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Practical Electronics

URGENT NEED

As part of the current plans to increase national productivity, four key industries have been selected for special guidance and sponsorship by the government. They are: machine tools, electronics, telecommunications, and computers. Since the last two mentioned are in fact specialised branches of the general electronics industry the inference is clear—the country's future rate of industrial development rests very largely upon the efforts and achievements of those engaged in applied electronics, particularly the higher qualified scientists, engineers and technologists.

★ ★ ★

Do we collectively as a nation really appreciate this fundamental truth of the technological age which is just in its infancy? It appears not. For some time now enlightened authorities have been issuing warnings concerning the inadequate number of qualified engineers produced by our educational establishments each year. Comparison with other leading industrial countries shows that we are lagging dangerously behind in technical education. Lord Snow, Parliamentary Secretary to the Ministry of Technology, recently stated that while every arts subject place in every university in Britain is filled, there remain vacant hundreds of science and technological places.

Unfortunately this is not altogether surprising. Traditionally in this country the pure sciences and arts have always been held in higher esteem than the applied sciences and technology, with the regrettable consequence that the engineer has never been accorded the status he deserves and which his counterpart in most other countries enjoys.

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Why should this tradition persist in our highly industrialised society? It cannot be because of any natural adversion to scientific and technical subjects as such. The creative, inventive spirit is usually there—it just requires stimulating. After all, many white collar professional people pursue hobbies of a scientific or technical nature in their leisure hours. And indeed one is tempted to speculate that many of these individuals would have quite happily embarked on an engineering career had they not been deterred from this course by parents or teachers at some vital period in their youth.

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There is ample evidence that lively interest in the subject of electronics exists among members of the younger generation of today. Those in positions of authority or influence should be on the alert for promising talent in this field and offer encouragement, pointing out the great opportunities the future has to offer to the qualified engineer.

THIS MONTH

CONSTRUCTIONAL PROJECTS

SPECIAL SERIES

GENERAL FEATURES

NEWS AND COMMENT

Our March issue will be published on Thursday, February 11

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THE COLOUR TELEVISION CONTROVERSY

The first public colour service began in the United States in 1951 using a system developed by the Columbia Broadcasting System. A major disadvantage with this system, however, was that the transmissions could be received only on a colour receiver, whereas parallel development had by then shown that it was possible to devise a *compatible* system which would allow black-and-white receivers to display a monochrome picture from the same transmissions.

So even while the CBS system was operating, a number of American organisations and manufacturers were co-operating through the National Television System Committee (NTSC) to evolve a new compatible system. The resulting system, known as NTSC, owed much to the pioneer work of the Radio Corporation of America at the end of World War II but with some notable improvements.

BY PATRICK HALLIDAY

MEETINGS of Study Group XI of the International Radio Consultative Committee (CCIR) to be held in Vienna between 24 March and 7 April will make a final effort to agree upon a single system of colour television for use throughout Europe. These meetings will be the culmination of more than two years of intense, and at times bitter, controversy between the supporters of three different systems: NTSC, SECAM and PAL.

Why, many people have been asking, has it taken so long to determine which is the best system? Could not half a dozen engineers have carried out a few tests and within a couple of months have come up with a clear and unambiguous verdict?

To appreciate the reasons for the long-drawn-out arguments, stretched over many meetings of the European Broadcasting Union Ad Hoc Committee on colour television and the higher-level CCIR meetings which so far have failed to reach agreement, it is necessary to trace briefly the recent history of colour television which began with a demonstration by John Logie Baird as long ago as 1928.

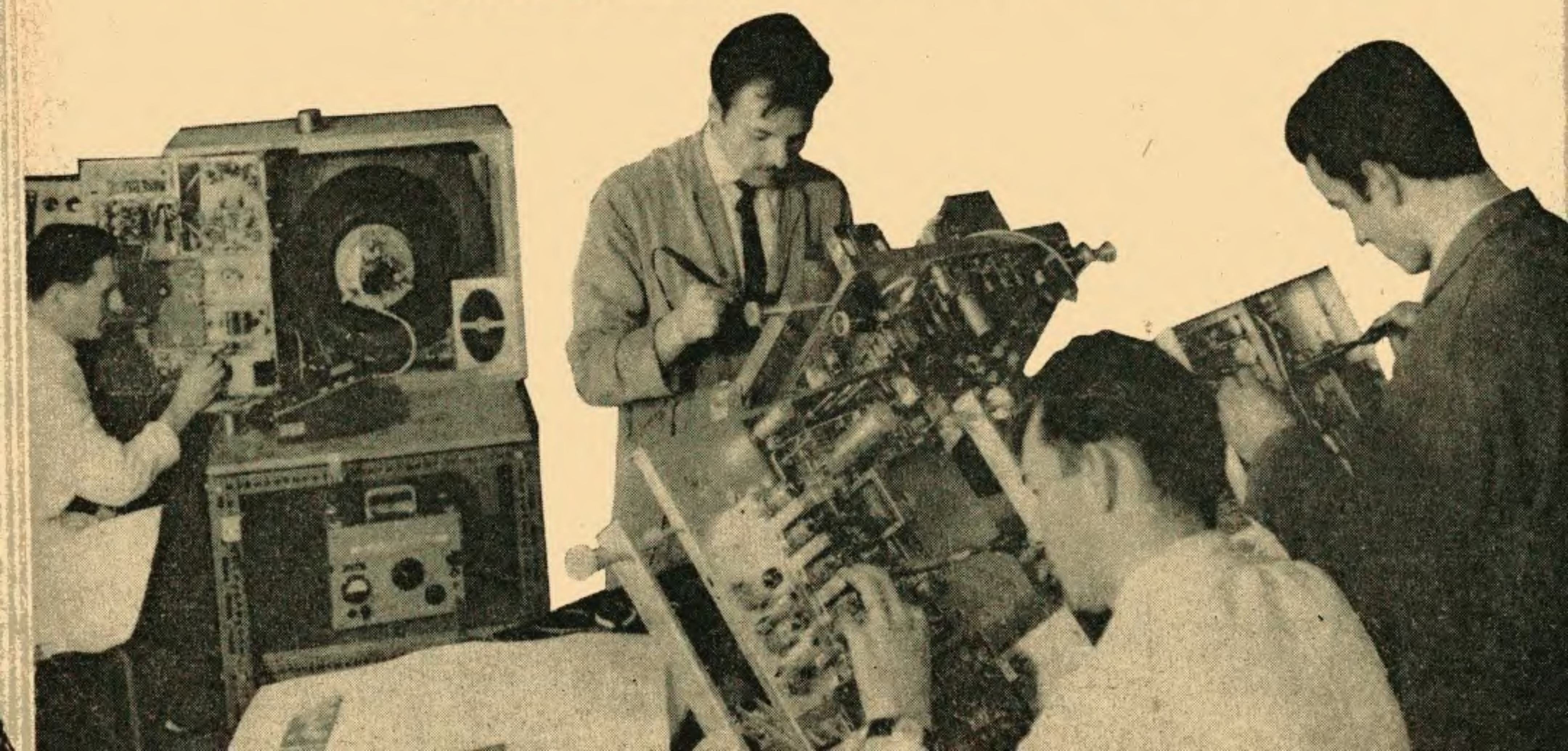
After field trials, the NTSC system was officially approved by the Federal Communications Commission and was brought into use on 1 January, 1954, as the standard American system. It has since been adopted in Japan and also in South America.

It can be fairly claimed that the NTSC system resulted from almost eight years of continuous development work, first by RCA and later by almost the entire American industry. All engineers who have worked with the system have paid tribute to the ingenuity of the solutions found to the many problems involved in devising a fully compatible system occupying no more bandwidth than the equivalent black-and-white system.

THE NTSC SYSTEM

Briefly, NTSC is a three colour system based on the principle that almost any colour can be defined in terms of the amounts of red, green and blue light present in the original picture element. By combining the three colour components in definite proportions, a signal corresponding to a black-and-white transmission—the *luminance* signal—is created.

SECAM colour receivers being assembled at the CFT factory near Paris



Two further signals are derived, each formed by combining the red and blue components in different ways with the luminance signal. These two additional signals, providing what is termed the *chrominance* information, are then *encoded* with the luminance signal into a single transmission.

With NTSC, the method of encoding is to transmit the two chrominance signals on a single sub-carrier which, for a 625-line system, is approximately 4·429687Mc/s (a multiple of half the line-scanning frequency). The means adopted to allow two different signals to be modulated on to a single sub-carrier is termed *quadrature modulation* and is similar to the manner in which two stereo sound tracks are recorded on the single track of a stereo gramophone record. It depends essentially on our ability to transmit two a.c. waveforms independently provided that these have a basic 90 degree phase difference, and that we subsequently use a detector which is sensitive to phase. The sub-carrier is thus modulated both in amplitude and in phase, and is thus sensitive to changes in either of these characteristics.

The actual sub-carrier is not transmitted with NTSC but is suppressed during the modulation process so that only the sidebands are transmitted. By careful selection of the nominal sub-carrier frequency, these sidebands can be mixed with the main luminance signal in such a way that they have relatively little effect upon a black-and-white receiver.

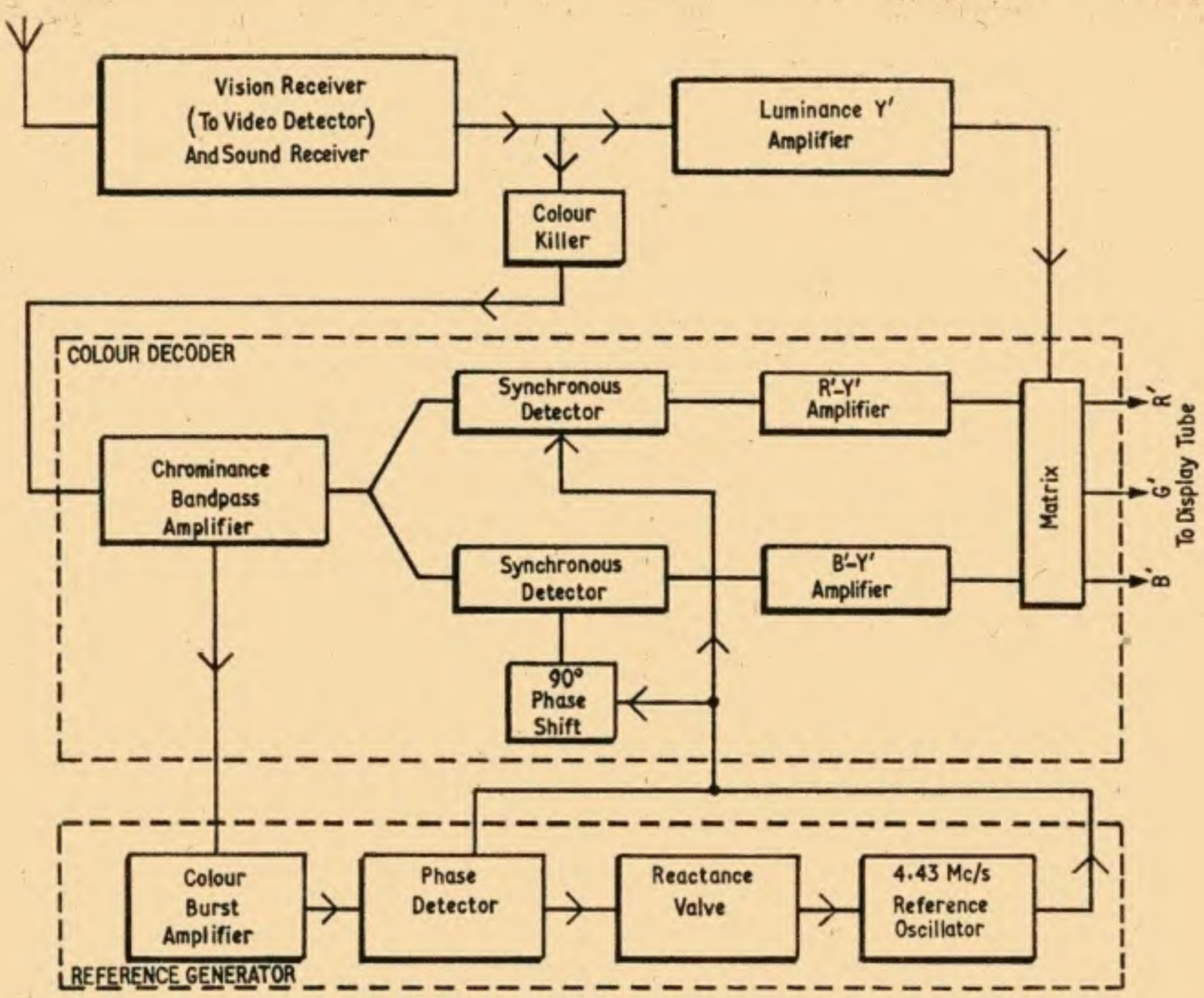


Fig. 1. Basic outline of a typical NTSC receiver

SHADOWMASK TUBE

In an NTSC colour receiver, all these various signals have to be separated and recovered and then applied to the display device which, until recently, has always been the *Shadowmask* cathode ray tube containing three separate electron guns, originally developed by RCA.

To recover the chrominance information, it is necessary to use synchronous detection requiring the re-insertion of a locally generated sub-carrier locked in frequency and phase to the original suppressed sub-carrier. To enable this to be done, short *colour bursts* of sub-carrier are transmitted during the back porch of the line sync periods to enable a local crystal-controlled oscillator to be synchronised with the high degree of accuracy which is necessary. Once the two *colour-difference* signals and the luminance signals have been recovered, it is possible to derive from these the basic three colour signals which are reproduced by means of the shadowmask tube.

There is no question but that, with the transmitter and receiver correctly set up and with a good propagation path between them, the NTSC system provides excellent colour pictures. This is recognised even by those who prefer the rival systems which, in fact, have very many points of similarity with NTSC.

HUE CONTROL

It was, however, fairly soon noted that NTSC put extremely exacting requirements on the transmitters, studio equipment and the links between them, and depended for faithful colour reproduction on the reasonably accurate setting of a number of controls at the receiver. For instance, the precise setting of the reference oscillator for re-injecting the sub-carrier, governs the hues. For final adjustment a user control is always provided (though some engineers consider that this could be eliminated with the latest techniques). Many Europeans who watched colour television in the United States have complained that the user hue control is often incorrectly set.

And when in the late 'fifties magnetic tape recorders for television were developed by Ampex and RCA, it remained for some years impossible to record colour pictures in this way.

These and other considerations led some engineers—particularly those outside the United States where no regular colour service had been established—to continue the search for improved techniques, which did not depend to such an extent upon the rather tricky characteristics of phase plus amplitude.

Many different systems and techniques were evolved, but most of these were soon eliminated from serious consideration. Where they did overcome the phase problem, they tended to introduce new problems or else resulted in very expensive receivers. But two systems were deemed worthy of further consideration; these were SECAM (the name is derived from a combination of the French words for "sequential and memory") and PAL ("phase alternation line").

THE SECAM SYSTEM

The SECAM system, originally developed by M Henri de France and in recent years by the Compagnie Française de Télévision—a company specially set up for this purpose by the large French electronics firm

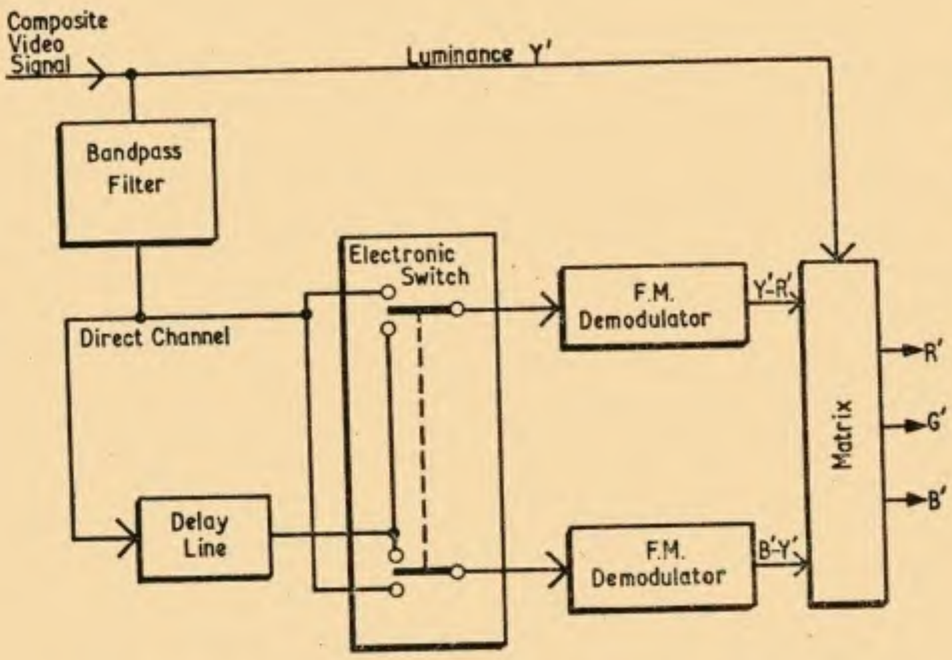


Fig. 2. Simplified decoder for SECAM receiver

CSF and a major French glass manufacturer Saint-Gobain—has passed through several phases. Basically it is distinguished from NTSC in that no attempt is made to transmit the two colour information signals simultaneously, but instead these are sent one at a time consecutively during alternate line periods. This eliminates the need for quadrature modulation and synchronous detection in the receiver, with their requirement for accurate phase conditions.

