27/6** per set

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continued on page 479

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1R5	7/6	6Q7GT	9/6	866A	15/-	EZ40	8/6
1S5	7/-	6SA7M	7/6	959	5/-	EZ80	8/6
1T4	6/-	6SG7M	7/6	1616	5/-	EZ81	8/6
2A3	8/6	6SH7M	5/-	1629	4/-	GT1C	10/-
2X2	3/6	6SJ7M	7/6	EA50	1/6	GZ32	12/6
3A4	4/6	6SK7M	6/6	EABC80	10/-	HK24G	25/-
3Q4	7/6	6SL7GT	7/6	EAC91	4/6	KT33C	9/6
3S4	8/6	6SN7GT	6/6	EAF42	10/6	PCC84	10/6
5763	10/6	6SQ7M	7/6	EB34	2/6	PCF80	13/6
5R4GY	12/6	6V6G	7/6	EB91	5/-	PCF82	10/-
5Y3G	8/6	6V6GT	8/6	EBC33	7/6	PCL82	13/6
5Y4G	6/6	6X4	6/6	EBC41	10/6	PL81	14/6
6AC7M	5/-	6X5GT	7/6	EBF80	9/6	PL82	9/6
6AG5	3/6	7B7	8/6	EBF89	10/-	PL83	10/6
6AK5	5/-	7C5	8/6	ECC82	9/6	PY80	9/6
6AL5	5/-	7C6	8/6	ECC83	10/-	PY81	9/6
6AM6	6/6	7S7	10/-	ECC84	11/-	PY82	9/6
6AQ5	8/6	7Y4	8/6	ECC85	10/6	PY83	11/6
6AT6	7/6	12A6M	6/6	ECF80	12/6	R19	12/6
6AU6	8/6	12AT6	8/-	ECF82	11/6	TT11	4/-
6B8G	4/6	12AT7	9/-	ECH42	10/-	UAF42	10/6
6BA6	8/6	12AU6	9/-	ECH81	10/-	UBC41	10/6
6BE6	7/6	12AU7	8/6	ECL80	12/6	UBF89	10/6
6BH6	7/6	12BE6	8/6	ECL82	12/6	UCC85	10/-
6BJ6	7/6	12C8M	7/6	EF36	4/-	UCH42	10/6
6BR7	11/6	12Q7GT	7/6	EF39	5/-	UCH81	10/6
6BW6	9/-	12K7GT	7/6	EF41	10/6	UF41	10/6
6C4	4/6	12SC7M	2/6	EF50	3/-	UF89	10/6
6C5M	5/6	12SJ7M	5/-	EF50(S)	4/6	UL41	10/6
6F6M	5/6	12SK7M	5/6	EF55	7/6	UY41	8/6
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6J5M	6/-	35L6GT	9/6	EF85	10/-	UABC80	10/6
6J6	4/-	35Z4GT	7/6	EF86	14/6	VU39	9/6
6J7G	7/6	35Z5GT	8/6	EF89	10/-	VR150/30	7/6
6K7G	5/6	42	7/6	EF91	6/6		
6K8G	7/6	50L6GT	[illegible]	EL32	4/-		
6K8M	10/6	[illegible]	[illegible]	EL41	10/-	VS70	3/-
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1D5	10/–	6AT6	8/6	6SJ7GT	8/–	10F9	10/6	35Z3	13/6	DF96	9/6	EF50	3/6	PL81	16/–
1H5GT	10/6	6B8G	2/11	6SN7GT	5/9	12AH7	7/6	35Z4	7/6	DK96	9/6	EF50(R)	4/11	PL82	9/6
1N5GT	10/6	6BJ6	7/6	6U4GT	12/–	12AT6	10/–	807(B)	3/9	DL96	9/6	EF80	8/–	PL83	10/6
1R5	7/6	6C4	4/9	6V6GT	6/6	12K7	7/6	807(US)	5/6	DM70	7/6	EF86	14/–	PY80	8/–
1S5	7/–	6F1	13/6	6X4	7/–	12Q7	7/6	954	1/6	EB91	6/6	EL41	10/6	PY81	8/11
1T4	5/6	6F6M	7/6	6X5GT	6/6	12SH7	5/6	955	3/11	EBC41	10/–	EL84	9/–	PY82	9/–
3D6	4/9	6F13	12/6	7B7	8/–	25A6G	12/6	956	2/11	EBF80	10/–	EY86	12/6	UBC41	10/–
3Q5GT	9/6	6F15	12/6	7C5	8/–	25L6GT	10/–	AZ1	12/6	ECC84	9/6	EZ80	8/6	UCH42	10/6
3V4	9/–	6J5GT	3/11	7C6	8/–	25Z4G	9/6	AZ31	12/6	ECH42	10/–	EZ81	9/–	UF41	9/–
5U4G	6/6	6K7G	2/11	7H7	8/–	35L6GT	9/6	B36	17/6	ECL80	13/6	PCC84	9/–	UL41	10/–
5Z4G	9/6	6K8G	7/6	7S7	9/6	35W4	8/–	CY31	12/11	ECL82	13/–	PCF80	10/6	UY41	8/6
6AG5	5/6													UY85	10/–

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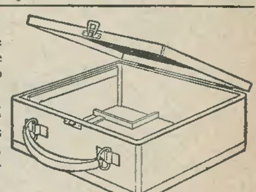

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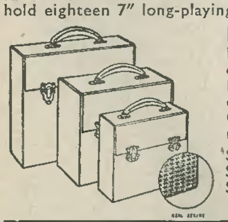

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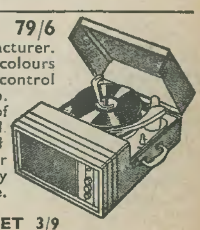

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continued from page 477

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