On the other hand, the SECAM system requires a special "delay line" in the receiver in order to store the colour information transmitted during one line period so that it is also available during the subsequent line period; by this means during any line period, both colour signals are available simultaneously even though only one is being transmitted at any time. With a 625-line system, the delay line has to store the signals for exactly the period of one line—that is 64 microseconds.

In the original SECAM system, the colour information was transmitted simply by conventional amplitude modulation of a sub-carrier, but the system was later improved when a change was made to frequency modulation of the sub-carrier. As in NTSC, the main carrier is modulated with the luminance signal.

With the elimination of quadrature modulation and the substitution of a rugged f.m. sub-carrier, the signal is much less susceptible to the various forms of distortion, such as differential-phase errors and differential-gain errors, which can seriously mar an NTSC picture. One result is that a SECAM signal can be sent much more easily over long microwave links or coaxial cable links between studios and transmitters, and it can also be recorded on magnetic tape almost as easily as a black-and-white signal.

At the receiver, with no synchronous detectors or reference oscillator, there is no need for a user-operated hue control.

Since only one colour-difference signal is being transmitted at any given time, instead of the two with NTSC, it might be thought that the vertical colour definition would be seriously impaired. Theoretically this is so. However, it is one of the fundamental principles of colour television that what the eye cannot detect does not matter. The eye views colour much more crudely than black-and-white picture definition (a fact which allows children to produce good coloured pictures provided that they are given a black-and-white outline to work upon). So this halving of the vertical colour resolution has little or no effect in normal circumstances. In practice, as SECAM supporters point out, the horizontal colour resolution of both systems is reduced to an even greater extent by bandwidth limitation.

THE PAL SYSTEM

The PAL system did not arrive on the colour scene until 1962. It was devised by Herr W. Bruch of Telefunken, whose fertile brain had earlier produced a number of colour systems as well as many of the standard circuits used in black-and-white television receivers. He has told me how he first became dissatisfied with experimental work on the NTSC system and turned to SECAM but found that this had, in his opinion, a number of limitations and so set about developing his own systems.

The most promising of these, PAL, is in many ways a development of a system investigated in the United States in the early 'fifties but passed over in favour of NTSC, combined with receiver techniques of the SECAM system. It differs from NTSC only in one small but important respect; the phase of one of the two colour information signals is reversed between alternate line periods. By this means, phase errors in the studio equipment, transmission links, propagation path and in the receiver—which would otherwise result in the need to compensate for incorrect hues—are averaged out between one line and the next, and are not apparent to the viewer.

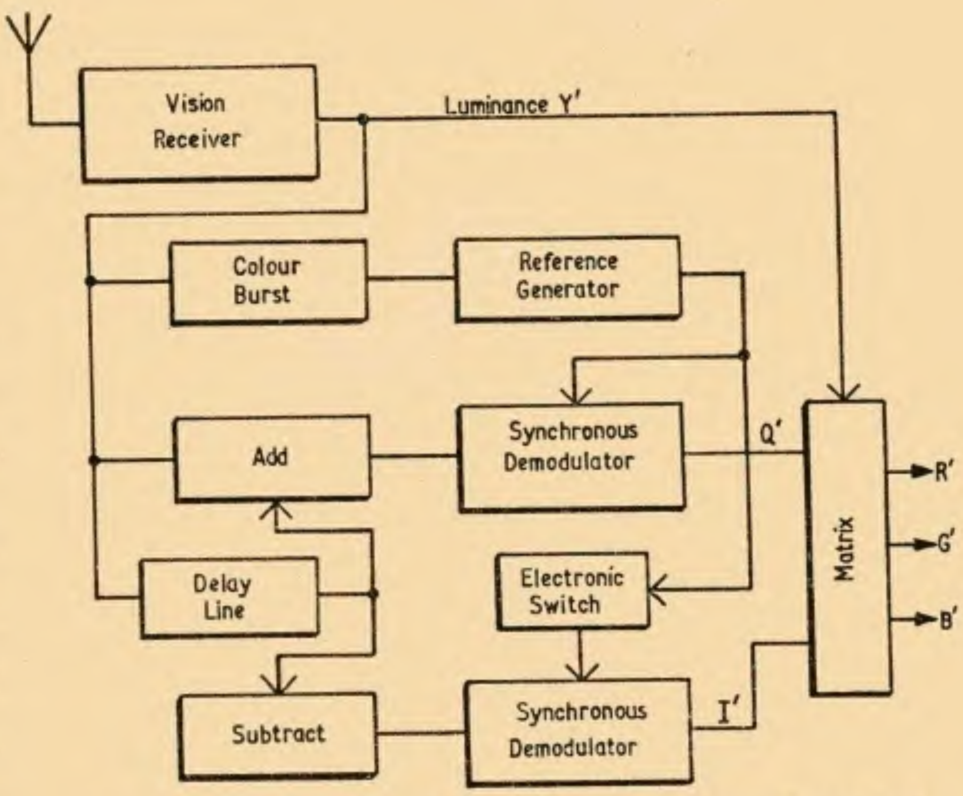


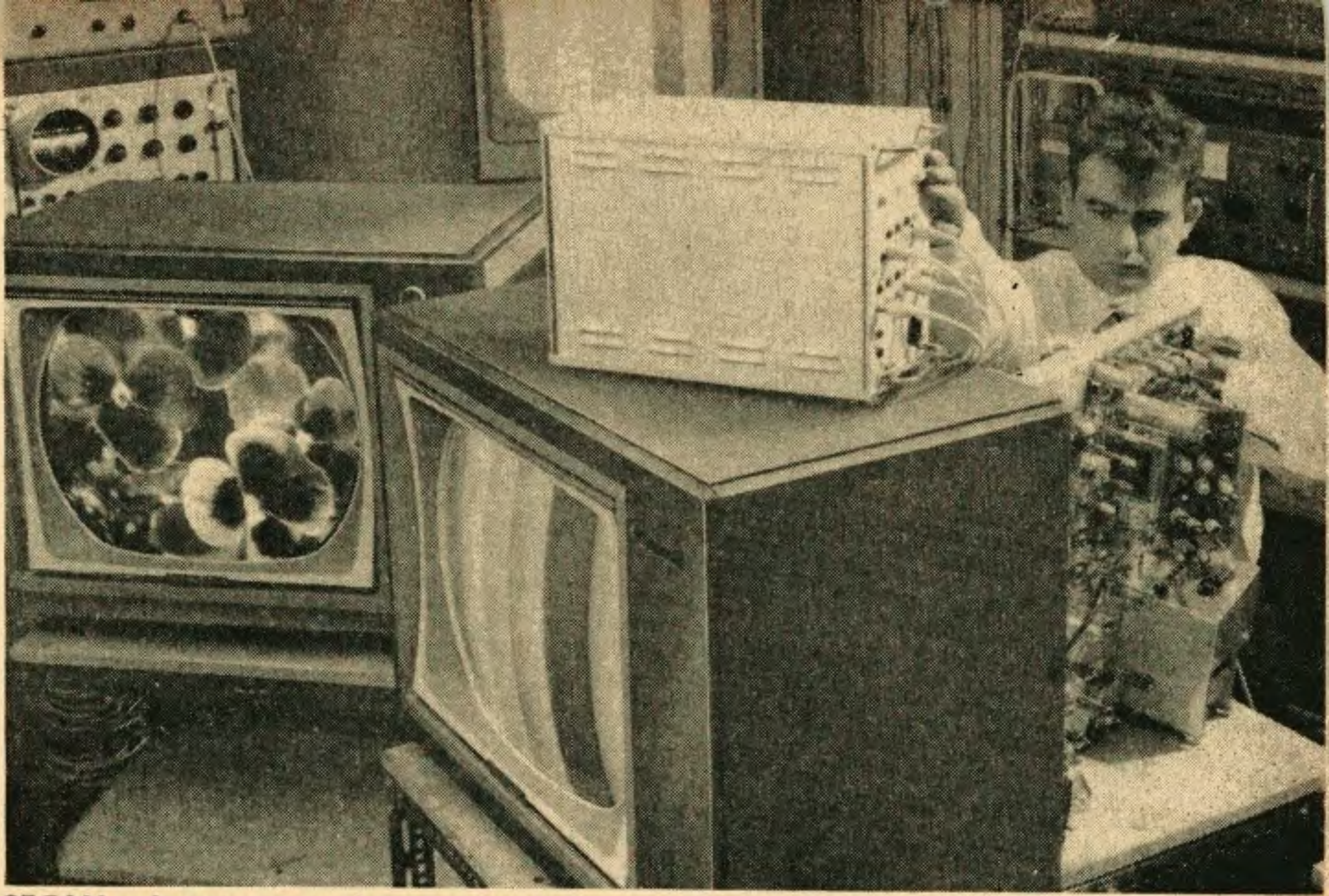
Fig. 3. Simplified decoder for "PAL de Luxe" receiver

This process of averaging out may be carried out by the eye or aided by the incorporation in the receiver of a delay line similar to (but more critical than) that for SECAM and such a receiver has been termed "PAL de luxe"; however, this is not absolutely essential and it is usually envisaged that if PAL were adopted most receivers would not have a delay line—this type of set has been called "People's PAL". A PAL receiver needs an electronic switch to correct the reversals of the phase before the signals are applied to the picture tube, but otherwise is almost identical to those for NTSC systems, though with less stringent stability requirements.

THE FIELD TRIALS

All three systems have been subjected to field trials in the United Kingdom, and there have also been extensive tests of one or more of the systems in a number of other European countries. France, for example, has recently carried out a major trial with SECAM, and NTSC has been extensively tested in Holland. Some important trials in mountainous areas were also carried out in Switzerland. What have all these tests shown?

In the first place, all three systems have proved capable of providing excellent colour pictures. Under the type of conditions which many would view colour, the differences between the systems as reproduced in the home would be so small that they can be disregarded for most practical purposes.



SECAM colour receivers being set up by means of a newly developed CFT waveform generator

During BBC tests in 1963, the SECAM signal definitely gave inferior results under extreme fringe conditions due to the appearance of a granular moving background known as "silver fish". However, CFT then proposed certain changes in the amplitude of the sub-carrier and in the filters, and the modified system (sometimes called SECAM3) has proved much less susceptible to this effect.

TRANSCODING SIGNALS

Almost all colour engineers appear to accept the CFT claim that SECAM signals offer fewer problems to the transmission engineer, being easier to handle over long transmission links and much easier to record on tape; PAL is generally placed between the other two in these characteristics. As a result of a great deal of work carried out by ABC Television at Teddington, the early problems involved in mixing and fading SECAM signals in the studio have been overcome. ABC have also developed extremely efficient techniques for "transcoding" SECAM signals into equivalent NTSC signals—which could be important if NTSC was chosen but the broadcasting authorities wanted to use SECAM encoding for video recording, etc.

On the other hand, recent months have seen a great improvement in the magnetic recording of NTSC and PAL signals, and this can now be performed very satisfactorily on the latest Ampex machines.

The ability to send SECAM and PAL signals over long transmission links (including relays from the U.K. to Rome and back) without the close tolerances demanded by NTSC has also been shown fairly clearly. However, an important modification to the NTSC signal (at least up to the time it is actually transmitted) originally proposed by Dr N. W. Lewis of the GPO and subsequently developed by BBC and GPO engineers, has shown that this problem can be overcome. By attaching additional pilot reference signals to the NTSC colour signal these can be used at the distant end to provide automatic compensation for errors in differential-phase and differential-gain along the links.

ALL SYSTEMS COMPATIBLE

All three systems are "compatible" and reproduce good black-and-white pictures on conventional receivers, but it is true to say that some have proved more compatible than others. In this respect NTSC has been widely judged to have the best performance, followed by PAL with SECAM third (and with SECAM3 considered rather poorer than with the earlier SECAM parameters). This is clearly an important point in favour of NTSC since for many years most viewers will continue to use monochrome sets but too much should not be made of it since the overall difference between NTSC and SECAM3 is so small that most viewers would be unaware of any significant difference, even though these could be detected by trained observers. With SECAM, the f.m. sub-carrier is present within the luminance channel at all times, whereas with NTSC and PAL the strength of the chrominance sidebands depends upon the "colourfulness" (saturation) of the picture element, and for much of the time is very low.

Field trials in mountainous areas have tended to show that NTSC is more susceptible to multipath reception than the other systems—with PAL proving particularly effective in such conditions. It should be remembered that whereas in the United States colour transmissions are mostly on v.h.f., in the U.K. it is intended to radiate colour only on the 625-line system which, at least for a number of years, will be located on u.h.f. The u.h.f. transmissions are generally considered to be more prone to multipath conditions. However, it is only fair to state that the BBC field trials do not suggest this is a major problem except possibly in a few hilly areas. An important claim for PAL is the ease with which it can be handled by low power, unattended "satellite" transmitters.

What of receiver costs? NTSC receivers can draw upon many years of development work and production statistics in the United States and can thus be accurately costed. PAL receivers must inevitably be rather more expensive to manufacture than those for NTSC because of the electronic switch and possible inclusion of a critical delay line. Nevertheless, compared with the total cost the difference would be a small one, especially for the "People's PAL".

The exact cost of making SECAM receivers in large numbers is still to some extent a matter of speculation, although several organisations have prepared reasonably detailed figures. Much depends upon the cost of the delay line—the cost of which would fall with mass production.

Suitable delay lines can be made from quartz or glass, but in 1963 CSF, the parent company of CFT, developed a delay line using steel which has so far proved very satisfactory for this purpose and which it is claimed could be produced cheaply for large numbers. The latest estimates thus put NTSC and SECAM receivers very close, though there is a greater degree of estimation involved in the SECAM figures. CFT believe that with some further development, now well advanced, the SECAM costs could be brought below those of NTSC. But clearly there would not be any major difference between the two.

RECEIVER CONTROLS

How much importance should be attached to the simplification of receiver controls which is possible with SECAM? Those who support NTSC say very little, and some go so far as to say they prefer to have controls for hue (phase) and saturation (amplitude) available. On the other hand, most of the European receivers have been operated in the homes of engineers and others with a technical background. There is evidence from the United States that such controls are often incorrectly set by non-technical viewers.

However, in all three systems, colour reception is also affected to some extent by the setting of the fine tuning control, and it is this control which tends to be blamed most often for any poor colour reproduction. A strong case can be made for the incorporation of automatic frequency control circuits in colour receivers.

One final argument which is sometimes advanced in favour of NTSC is that this system would be easier to use in conjunction with single-gun colour display tubes, should these ever come into widespread use. So far, apart from one Japanese receiver which is to be marketed shortly using a chromatron (Lawrence) single-gun tube, all production receivers for all three systems have utilised the three-gun shadowmask display tube.

To sum up. All three systems have proved to be capable of providing a good colour service —and the 1963 and 1964 trials have provided a valuable spur for further improvements. The majority opinion in the United Kingdom definitely favours the NTSC system, but SECAM is supported by a strong minority of experienced colour engineers. The advantages of PAL are recognised, but the system gains less support in the U.K. largely because of the added cost of the receivers.

In Europe, only Holland apart from the U.K., has openly supported NTSC, with the position of all other countries—including the U.S.S.R.—still to some extent uncertain. We shall have to wait until April to know whether all the conflicting views can be moulded into a single agreed system.

Even if a system is finally chosen, there are a number of problems which will still face British television. The starting of a national colour service is a costly business; there are other calls on available resources, including the expansion of educational television.

DUAL STANDARD RECEIVERS

A special problem exists for Britian—that of dual-standard colour receivers—unless it is accepted by viewers that a separate black-and-white receiver is retained for watching 405-line v.h.f. transmissions. A dual-standard i.f. amplifier introduces problems of phase linearity.

TABLE I

MAJOR COLOUR TELEVISION PARAMETERS

Sub-carrier Frequencies:

625 line NTSC	4·4296875Mc/s
625 line SECAM	4·4375Mc/s (f.m. ± 770kc/s)
625 line PAL	4·43361875Mc/s
525 line NTSC	3·579545Mc/s
405 line NTSC	2·6578125Mc/s

Luminance Signal: $Y' = 0{\cdot}3R' + 0{\cdot}6G' + 0{\cdot}1B'$

NTSC wideband chrominance signal (I') about $\frac{1}{3}$ bandwidth of luminance signal

NTSC narrowband chrominance signal (Q') about $\frac{1}{9}$ bandwidth of luminance signal

Phase relationships (NTSC):

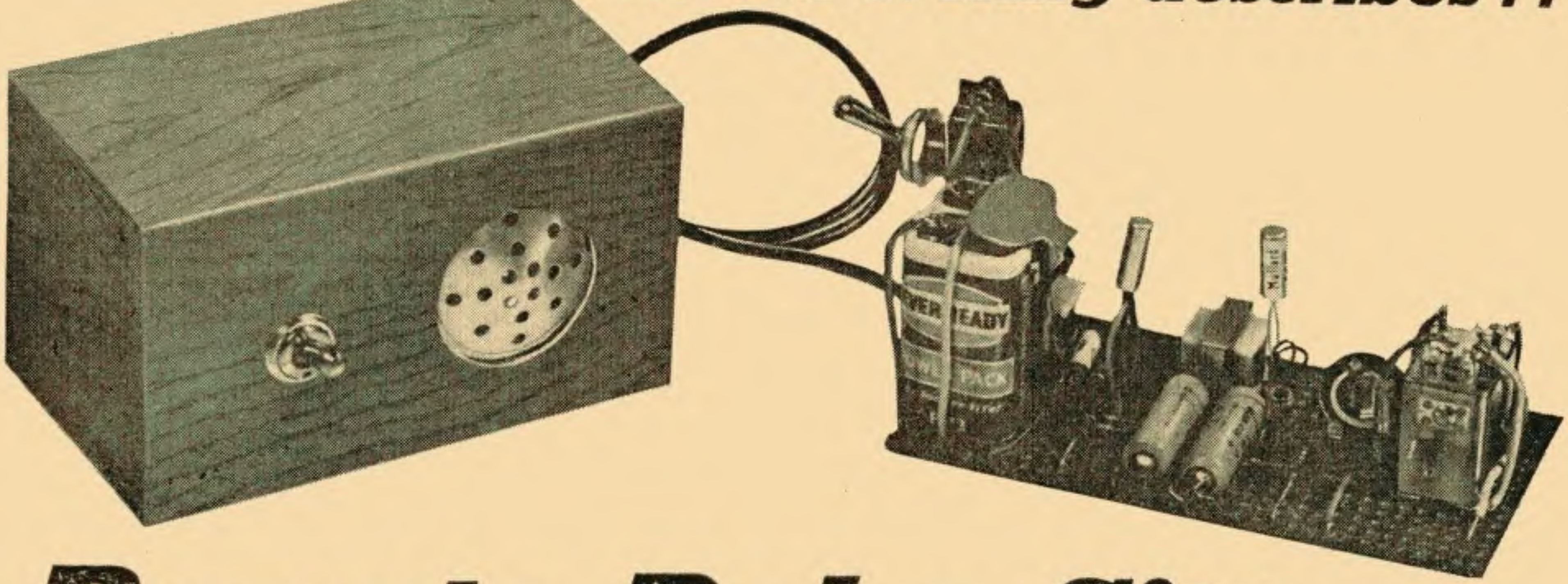
$B'-Y' = 0°$	$I' = 123°$	Magenta = 61°	Green = 241°
$R'-Y' = 90°$	$Q' = 33°$	Blue = 347°	Yellow = 167°
$G'-Y' = 147°$		Cyan = 283°	Red = 103°

In no country has the growth of colour television been as rapid as expected, at least during the early years. It has been said that the greatest competitor to colour is black-and-white television. Nevertheless, today, slightly more than a decade after the start of the NTSC service, American colour television has become a major industry, with sales of receivers—which now cost about 2½ times as much as an equivalent black-and-white set—running at roughly one million a year.

So whatever happens at Vienna, the U.K. and Europe still have a long way to go before colour is likely to be widely used. But the first and urgent problem is for the national administrations to agree on a single system—and that, as we have indicated, is still no easy matter. ★

Colour control consoles at a demonstration in London of British colour equipment and cameras by English Electric and Marconi Company

Gordon J. King describes . .



Remote Baby Sitter...

ONE OF THE problems in domestic life is to hear a child or baby crying in the bedroom while the rest of the family has settled down to an evening's viewing. This problem can be more or less solved by establishing an audio channel between the infant's bedroom and the viewing room.

A microphone placed over the cot will respond to any "alarm signal" and the resulting audio can be fed through screened cable to an amplifier and loudspeaker in the viewing room. This method appears to make sense until it is put into practice. It is then found that unless the amplifier's microphone gain and output power are quite high, a low-level baby cry is invariably masked by the TV sound.

One then tends to keep an ear on both the alarm speaker and the TV sound. This can prove very disconcerting and it is almost as bad as listening for the cries of the baby without any audio assistance. If high gain and high power are adopted in the audio channel, hum can become a problem and all kinds of unwanted noises can be picked up.

AUDIO ASSISTANCE

An alternative arrangement is to employ the television's audio channel and feed the amplified microphone signal into this, thereby causing the alarm signal to be superimposed upon the TV sound.

This arrangement has been used quite successfully in practice and at least one set manufacturer adopts it as an extra. The microphone signal is fed to the audio stages of the set through a small transistorised audio section, which is fitted to the inside of the set, picking up its power from the set's power supply.

Nevertheless, a better arrangement is for the alarm signal to mute the TV sound while at the same time directing it through the set's audio channel. The cries of the baby cannot then be missed. With this idea in mind the author proceeded on the following lines.

There are two sections. The first is a microphone amplifier and the second a control unit. Both are powered from internal batteries. Since the control unit is connected to the inside of the television set, isolation from any possible high voltage source has been adopted.

Since the alarm signal has to operate a relay a reasonable degree of pre-amplification is essential, especially as the actual sound may be at very low level. To cater for this the microphone amplifier has two stages; the control unit adds a third stage.

MICROPHONE AMPLIFIER

The microphone amplifier circuit is shown in Fig. 1. Here we have TR1 with a fairly high impedance input feeding TR2 with a transformer as its collector load.

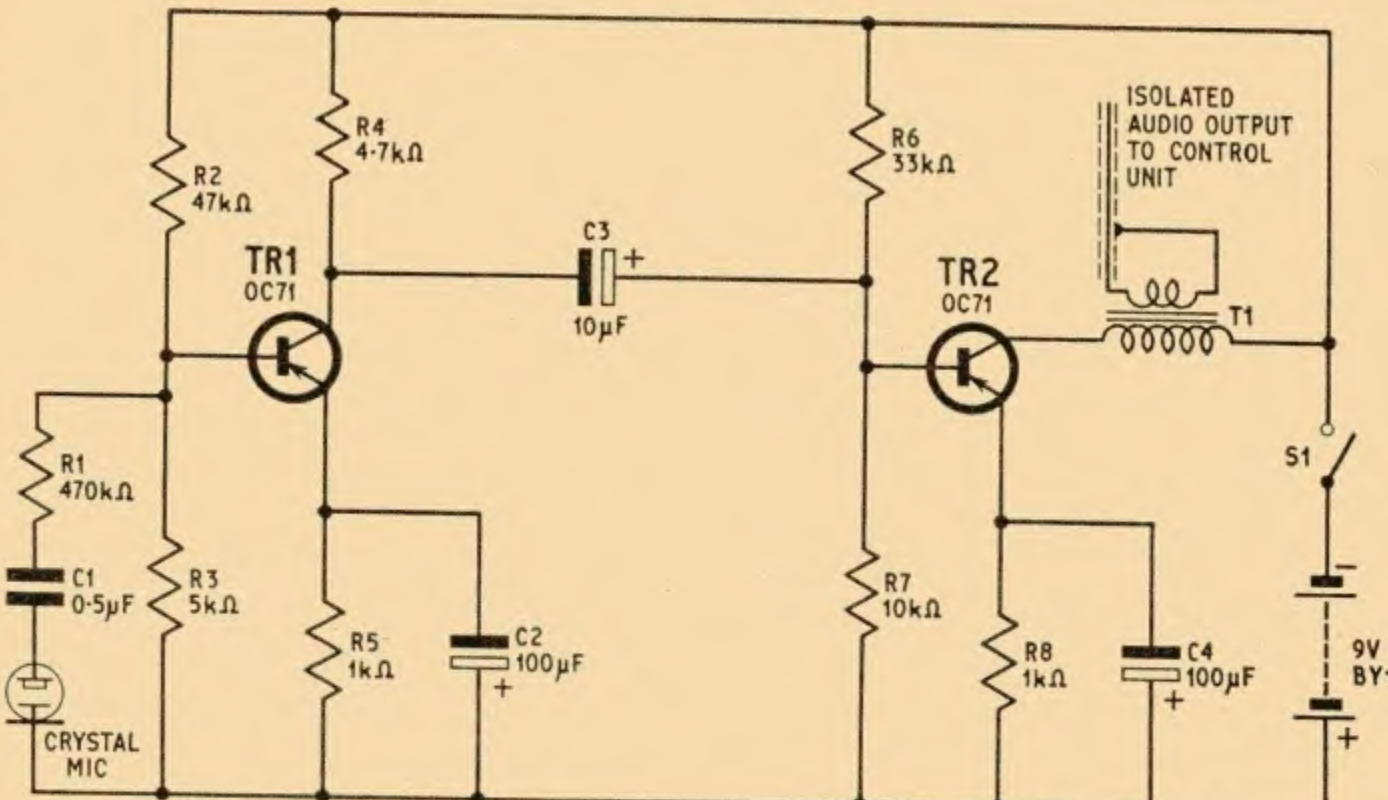


Fig. 1. Circuit of the microphone pre-amplifier which is situated close to the child

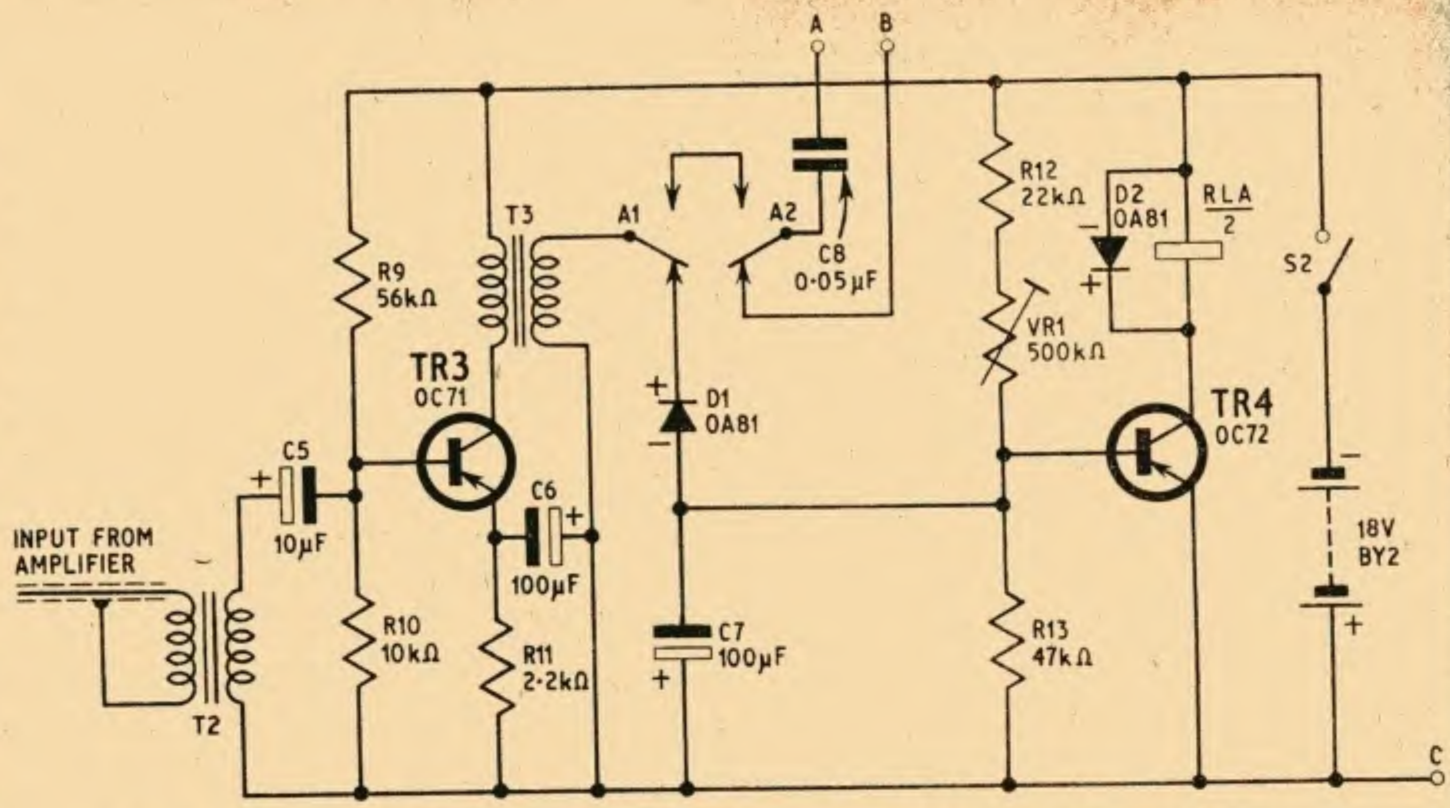


Fig. 2. Circuit of the control unit to be mounted in the broadcast receiver

Both stages are in the common-emitter mode and the high impedance at the input is provided by the 470 kilohm series resistor at the base of TR1. This permits the use of an inexpensive crystal microphone or microphone insert. A very high input impedance would be needed with such a microphone in high quality sound reproduction, but since we are not unduly concerned with the aesthetics of sound in this application we can afford to use a low input impedance. With a crystal microphone this results in a loss of bass response, but provides a high level input which is desirable to achieve as high an output signal as possible.

Instead of a crystal microphone a cheap moving-coil unit can be used if it is connected to the base via a suitable matching transformer. It may be possible to secure greater microphone sensitivity by this means, but the output from a crystal unit is generally quite high and one can afford to loose a bit of gain by the series matching resistor. If it is found that extra microphone gain is necessary the series resistor may be reduced to about 100 kilohms.

Most of the signal gain is given by TR2. This, again, is in the common-emitter mode in a very straightforward circuit. Good d.c. stabilisation is applied to both transistors by the base potential dividers and the emitter resistors. These need to be by-passed by electrolytic capacitors to avoid feedback.

Incidentally, by introducing about a 100 ohms of unby-passed resistance in the emitter of TR1, negative feedback is applied to the stage which itself has a tendency to increase the input impedance. This can be tried if improved quality audio is felt desirable or if the overall gain is too high.

CONTROL UNIT

The control unit has one OC71 and one OC72. TR3 is an audio amplifier and TR4 is the control transistor (see Fig. 2).

The alarm signal from the secondary of the microphone amplifier transformer (T1) is coupled through screened cable (coaxial cable is suitable) to the primary of the control unit's input transformer, T2. The signal across the secondary of T2 is applied to the base of TR3.

This transistor, as with the others in the pre-amplifier, is arranged to give a high gain in the common-emitter mode, with transformer loading in the collector. However, this time the secondary of the transformer is connected to a rectifier and time delay circuit comprising D1, R13 and C7. This circuit is maintained through the contacts A1. Fig. 2 shows the conditions of all relay contacts when the relay is de-energised.

Now let us consider the action of the control transistor. Assuming that there is no audio signal from the microphone, TR4 is arranged to be almost non-conducting.

The collector current through the relay winding is so small that the relay fails to operate. This condition is set by the preset potentiometer in the top arm of the base potential divider. Adjustment is made so that the relay energises and holds. Then the control is increased in resistance until the relay just drops out. This is the most sensitive threshold state.

Under this condition a slight increase in collector current will bring in the relay. This, of course, is incited by an increase in forward current in the emitter-base junction of the transistor, by making the base go more negative with respect to the emitter.

When the baby cries the amplified signal across the secondary of T3 is rectified by D1. The resulting d.c. makes the top of the base resistor R13 go negative with respect to the battery positive line. In other words, the base of TR4 is caused to go more negative with respect to its emitter. This increases the collector current which operates the relay.

Now, when C7 and R13 have developed a voltage across them, the reservoir capacitor C7 charges. At the same time contact A1 on the relay changes over. This disconnects the signal from the rectifier D1. The charge in C7 keeps this transistor conducting until the capacitor has discharged through R13 and the transistor. The discharge time depends upon the value of C7 and R13.

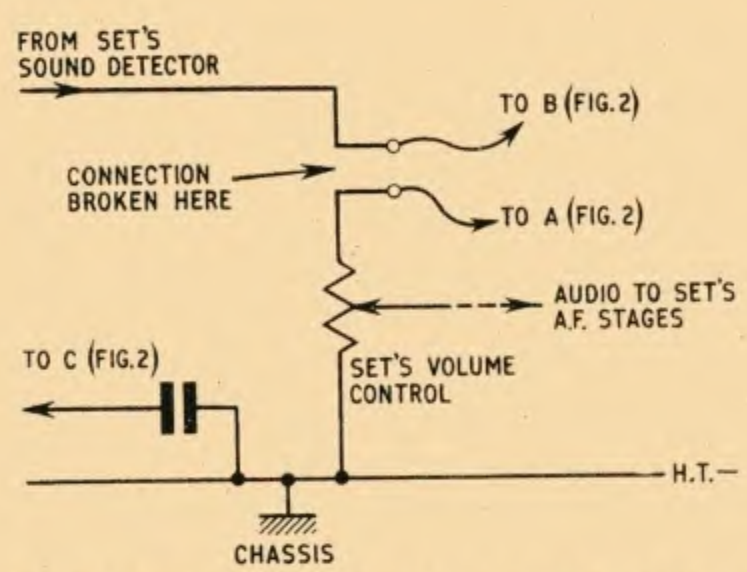


Fig. 3. Modification to the television or radio volume control circuit to accept the control unit

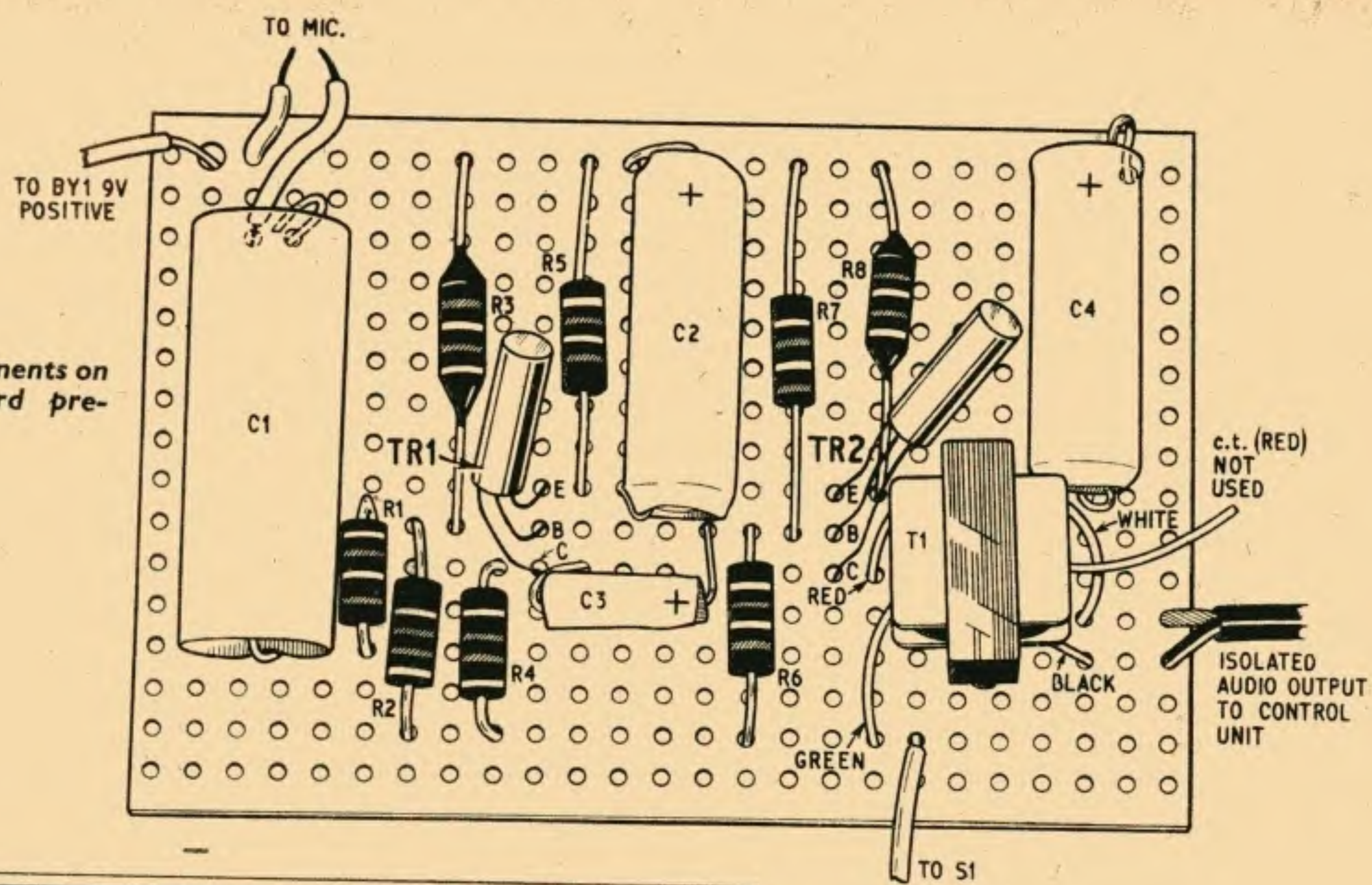


Fig. 4. Layout of components on the printed wiring board pre-amplifier unit

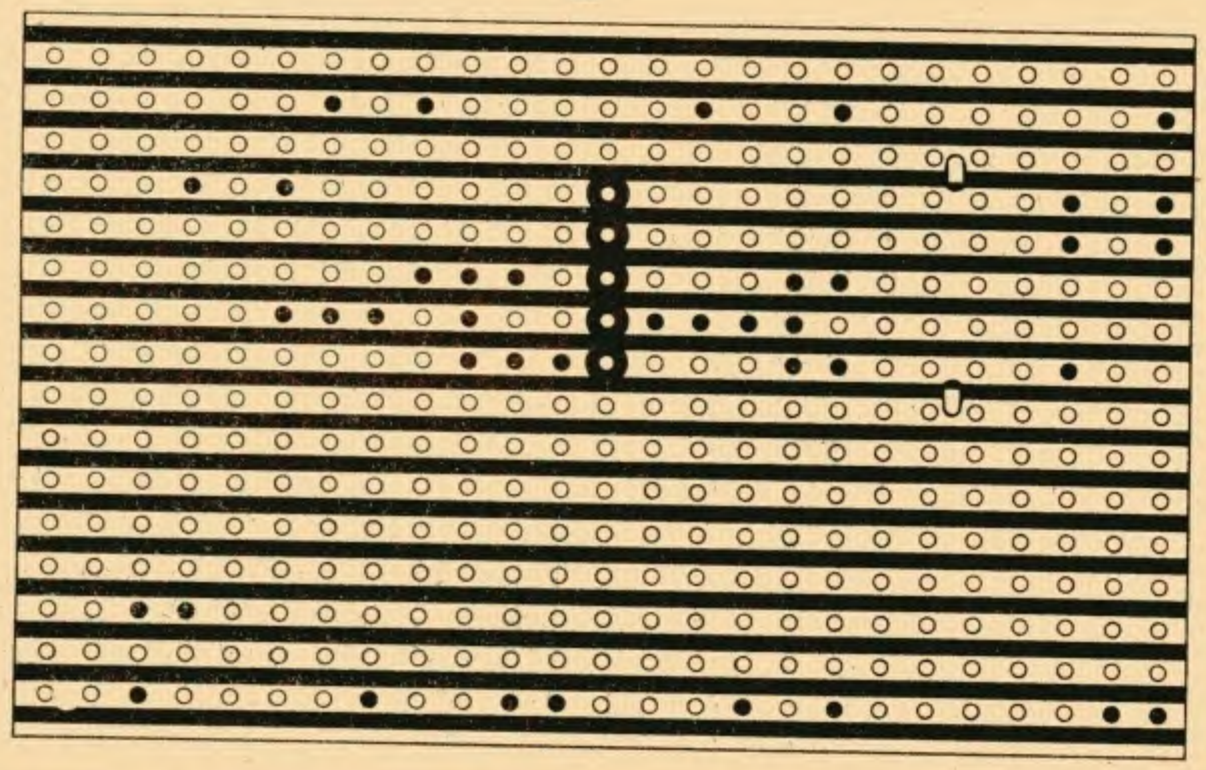


Fig. 5. Underside view of the pre-amplifier unit showing the breaks in the copper strips. The black dots indicate the holes which are used for component wiring

Contact A2 on the relay also changes over when the baby cries. The audio across the secondary of T3 is conveyed through A1 and A2 to terminal "A" in Fig. 2.

TV RECEIVER CONNECTIONS

It should be emphasised at this point that receivers which are on hire purchase or on hire from a television rental company should *not* be used for the experiment. Privately owned sets only can be used.

Fig. 3 shows the modification to the television receiver to secure the muting condition and establish an audio path into the audio stages of the set. All commercial sets have a volume control. The slider of this control connects to the audio amplifier in the set, the "bottom" of the control is connected to the receiver chassis while the "top" of the control is connected to the set's detector circuit.

All we need to do is to break the circuit at the top end of the volume control, as shown, and then remake the circuit through terminals "A" and "B" on the control unit. Thus, while relay contact A2 remains in the position shown in Fig. 2 the audio signal from the set's detector gets back to the volume control and the sound channel of the set functions in the ordinary way. However, when the baby cries and the contacts change over, the television audio circuit is broken.

Under this condition contact A1 has also changed over. This means that the audio across the secondary of T3 is passed via terminal "A" to the top of the volume control, in place of the television signal.

It is, of course, necessary to establish an "earth" circuit for the audio, and this is done by connecting terminal "C" (Fig. 2) to the chassis of the receiver, as shown in Fig. 3. Note the d.c. isolating capacitor in the earth circuit.

DANGER!

The majority of television sets are made for a.c. or d.c. mains. Instead of using a mains transformer the heaters of the valves and the picture tube are connected in series, with a voltage dropper also inserted to make up the mains voltage. Since there is no mains transformer, one lead from the mains supply is connected to the metal chassis of the set, or to the h.t. negative line, or both. If this happens to be the "live" side of the mains a serious, if not fatal, electric shock could be received by anyone touching any circuit or connection made to the chassis.

The aspect is entirely different when connections are made inside the set and then exposed outside. *Extremely dangerous conditions could arise unless the following precautions are taken.*

The design of the system is such that mains isolation is given both at the output of the microphone amplifier and at the input of the control unit by transformers T1 and T2 respectively. This means that neither the pre-amplifier, microphone, nor the coaxial link between the amplifier and the control unit could be "live".

However, it is necessary to make connections from the receiver chassis or h.t. negative line to the control unit to complete the audio circuit. The "earthy" connection from the set is made through a 0·05μF isolating capacitor which is best mounted on the television chassis. Under normal conditions of listening to a programme, terminals "A" and "B" are shorted by a pair of contacts on the relay.

When the baby cries we get a circuit from the "earthy" side of the set, through the volume control, through contacts A1 and A2 and through the secondary of T3 to the battery positive line of the control unit. To be doubly safe a 0·05μF capacitor is connected in series with the circuit at terminal "A". This means that an extra capacitance exists in the TV audio circuit and a little drop in bass may be observed. If this drop is apparently severe the capacitance may be increased to 0·1μF or 0·25μF.

CONSTRUCTION

The microphone pre-amplifier unit is built on a piece of Veroboard measuring 3⅞in × 2½in (see Figs. 4 and 5). The transformer mounting lugs are passed through holes which have to be drilled, then bent over on the underside. Make sure that these lugs do not short with any other components A special tool is available from Vero Electronics for breaking the copper strips but a twist drill or penknife may be used.

Sub-miniature components are used for both units and there should be ample space for mounting the batteries on the boards. When wiring the switches and microphone it is a good idea to use stiff wire so that they can be held in position for mounting into a suitable case. This can be seen in our heading photograph.

The control unit is built on a piece 5in × 2½in. The relay is mounted as shown in Figs. 6 and 7, the holes for the relay mounting screws being drilled between the strips. The copper is cut away from the holes so that when the screws are fixed they do not short (see Fig. 7).

The copper should be trimmed to accept the transformer mounting lugs without breaking the strips (see Fig. 7) and without shorting adjacent strips.

The 500 kilohm potentiometer is of the 'skeleton' printed circuit type. By carefully bending one tag completely back 180 degrees and bending the slider tag slightly the preset will stand on the board without any additional wiring.

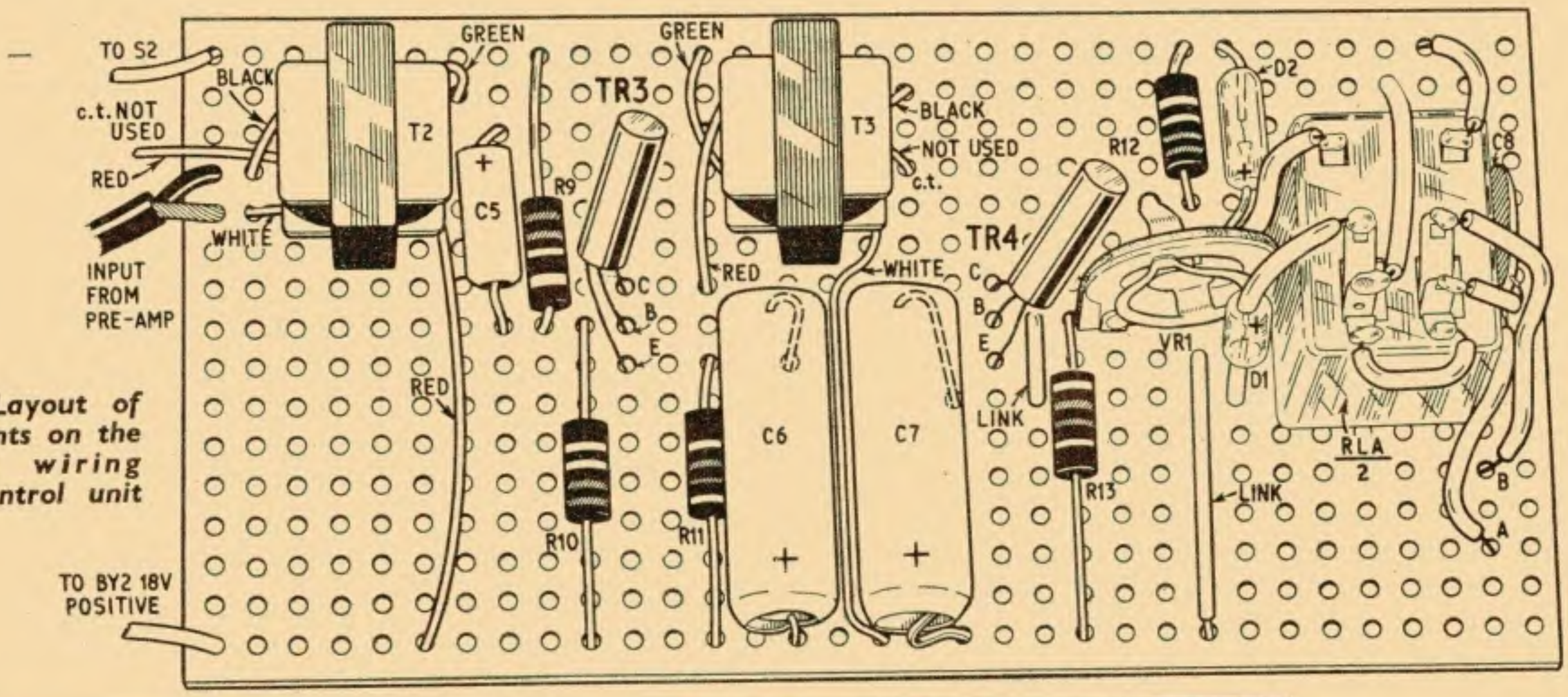


Fig. 6. Layout of components on the printed wiring board control unit

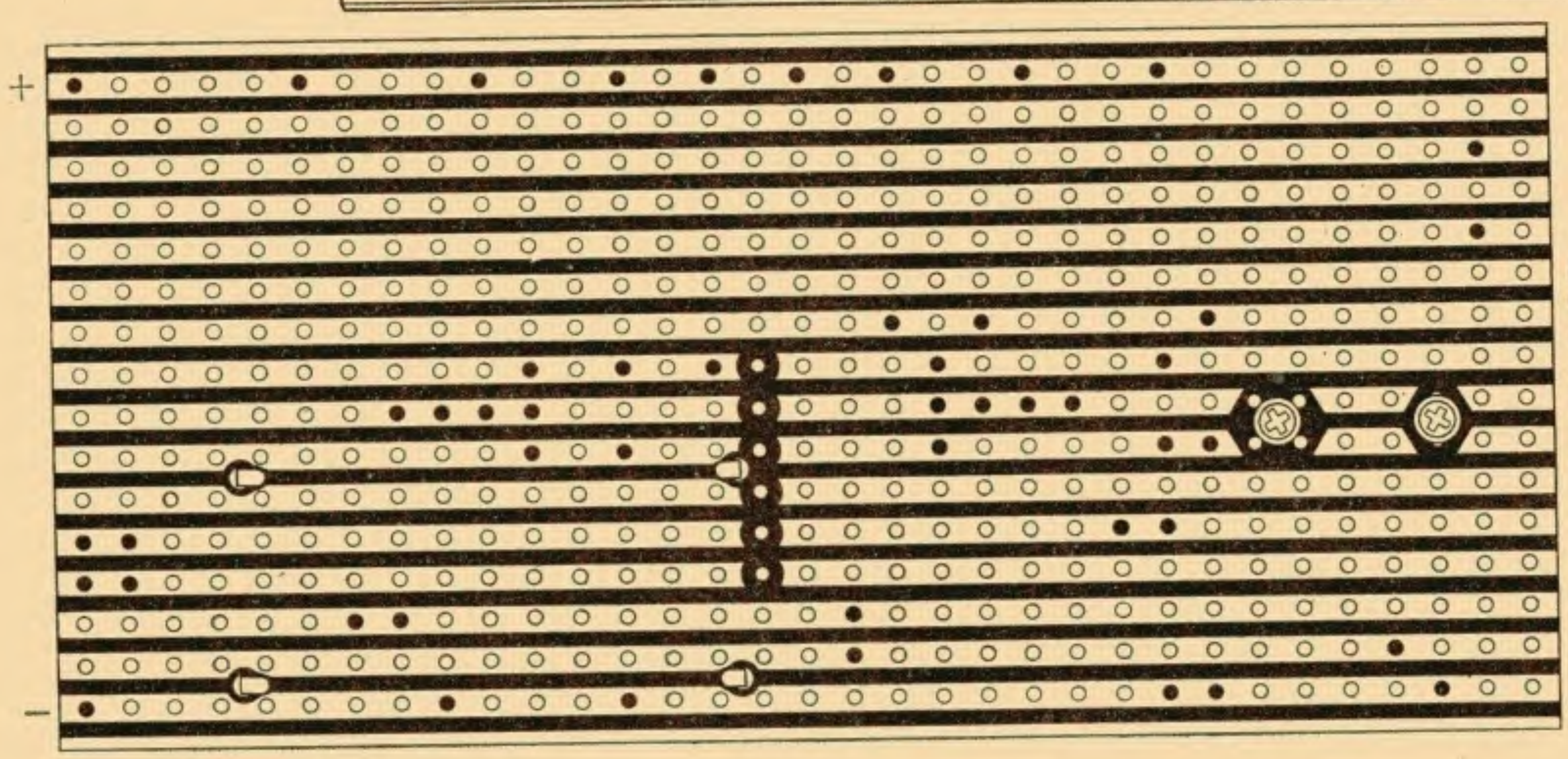


Fig. 7. Underside view of the control unit. The black dots indicate the holes which are used for component wiring

COMPONENTS . . .

MICROPHONE PRE-AMPLIFIER

Resistors

R1 470kΩ | R5 1kΩ
R2 47kΩ | R6 33kΩ
R3 5kΩ | R7 10kΩ
R4 4·7kΩ | R8 1kΩ

All resistors ¼W 10% carbon

Capacitors

C1 0·5μF 150V paper T.C.C. P988/9
C2 100μF 10V elect. T.C.C. Elkomold A2
C3 10μF 12V elect. T.C.C. CE3H
C4 100μF 10V elect. T.C.C. Elkomold A2

Transistors

TR1 and TR2 OC71 (Mullard)

Miscellaneous

T1 Rex type LT44 transformer (Henry's Radio)
S1 Single-pole, on-off switch
BY1 9V layer type battery
Crystal microphone insert (Henry's Radio)

Veroboard

VB1503 2½×3⅝in } Home Radio (Mitcham) Ltd.
VB1504 2½×5in }

CONTROL UNIT

Resistors

R9 56kΩ | R12 22kΩ
R10 10kΩ | R13 47kΩ
R11 2·2kΩ | All resistors ¼W 10%

Potentiometer

VR1 500kΩ preset log (Radiospares skeleton)

Capacitors

C5 10μF 15V elect. T.C.C. CE5H
C6 100μF 20V elect. T.C.C. Elkomold B2
C7 100μF 20V elect. T.C.C. Elkomold B2
C8 0·05μF 100V paper T.C.C. CP201H

Transistors

TR3 OC71 TR4 OC72 (Mullard)

Transformers

T2 and T3 Rex type LT44 (Henry's Radio)

Diodes

D1 OA81 D2 OA81 (Mullard)

Relay

RLA Type MH2, 700Ω (Keyswitch Relays Ltd., Cricklewood Lane, London, N.W.2)
Two sets of changeover contacts on relay

Miscellaneous

S1 Single-pole, on-off switch
BY1 Two 9V batteries in series

The units can be made up on printed circuit boards or similar assemblies (see Fig. 4). The control unit can then be fitted to the inside of the receiver cabinet. It should be mounted well clear of high temperature components, since transistors can be damaged if overheated.

Thermal runaway should not occur as the stabilisation is good, but collector leakage in TR4 could upset the threshold adjustment made on the preset potentiometer, and either prevent the relay coming in when it should or cause it to come in when it should not.

With the assembly fitted inside the cabinet, the isolation precautions mentioned previously would be less important and would apply mainly while the unit is under adjustment outside the cabinet. Care should be taken to ensure that the coaxial cable links do not make inadvertent contact with any part of the set.

Alternatively, the assembly could be housed in a small plastics box which can either be fitted in the set or can be stood on the table behind the set. The quiescent consumption of the control unit is only about a milliampere although it does rise to several milliamperes when the relay is energised, meaning that a pair of type PP4 or similar 9 volt batteries should be used.

The microphone amplifier can also be housed in a similar type of box with one 9 volt battery and an on-off switch. By using a small crystal microphone insert, it is possible to fit the microphone in the box with the printed board assembly. Precise constructional details are not given since there are many methods which the constructor may prefer. The layout is not unduly critical.

With everything connected up and the control unit exposed for adjustment, the microphone amplifier should be switched off and VR1 in the control unit adjusted carefully for the threshold condition described earlier. With the microphone amplifier switched on, a sustained noise should energise the relay.

COMPONENTS

All the small components are standard types as given in the components list. The microphone insert can usually be picked up from component specialists or Government surplus supply shops, as also can the relay. T1 and T2 can be interstage transistor coupling transformers or transistor driver transformers as given in the components list. T1 should be arranged to give a matched step-down into the coaxial link, while T2 steps up again to match the input of TR3. T3 should be step-down into the diode D1 to provide adequate current drive to TR4.

A word or two about the relay would not be amiss as this is probably the most critical part. The relay needs to energise preferably at 13mA, but a slightly higher value would do. In practice, it will probably be found that the collector current is set to about 7mA with the relay just de-energised. This is in order provided the relay will energise when the collector current TR4 rises sufficiently. The relay thus needs to be a very sensitive type. ★

the 73 page by Jack Hum G5UM

Build or Buy?

In *The 73 Page* last time we promised to explore some of the routes which open up the delights of shortwave reception to the newcomer to practical electronics. These routes are severally signposted.

Among the signposts is one labelled "modern communications superhet", and to follow *this* route is to devote oneself to months of constructional work and not a little expense.

It is for this reason that the searcher after a communications receiver is usually advised to buy one ready-made—new, of course, if he has the money, used if not.

To buy a really modern receiver, complete with facilities for receiving single-sideband, with calibration markers and in general the ability to cope with today's conditions, will cost something in the region of £100. But remember that this will represent an investment for many years ahead, and one which can be experienced painlessly thanks to the hire-purchase terms suppliers offer.

But hear the set first! Ask for a home demonstration so that performance may be evaluated under the conditions in which the receiver will ultimately spend its life, not in a city centre shop suffering from a high local noise level.

If your choice is a used model scan advertisers' announcements for something to conform with the price you are prepared to pay.

Classic Receivers

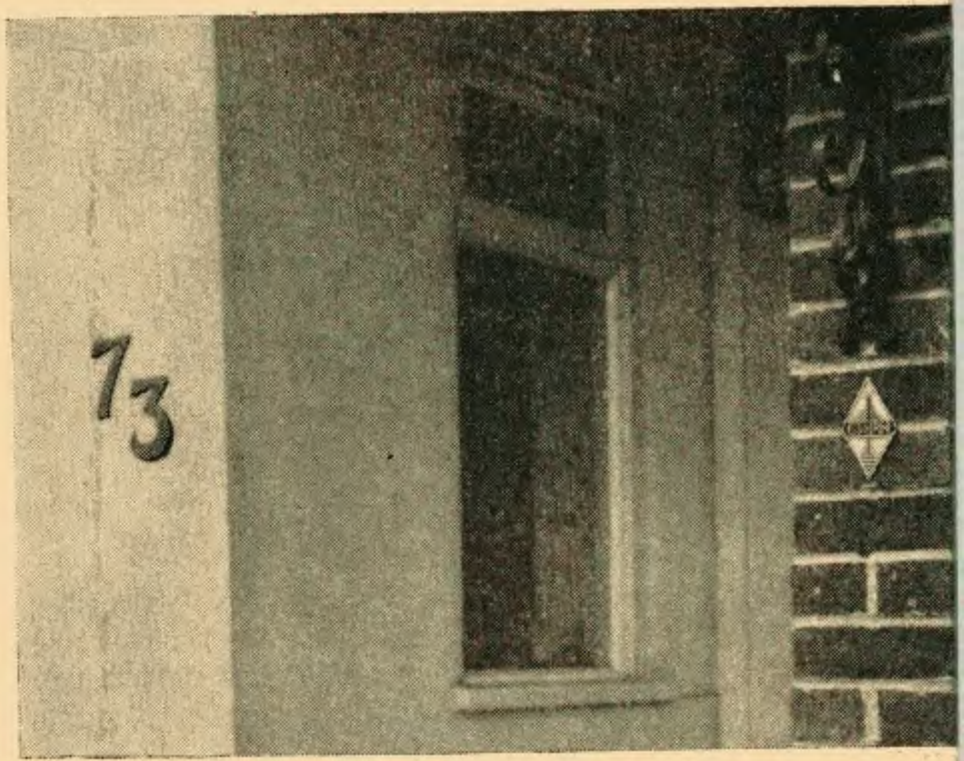
One of the classic communication receivers of all time, the HRO, can now be had at around the £25 mark, while the American Air Force BC348, inferior in bandspread to the HRO, but to be preferred to its British equivalent, the R1155, is worth looking for at £20 or less. And there are some dozen other types, nearly all of wartime vintage and req·iring careful appraisal and a "demonstration run" before purchase.

Points to determine are that the receiver will produce signals on all the wavebands to which it is switched (if not, suspect local oscillator); that if it comes with detachable coils (e.g. the HRO) all the coil assemblies are available; that the calibration is reasonably accurate; that a suitable power supply unit can be obtained; that all controls function—not forgetting the crystal filter; that the external appearance is good enough to grace your "shack" (as everyone calls the radio-room).

Skyhooks, Good and Not So Good

Because a communications receiver equipped with perhaps a half-watt audio stage as its final valve appears to "belt it out" with no more than a few feet of wire connected to its aerial terminal, there is an ever-present temptation (and danger) to imagine that this is all it needs. An exercise in *un*practical electronics, indeed!

This misguided approach is seen at its nadir in the instance of the transmitting amateur who goes to great lengths (in every sense of the word) to provide himself with a fine resonant aerial for the sending equipment yet throws away efficiency by using for the receiver aerial a random length of bell wire slung across the floor. It should be the other way about: it is *the receiver* which needs at all costs the best possible start in the way of a "skyhook" good enough to capture those elusive microvolts from perhaps 10,000 miles away.



The phrase "73" is much sought after as a house number by transmitting amateurs. Here it is on the house of Mr. R. C. Hills, G3HRH

We have used the phrase "a fine resonant aerial". Yes, but resonant to what? Many shortwave listeners will answer: "To everything—because we want to cover the complete shortwave spectrum from 1·8 to 30 Mc/s." And they will know well enough that to *this* proposition it is impossible to add a "Q.E.D."

To the listener whose attentions are confined to one band the answer is simple: *Put up a dipole.* For example, to pull in those 73s on the most popular band of all, 14 Mc/s, erect 33ft of wire split in the centre and fed at that point with common or garden coaxial cable of any length, or even, for extreme economy, with a length of flex (it makes good low impedance feeder when not wet!)

Do not forget the inherent directivity of a dipole: if you run it north-south you will receive along an east-west path. Best reception is at right angles to the run of the wire.

But few wish to confine their listening to one band only; even fewer have space in which to erect separate dipoles for all bands, and what is more to keep them sufficiently clear of one another that they do not interact.

Multi-Band Aerial

Ultimately, the compromise solution of making the best of most worlds must be settled for, namely, to erect an aerial *reasonably* resonant over as much as possible of the required listening spectrum.

It will be 136ft long from the remote insulator to the actual aerial connection on the receiver (half-wave long at 3·5 Mc/s, full wave at 7 Mc/s, four half-waves at 14 Mc/s and eight at 28 Mc/s).

It will be as high as mechanical considerations permit (to reduce screening by buildings and to abate electrical interference emanating from within them).

It will if possible run northwest to southeast to allow its big 45 degree lobes at 14 Mc/s to tap the major centres of amateur transmitting activity.

You can't squeeze in 136ft? Well, try 66ft, and halve the above figures.

the 73 page by

sound on tape

A SHORT SERIES FOR THE HOME RECORDING ENTHUSIAST

By H. W. HELLYER

PART FOUR

IN Part Two of this short series we touched briefly on the subject of input mixing. Correspondence has shown that there is considerable interest, especially in the matter of mixer unit construction. Whereas a number of units are marketed at prices that vary from less than three pounds to more than forty, most of these are designed to match specific machines, and some readers will prefer to build a unit that can be designed to suit their special needs.

MATCHING PROBLEMS

The main problem associated with mixers is the maintenance of correct matching.

Matching is the procedure of transferring maximum energy by ensuring that no loss occurs when the input of the one unit is powered from the output of the other. A popular example of a mismatch that can be tolerated because adequate power is available, is the connection of the loudspeaker circuit of a radio to the medium-to-high impedance "radio" input of the tape recorder.

Other factors apart from power transfer concern us, however, when dealing with the transfer of audio frequencies, and for this reason the ultimate design of a mixer unit must depend on the tape recorder or amplifier with which it is intended to be used, and the inputs from which it is to be fed.

It will be recalled that there are two basic types of mixer; the *passive* and the *active*.

The passive mixer simply takes two or more inputs, with or without control of the signal level, combines them and presents the composite signal to the input of the tape recorder. Where adequate gain is available, as with two similar microphones matching a tape recorder capable of handling the signal, this method is usually satisfactory.

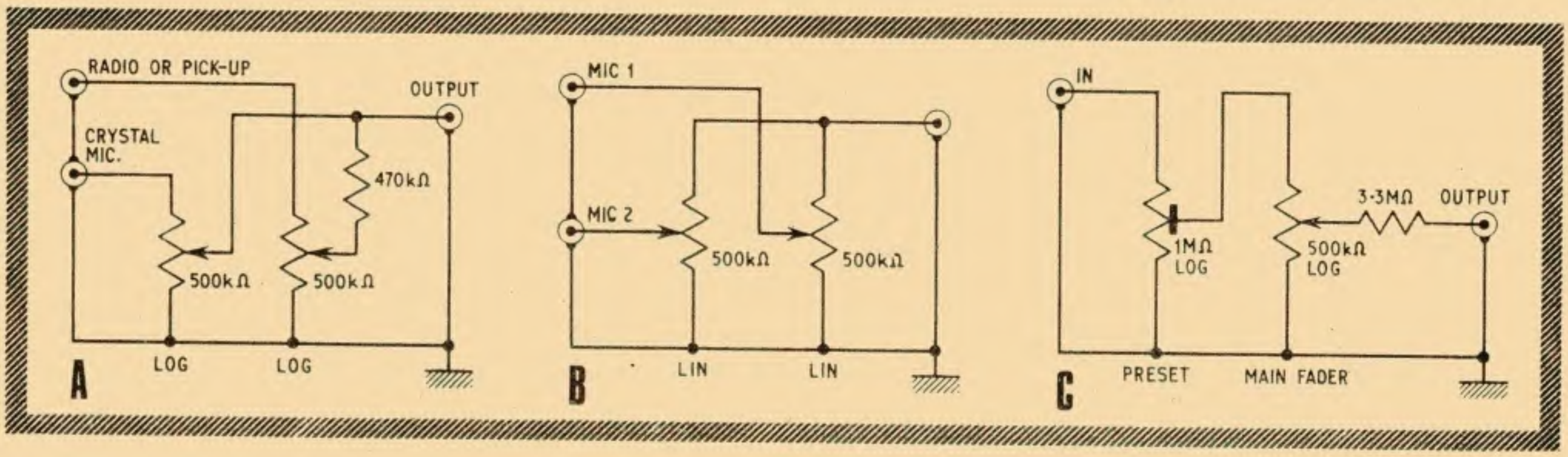
When there is a wide variation of signal level, as when a low level microphone and a high level radio or pick-up output have to be combined, the range of control on a passive unit may not be sufficient to load the tape recorder input adequately, and then some amplification of the low level signal is needed. This requirement can be met by the use of an active type of mixer.

PASSIVE MIXERS

A typical circuit of a two channel passive mixer is given in Fig. 4.1a. Here the output from a crystal microphone is combined with the output from a radio tuner or gramophone pick-up. The latter section has an additional series resistor which limits the input, so giving a roughly similar output level to that obtained from the microphone section. This is the sort of simple device that could be used if, for example, it was required to use microphone, radio and gramophone to feed the input of a standard tape recorder, which has only the microphone and "high level" input sockets. The output from this mixer is then fed to the microphone socket of the recorder.

If two microphones are to be used, the limiting resistor could be omitted. But then it is necessary to connect each microphone to the slider of its appropriate control, as in Fig. 4.1b, to avoid the inputs being shunted. The presence of the limiting resistor tends to increase noise level. A point to be noted is that the fader controls on the first example are *log law* and the latter pair are *linear*. This is to obtain a smooth regulation of output level.

Fig. 4.1. (a) Simple passive mixer *(b) Alternative method of connection to avoid shunting of output* *(c) Cascaded controls, giving wider range of movement of main fader*



An even smoother range of control can be obtained with the double potentiometer circuit of Fig. 4.1c. The first potentiometer is preset to near the required signal level, then the main fader control is reduced as required, to give control over its whole range of travel, instead of merely over a small arc of travel as would be the case with a single control and a strong signal. (It must be remembered that all these " passive" devices need a strong signal—weaker inputs will need amplifying, as we shall discuss below.)

DIFFERING IMPEDANCES

Thus far, we have only considered high impedance inputs. More often, the problem arises when we need to mix a high and a low impedance input, of widely differing signal levels.

Again, remembering that mixing will always occasion an *insertion loss* (i.e. two identical inputs will present a combined signal less than a single, unmixed input) the values of the circuit components will always be determined by the available signal from the weakest source. Of course, it is always possible to attenuate the strong signal—but this is not usually advisable because of the deterioration in signal-to-noise ratio that results.

This is why it is often necessary to build a pre-amplifier inside a microphone housing—not simply to boost the signal, which could perhaps be done more conveniently within the main amplifier, but also to overcome the possible noise encroachment in cables, connections, etc.

Note that the microphone transformer is mumetal shielded, and the common earth is taken to the centre tap of the primary.

MIXER-AMPLIFIER

Where the insertion loss is such that the gain control of the tape recorder has to be kept advanced, some pre-amplification of the input signal is indicated.

As explained previously, amplification of the signal is necessary to overcome adverse signal-to-noise ratio. To be practical: suppose a microphone is capable of delivering a millivolt of signal, and the amount of noise in the signal (inherent microphone noise, etc.) is as small as one-hundredth of the useful microphone signal—this gives a 40dB signal-to-noise ratio, and is just tolerable, if no other losses occur. But if a passive mixer is used—even a two-channel type of good construction—the available signal will be 500 microvolts ($\frac{1}{2}$ millivolt) or less, and the noise is not reduced. In this case the signal-to-noise ratio becomes 50:1, or 34dB. This is too bad for normal work, giving the effect of a troublesome hiss.

The answer is to amplify the signal as early as possible to overcome the noise level (which will be amplified as well as the wanted signal in any subsequent stages). If the gain of the first amplifier is, say 100 times, then the signal-to-noise ratio can be better than 60dB without any great stringency about construction.

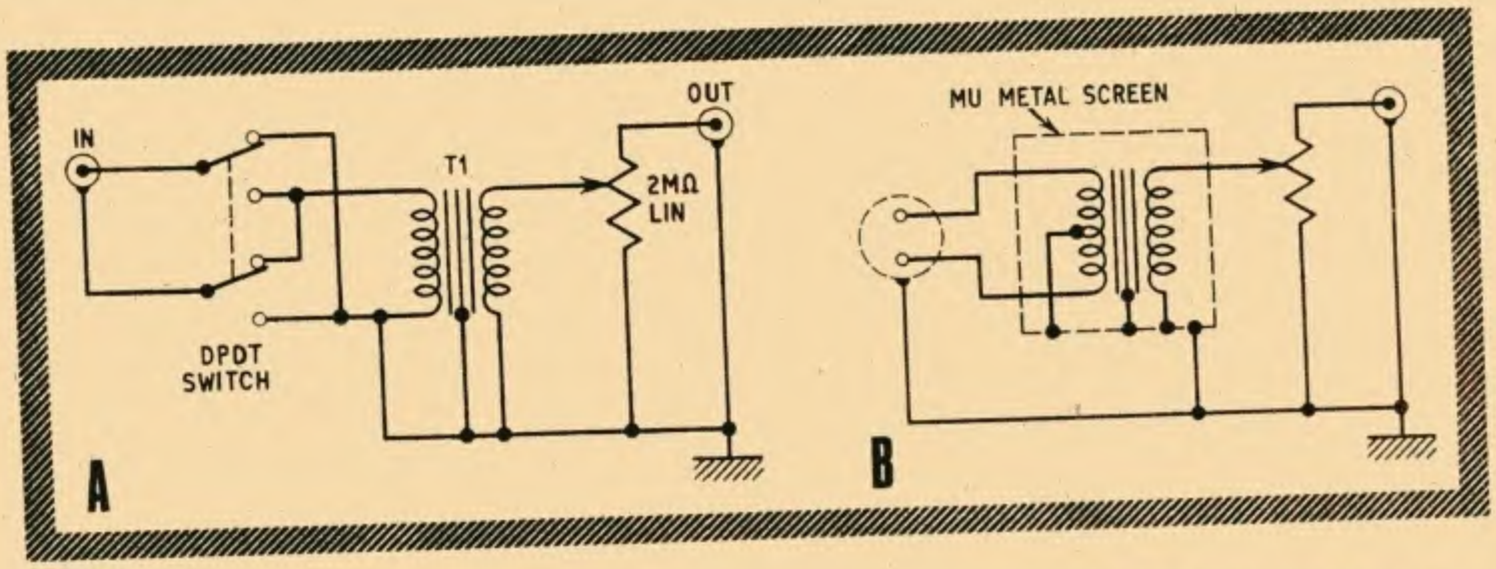


Fig. 4.2.
(a) Low impedance microphone input, with phase reversal switch
(b) Method of connection for balanced microphone input

When a low impedance input has to be allowed for, when a ribbon or moving coil microphone is used, the best energy transfer is procured by use of a matching transformer. This provides the needed impedance step-up to match the input of the main machine.

Fig. 4.2a shows a single channel circuit which matches a low impedance input to a medium impedance output. The transformer used must be chosen to suit the particular microphone. The potentiometer allows control of signal level. The d.p.d.t. switch is provided for reversing the phase of the input; this may be necessary if more than one microphone is used, on account of a frequency cancellation effect which sometimes occurs.

A further point to note about Fig. 4.2a is the way the output of the transformer is applied to the potentiometer. This method is necessary when combining this circuit with any of those in Fig. 4.1, to avoid the low d.c. resistance of the transformer primary shunting the common output.

Fig. 4.2b shows the alternative input arrangement that is necessary when a balanced microphone input is used.

BASIC PRE-AMPLIFIER

One example of this type of pre-amplifier is given in Fig. 4.3. This is an early Mullard circuit, employing a grounded base transistor of common type, and suitable for amplifying the low impedance output of a microphone or gramophone pick-up. An input of 16mV will produce an output of 1V, which is adequate to load the high level input of the tape recorder. Low frequency response is maintained by the use of the large value electrolytic in the emitter circuit, which is at low impedance. The output is taken off the collector load, 6·8 kilohm resistor and via the 0·1μF capacitor to the high impedance outlet. Frequency response is about 3dB down at 100c/s and a similar amount at 200kc/s, relative to the standard level at 1,000c/s.

Several of these units could be arranged in a "building block" fashion to form a mixer, the outputs being taken to a series of faders or to a common output, there being very little drain on the 6V battery. But where a number of different signals have to be combined, and some of them amplified, a more ambitious mixer is needed.

FOUR-CHANNEL MIXER

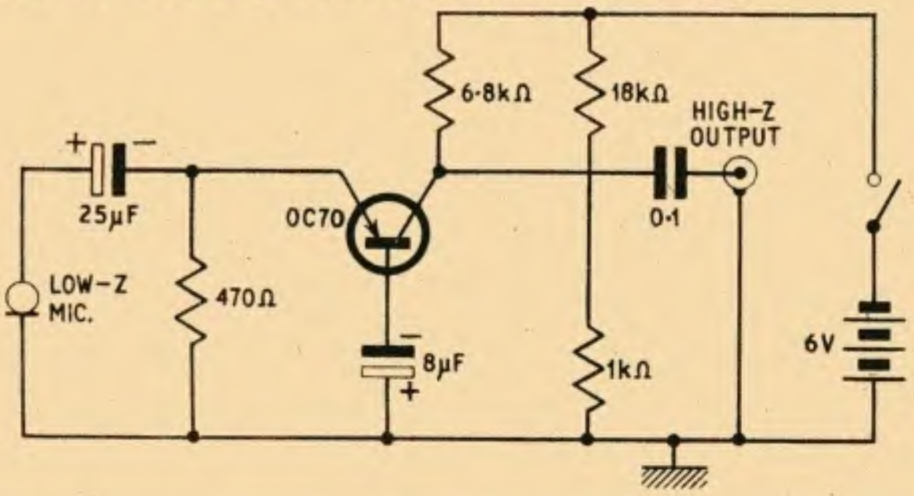
A suggestion that could be used as a basis for development is given in Fig. 4.4. Here we have four similar medium-to-high impedance inputs combined after their individual fader controls to feed a single stage of amplification.

In practice, it might be advisable to use a high impedance line, via its fader, with no further amplification, two medium impedance inputs, suitable for amplifying the output of a gramophone pick-up and radio tuner, and a separate low impedance channel, with a circuit as in Fig. 4.3, combining at the output.

Better again would be the method used by many commercial designers, whereby each input channel has its appropriate amplifier and fader, the output from each being taken to a buffer amplifier, which has an overall fader. The output of the buffer amplifier is usually at low impedance to allow the use of a long lead between the mixer and the main amplifier. This low impedance output is obtained quite simply by designing the buffer as a cathode follower, sacrificing gain for stability and control. In the more ambitious models, there may be a modulation indicator, either a meter or a magic eye. (As explained in the previous article, a magic eye has advantages in this application by its rapid response to signal peaks.) Many units are also self-powered.

Transistorised mixers are coming more into vogue. The well-designed and constructed transistorised unit has the great advantage of portability, and the no less important attribute of hum reduction, due to the freedom from mains power.

Fig. 4.3. Low impedance microphone pre-amplifier



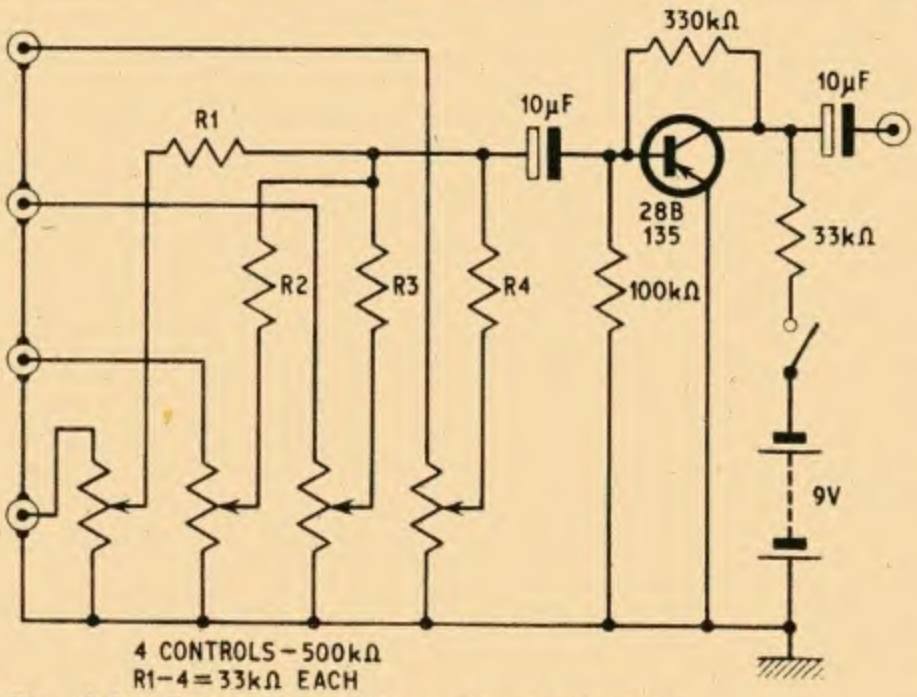


Fig. 4.4. Four-channel transistorised mixer

TONE CONTROLS

A refinement which is sometimes found is the incorporation of tone controls in the mixer unit. If the mixer is intended to feed the output of a pick-up or radio tuner to an amplifier, there may be some justification, but where the aim is recording, the use of tone controls is to be deplored. A level input should be sought, the equalising circuits of the tape recorder supplying the necessary response "shaping", and then tone control can be applied during playback to compensate for variations in listening conditions.

One of the most frequent complaints by users of home constructed mixers is the lack of bass response caused by the insertion of the unit. As discussed above, matching of microphone to mixer and mixer to tape recorder is important, not only for loss reduction but also for the preservation of all the frequencies at correct level. A crystal microphone coupled into an impedance which is not sufficiently high will sound "tinny", although giving adequate output. Most crystal microphones expect to "see" an impedance of a megohm or more—and many will not give adequate bass with less than a 4·7 megohm match.

This trouble does not arise so much with low impedance devices, but there we have to preserve the signal, which may be very small. Losses can be kept to a minimum by correct input matching. Remember that a loss in the microphone input portion of the circuit will result in an increased noise level made worse by subsequent amplification. The "front end" needs plenty of careful attention—which is why we have devoted most of this final article toward it.

MAINS ISOLATION

All this talk of connecting other equipment presupposes one important thing: that the radio set or other piece of equipment is isolated from the mains; that is, powered by a double-wound mains transformer.

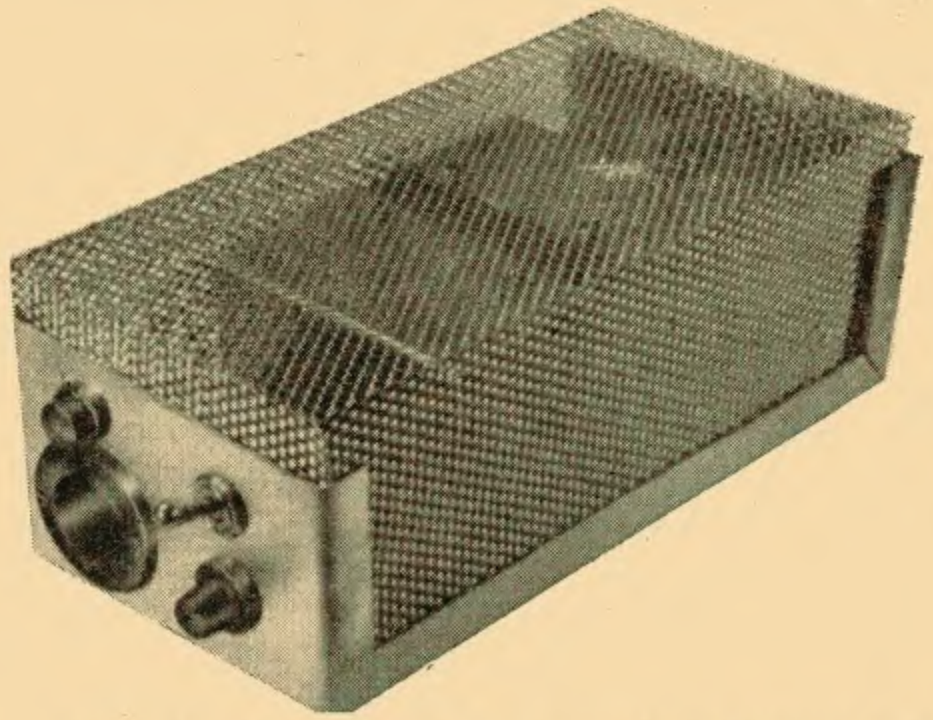
Although this is standard practice with tape recorders, such is far from the case with radios and radiograms (despite the fact that the latter are unsuitable for d.c. operation because of the turntable motor). The great majority of television receivers also use a.c./d.c. techniques. This is not a virtue of the magnanimous maker, giving us an extra facility, but happens because an a.c./d.c. receiver is cheaper to produce, having no mains transformer.

In such cases we must then supply our own mains transformer to isolate the set and remove the possible danger of shock. It is true that the connection of the mains the right way round, i.e. neutral to chassis, will reduce this danger, but if an earth has been fitted to the tape recorder, this practice is again likely to lead to danger—or, at least, blown fuses. A good earth is desirable, in any case, for the reduction of hum.

The practice of isolation by a capacitor in each lead also has complications. To be electrically safe, these capacitors should be no greater than 0.005μF. The impedance of such a capacitor at the low frequencies is significant, and hum will probably result. The correct method is to fit a 1 : 1 isolation transformer between mains and the a.c./d.c. equipment. Although these cost a pound or two, the enthusiast should never try to manage without.

The aim of this short series has been to introduce the keen electronics man to the subject of tape recording, and to demonstrate that there is a little more to it than threading the tape, tapping the mike, and watching the spools go round. ★

DC/AC INVERTER



THIS INVERTER is designed to operate from a 12V d.c. source to provide an output of 230V a.c. at about 65 to 70mA current (i.e. an output of approximately 15W). The design is based on readily available components to which a few refinements have been added, including d.c. and a.c. fuses, on/off switch, a.c. mains plug, indicator lamp, d.c. supply terminals and a diode to prevent damage through reverse connection of the d.c. supply.

CIRCUIT

Fig. 1 shows the complete circuit diagram of the unit. It will be seen that the circuit is basically a push-pull relaxation oscillator with a step-up transformer. The d.c. input is applied across two transistors, in series with two halves of the main transformer primary winding. Each transistor acts as a regenerative switch. The base current is derived from an induced low voltage from T1 across a very low resistance, R2. The storage stroke in one transistor occurs simultaneously with the discharge stroke in the other.

The 12 volt d.c. supply is presented alternately via each transistor collector circuit to each half of the main winding of T1, point 4 being the common negative terminal. Current is, therefore, flowing in opposite directions through the winding inducing an alternating current in the secondary across 1 and 2.

Stabilisation is maintained through the controlled base circuit by supplying it with a current dependent on the collector circuit.

Constructional procedure can be divided into three distinct building operations:

(*a*) Main Chassis
(*b*) Transformer Inverter
(*c*) Assembly of Transformer Inverter to Main Chassis.

Before carrying out operation (*c*), the transformer inverter should be tested, since circuit adjustment at a later stage of assembly is difficult.

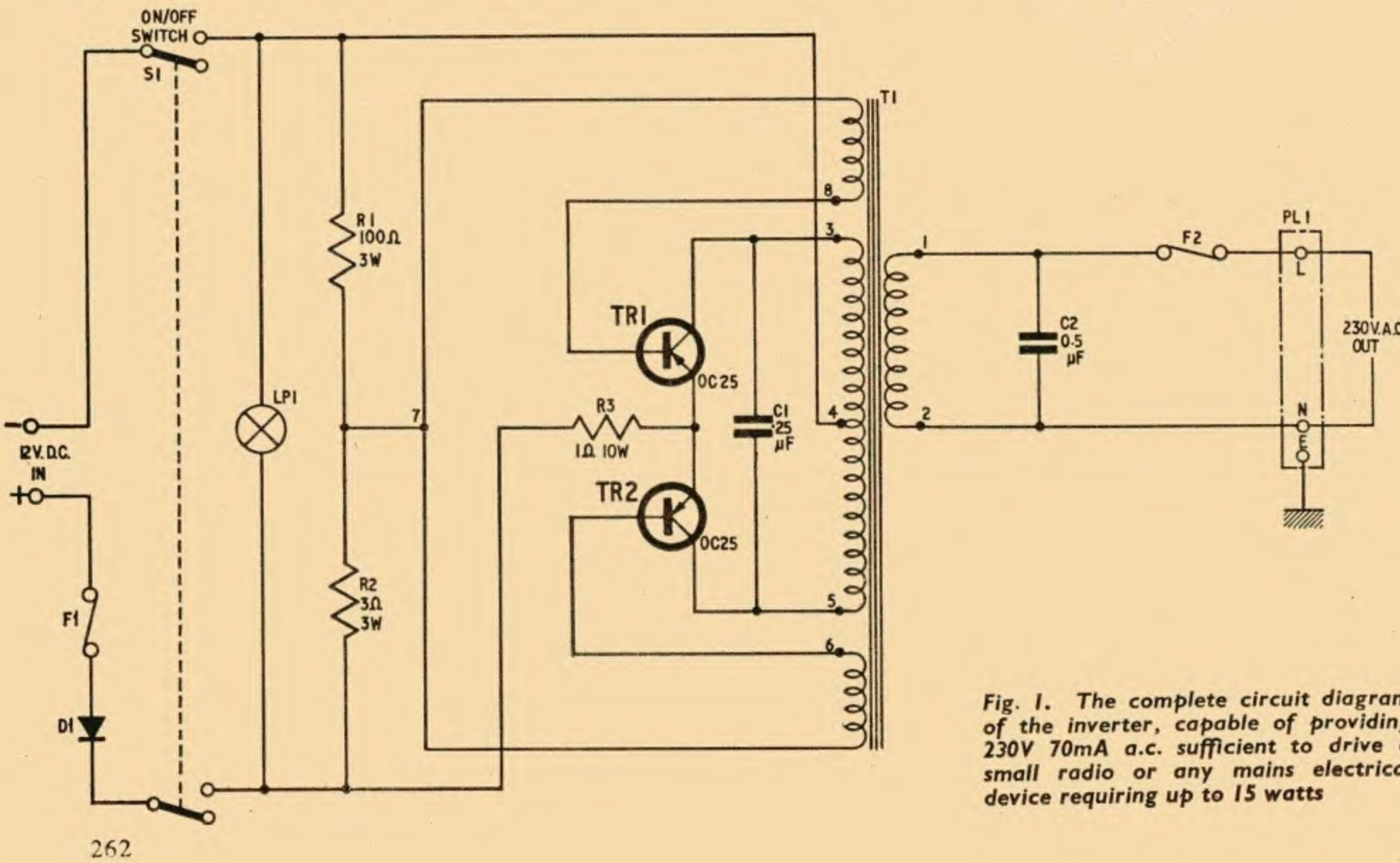


Fig. 1. The complete circuit diagram of the inverter, capable of providing 230V 70mA a.c. sufficient to drive a small radio or any mains electrical device requiring up to 15 watts

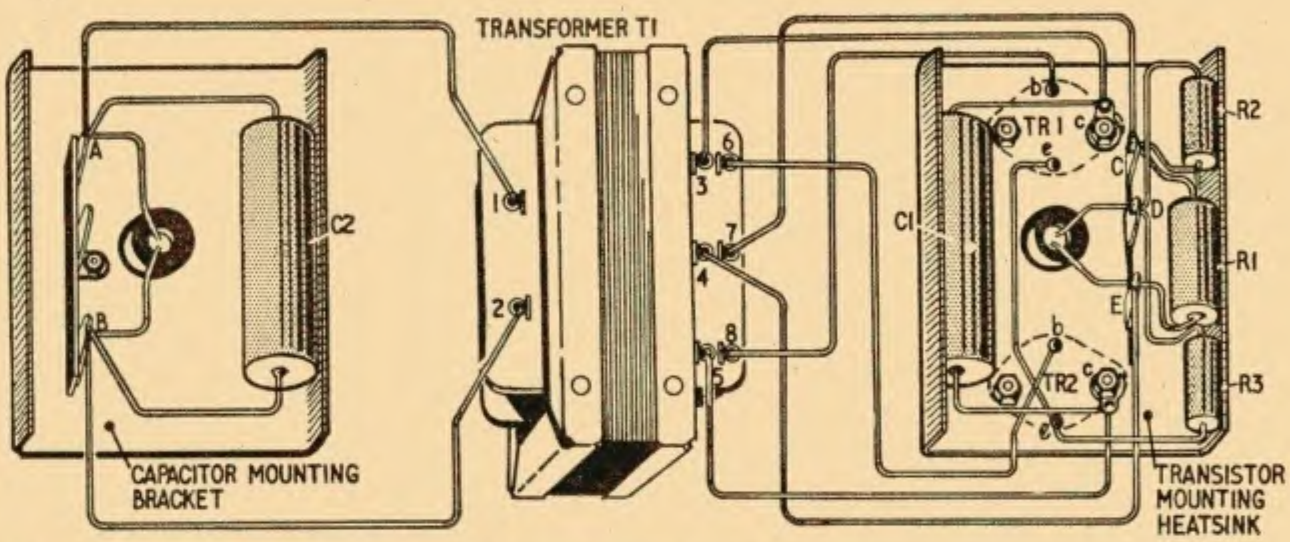


Fig. 2. Wiring diagram of the transformer and transistors

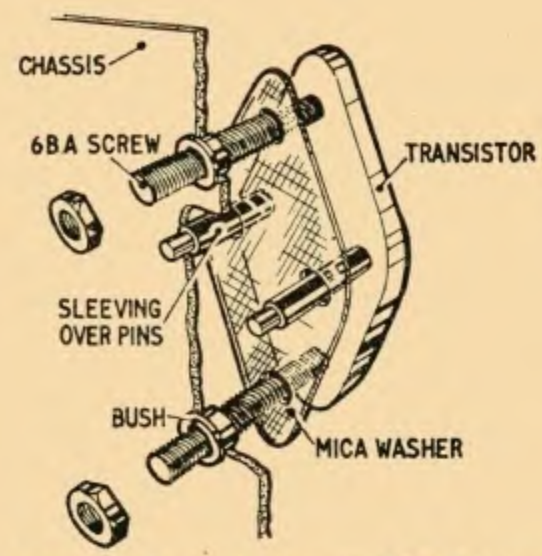


Fig. 3. Exploded view of the transistor mountings showing the insulation bushes and washer

MAIN CHASSIS

The main chassis is made up from 16s.w.g. aluminium sheet and is of simple design. The marking out on the sheet of aluminium was done from the dimensions given in Fig. 5, with an extra ⅛in at each bend and ⅛in diameter holes drilled at each corner of the seams to allow for bending the metal.

The holes for mounting the switch, fuses, lamp, plug and terminals will depend on the types used, but should be cut or drilled before bending up the chassis.

The transformer mounting tray is also fabricated from 16s.w.g. aluminium and the same method and procedure of bending and drilling adopted as for the main chassis. See Fig. 5.

The expanded metal grille shroud provides a generous flow of cooling air to the transistors while preventing possible harm to components or persons, and is fixed to the main chassis with eight self-tapping screws.

TRANSFORMER INVERTER

The transformer inverter comprises the transformer to which are fixed two U channel pieces which carry the resistors, capacitors and transistors wired in accordance with Fig. 2.

The d.c. input supply leads to tagstrip terminals D (−ve) and E (+ve) and the a.c. output supply leads from tagstrip terminals A and B, which pass through the grommet holes in each U channel piece, should each be about 5in long to facilitate wiring at the final stage of assembly.

TESTING

Check the continuity of wiring of the transformer inverter and correct connection of transistors.

Connect a suitable load to the a.c. output leads, such as an electric shaver or, if unavailable, a 15W 230V bulb or 5 kilohm 10W resistor, and connect a voltmeter set to read 230V a.c. across the load.

Connect a 12V d.c. source such as a car battery to the d.c. input ensuring correct polarity of connection.

The output voltage on the meter should rise to about 230V immediately. If the output fails to rise quickly or is low, reduce the value of R3 (or short it out) until satisfactory results are obtained.

Avoid removing the load with the power switched on if possible since damage may result to the transistors.

ASSEMBLY ONTO MAIN CHASSIS

After wiring and testing the transformer inverter, fit the two U channel pieces to the transformer, and mount the whole onto the transformer mounting tray using 6 B.A. screws, nuts and washers.

Next, fit the transformer inverter complete with mounting tray into the main chassis with the transistors facing the d.c. input terminals.

Wire up the d.c. and a.c. leads from the transformer inverter to the main chassis as on Fig. 4, and the whole assembly is ready for final testing, the same method as before being used, except that the d.c. input is applied to the terminals on the main chassis and the a.c. output is taken from the output plug. The switch, fuses, lamp and safety diode are operational as well.

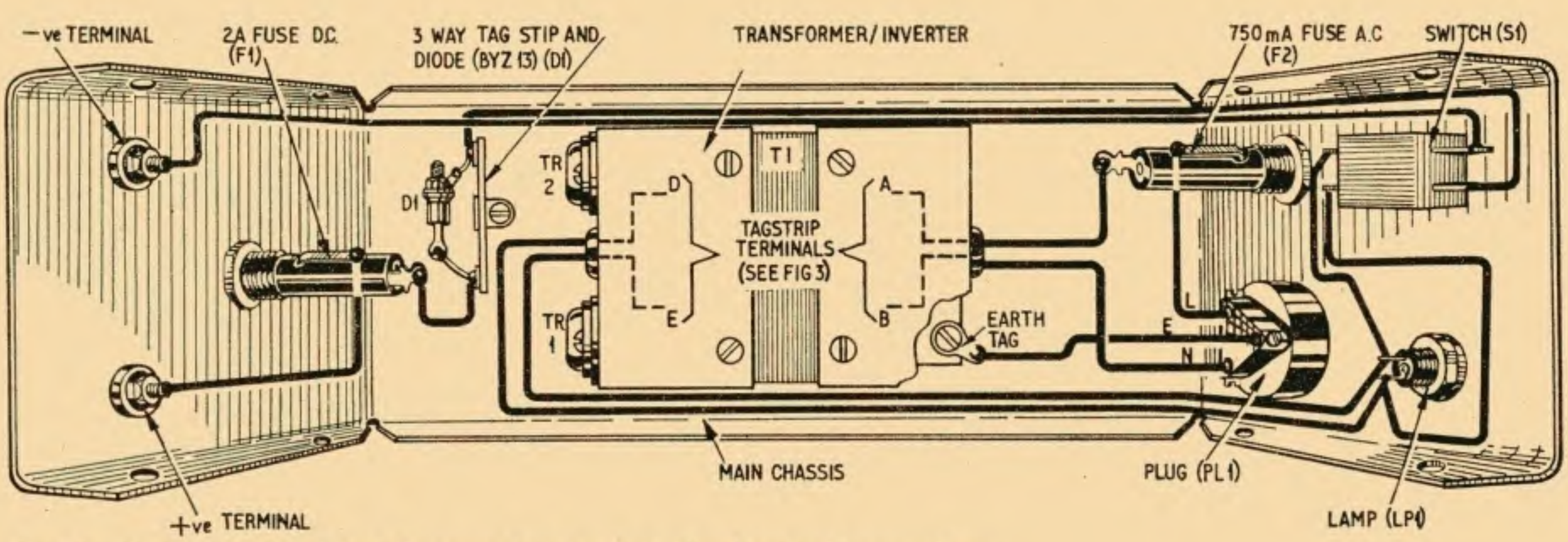


Fig. 4. Main chassis wiring diagram showing input and output connections

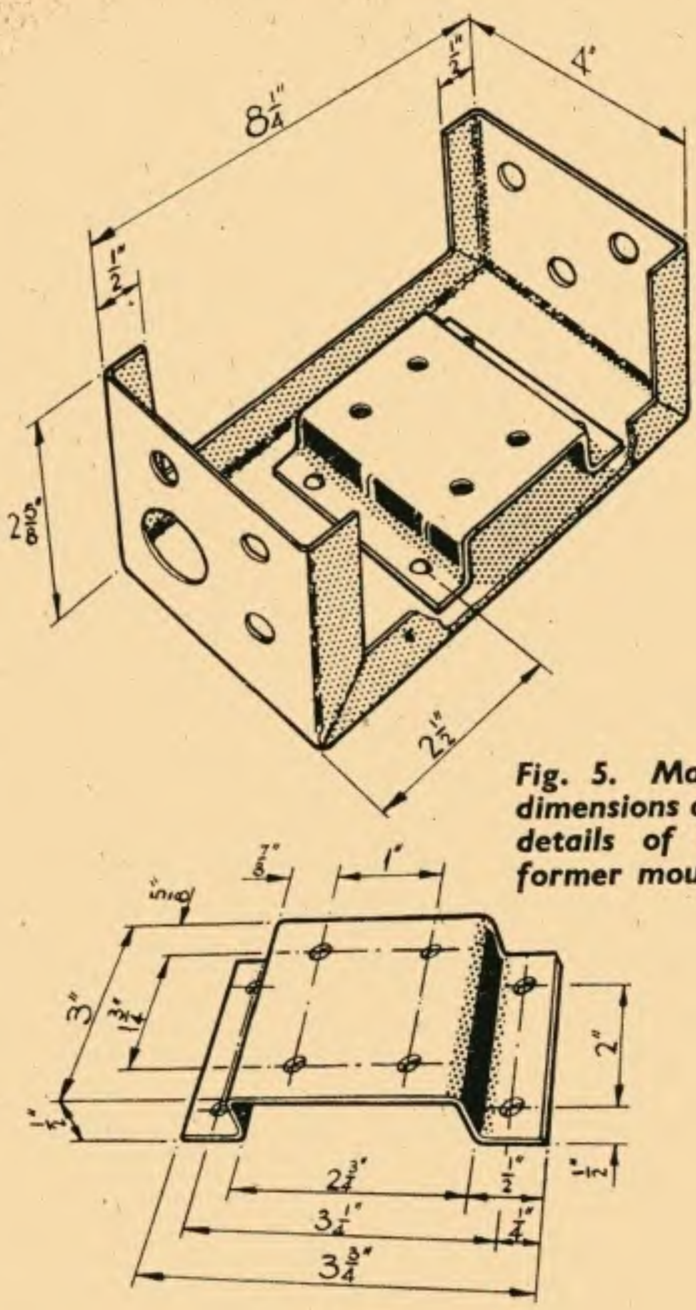


Fig. 5. Main chassis dimensions and drilling details of the transformer mounting plate

COMPONENTS . . .

Resistors
- R1 100Ω wire wound 3W
- R2 3Ω wire wound 3W
- R3 (See text)

Capacitors
- C1 0·25μF paper 150V
- C2 0·5μF paper 500V

Transistors and Diode
- TR1, TR2 OC25 (with insulating bushes, and washers Nos. 56201a and 56201b)
- D1 BYZ13 or equivalent

Transformer
- T1 Repanco Type TT51 with heat sinks

Fuses
- F1 2A fuse and holder
- F2 750mA fuse and holder

Switch
- S1 D.P.S.T. on/off switch

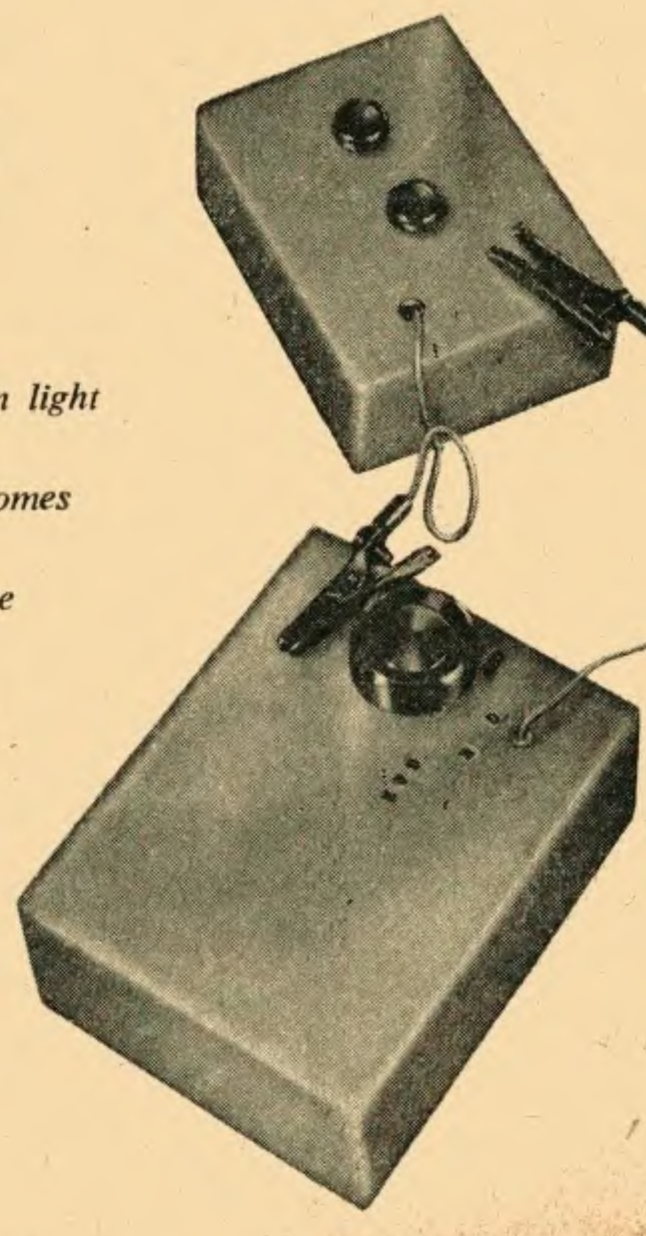
Miscellaneous
- LP 12V lamp and bulb
- PL1 3 pin mains plug and socket (Bulgin types SA1861 and SA1862)

Aluminium sheet 16s.w.g. Expanded metal grille. 6 B.A. screws, nuts, washers, solder tags and sleeving. ⅜in grommets. Three 3-way tag strips. Four rubber mounting feet.

★

MAGIC BOXES

Something Screwy Here!



Turn this knob on box A to 'G' and the green light on Box B comes on.

Then turn the knob to 'R' and the red light comes on and out goes the green.

Now set the knob to 'G' and 'R'—yes, you've guessed it!—both lamps light up.

But hang it all—this can't be right—not with only two *wires connecting box A to box B?*

★ ★ ★

Are *you* baffled also — or perhaps the circuit arrangement is quite obvious to you?

If you think you can solve this problem — see page 300!

Anyhow you can check your solution next month when the secret of the boxes will be revealed !

THE SEMICONDUCTOR . .

PART 1. P & N JUNCTIONS

EXPLAINED BY CHARLES NORMAN

I WONDER why so many of us are half afraid of transistor work. Admittedly it can be a bit fiddly, and printed circuits do sometimes offer a tricky problem. But, with the right approach, working on transistorised equipment is no more difficult than servicing valve receivers. In fact, because there are no heaters to bother about, and because many transistor faults show up on a simple resistance test, it can be much easier.

We all know these days that matter consists of atoms, which are composed of one or more electrons orbiting at a fantastic speed round a heavy nucleus. In some substances, especially metals such as copper and aluminium, the outer electrons are so feebly attached that they jump backwards and forwards from atom to atom. If we apply a voltage across this type of material, we get the steady flow of electrons that we call a current. As the material conducts this flow, we call it a conductor. An insulator is a material which under normal conditions will not pass a current.

Now there are a few materials which are neither good conductors nor good insulators. Under protest, they will pass a small current which increases with temperature. Because their behaviour is about halfway between that of conductors and insulators, they are called semiconductors.

ATOMIC STRUCTURE OF GERMANIUM

Fig. 1.1 gives an idea of the atomic structure of this metal. Each atom has an outer "shell" of four electrons, between which and the nucleus are other shells which have nothing to do with the electrical properties of the material. The outer electron orbits interlock with those of neighbouring atoms, forming a very stable arrangement called by scientists a diamond lattice structure. Because all of the electrons are used to maintain this structure, it is very difficult to move them from their orbits. Consequently, under normal conditions, germanium is a poor conductor.

Now germanium can be made to conduct by "doping" it with a very small quantity of either of two types of impurity. Fig. 1.2 shows germanium to which *arsenic* has been added. Now arsenic is pentavelent, i.e. it has five outer electrons. So when it enters into a diamond lattice structure, four of its outer orbits interlock with those of the germanium, leaving one electron "unemployed".

Because this electron has now no rigid bond to hold it in place, it is free to wander about the material, jumping haphazardly from one atom to another, in the same way as "free" electrons in a conductor. Consequently, if a voltage is applied across germanium that has been treated in this way, it will quite readily conduct.

The amount of arsenic added to the germanium must be kept within strict limits, otherwise a different form of bonding between the atoms will be introduced and the conducting effect will not be achieved. Because the material has a surplus of bonding electrons it is called negative or n-type germanium.

DONOR IMPURITY

Normally, a body with surplus electrons is negatively charged, but the free electrons in n-type germanium are not surplus to the material, but merely surplus to the bonding. It contains exactly the full quota of electrons to make up both germanium and arsenic

Fig 1.1. Atomic Structure of pure germanium

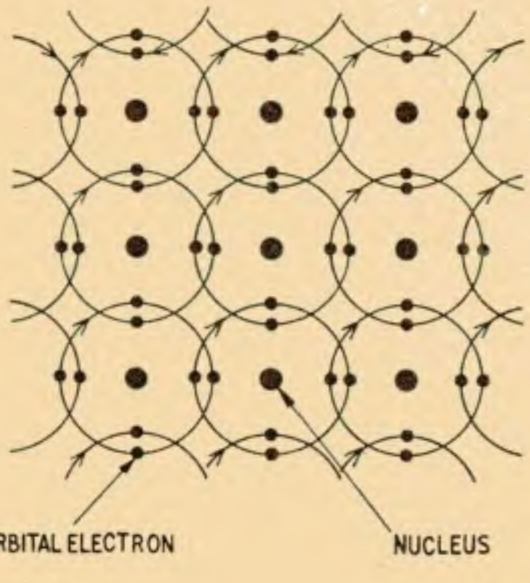


Fig. 1.2. Doping of germanium with arsenic results in one electron becoming "free"

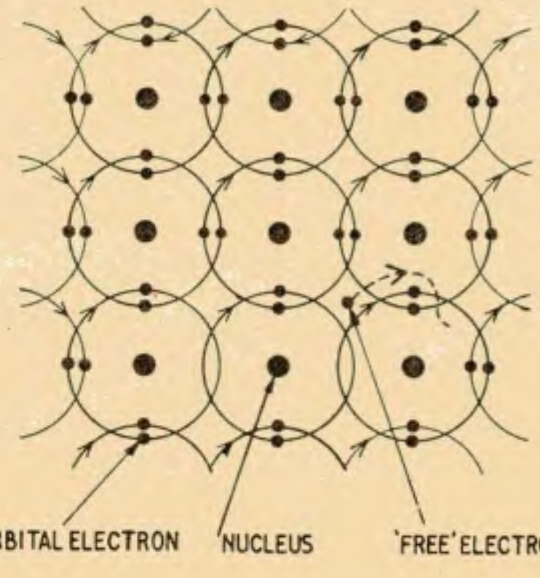
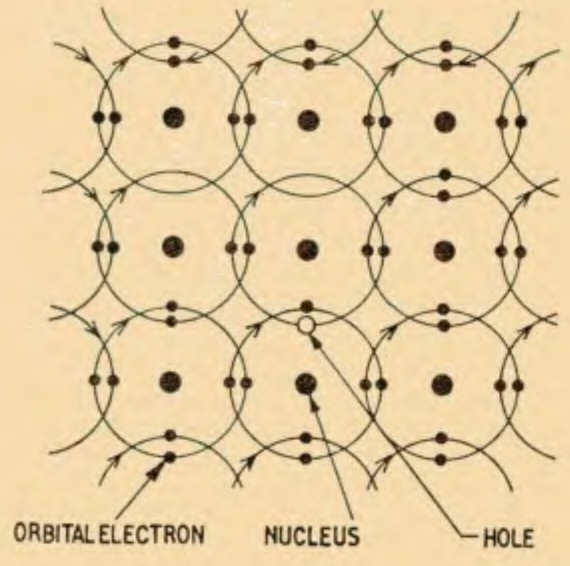


Fig. 1.3. If a trivalent impurity is introduced a deficiency of one electron is created known as a "hole"



atoms, no more and no less. Consequently, *n*-type germanium is electrically neutral. Because arsenic supplies the free, or "carrier" electrons, it is called a *donor* impurity. Another suitable donor is antimony.

Fig. 1.3 shows the way in which the atomic structure of germanium is affected by the addition of a trivalent impurity such as indium or aluminium. Trivalent elements have only three electrons in their outer shell. Consequently, although the impurity enters into the diamond lattice structure, there is a missing bond wherever an atom of impurity occurs. In other words, there is a "hole" where an electron ought to be.

ACCEPTOR IMPURITIES

Because this type of germanium has a deficiency of bonding electrons, and because a deficiency of electrons normally implies a positive charge, it is called *p*-type material. Again, since there is no *overall* deficiency of electrons, *p*-type germanium is electrically neutral. Indium and aluminium are called *acceptor* impurities because they take one of the bonding electrons.

The holes in *p*-type material are each constantly striving to capture an electron, from a neighbouring orbit. This from time to time, they do, leaving a hole in its place. This hole in turn, fills itself as rapidly as possible from another electron orbit, leaving a hole in yet another position. The net result is that the holes wander about in the material in the same way as the free electrons in *p*-type germanium.

There is one important difference though. The holes, since each is a deficiency of one electron, are positive. Consequently, if a voltage is applied across *p*-type material, the current in it will consist of holes moving from positive to negative rather than electrons moving from negative to positive. But as this movement of holes is really a movement of electrons from one vacant position to another, the voltage source "sees" a normal electron flow. The electrons from the battery cannot fill the holes, since the material is already electrically neutral and cannot accept extra electrons without becoming positively charged.

P-N JUNCTION

Now suppose a bar of *n*-type germanium is fused end-on to a bar of *p*-type material as in Fig. 1.4. On the right-hand side of the junction are free electrons, which are negative. On the other side are holes, which are positive. The electrons want to fill the holes, and the holes want to be filled. So both move towards their own side of the junction. At the junction they must stop, because they cannot cross it without destroying the electrical neutrality of the materials. The net result is a concentration of holes and electrons on opposite sides of the junction. The few carriers that do cross form a small potential barrier that opposes further movement.

Before a current can flow, this potential barrier must be overcome by applying a potential difference across the junction.

Fig. 1.4(*a*) shows a battery with its positive pole connected to the *p*-type germanium and its negative pole connected to the *n*-type. The negative pole supplies electrons to the *n*-type material so that the free electrons can cross the junction without making the material positive. Thus there is no force to draw them back and, under the pressure of the battery e.m.f., they move steadily across the junction into the holes of the *p*-type material. The concentration of electrons on their side of the junction is maintained by the battery.

At the other end of the bar, the positive pole of the battery is hungry for electrons, which it abstracts from the *p*-type material, creating one more hole for each electron taken in this way. Since these holes are positive, they are repelled by the positive battery potential towards the junction, where they take the place of the holes as fast as they are filled by electrons from the *n*-type germanium. Thus the concentration of holes is maintained and a steady current flows.

Although the current is carried by holes in the *p*-type material and by electrons in the *n*-type material, the battery supplies only a steady flow of electrons.

EFFECT OF REVERSED BATTERY

Now suppose the battery connections are reversed as in Fig. 1.4(*b*). The holes see a large supply of electrons at the far end of the bar. Immediately they move towards it and begin to be filled. But each electron absorbed by a hole is a small negative charge added to the *p*-type material, which therefore grows steadily more negative in opposition to the negative battery pole.

On the other side of the junction electrons are attracted by the positive battery pole. Since there are no free electrons in the *p*-type germanium to cross the barrier and replace those drawn into the battery the *n*-type material rapidly acquires a positive charge, which again is in opposition to the battery e.m.f. In a very small fraction of a second, the positive and negative charges become equal and opposite to the battery voltage, so that practically no current flows.

So according to the polarity of the battery connections, a composite bar of *p* and *n* type germanium behaves either as a fairly good conductor or as an insulator. In other words, the junction will rectify an a.c. signal.

Next month: the principles of diodes

Fig. 1.4. A pn junction is produced by fusing a piece of n-type material to a piece of p-type material

Fig. 1.4a. The battery provides a forward bias, and current flows across the junction

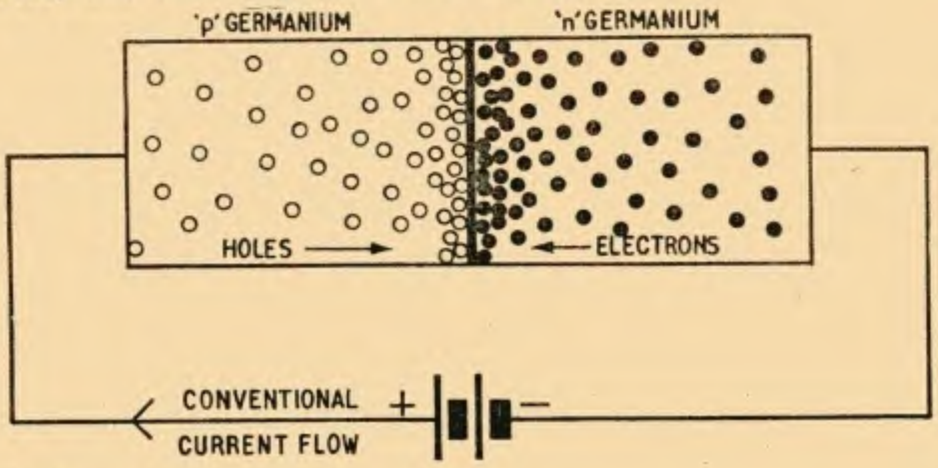
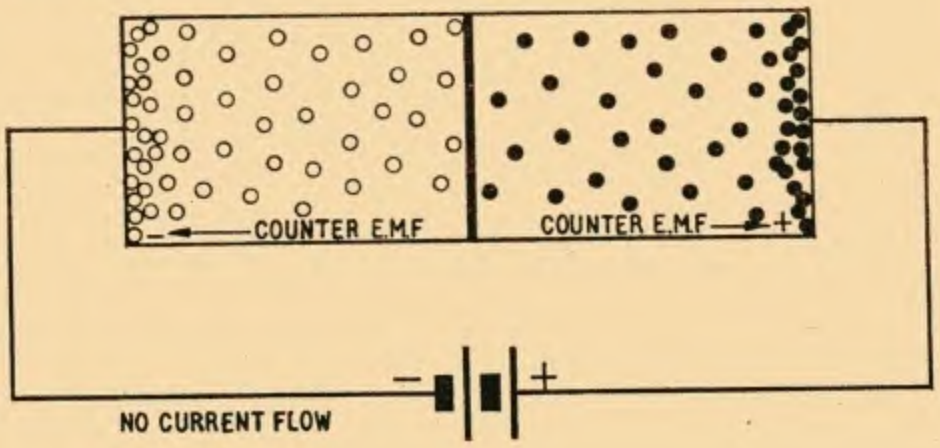
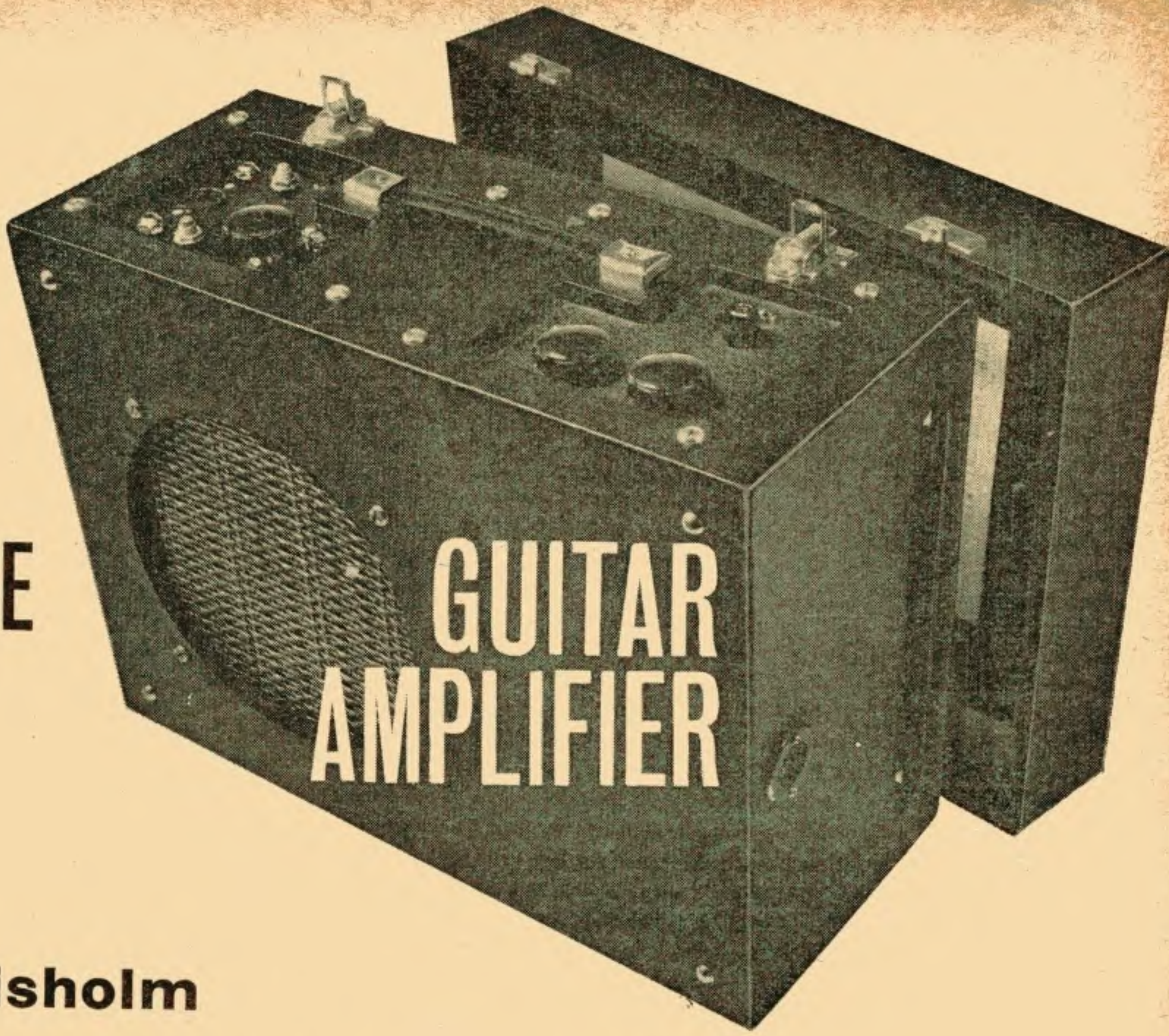


Fig. 1.4b. The battery has been reversed, with the result that no current flows



PART ONE

GUITAR AMPLIFIER

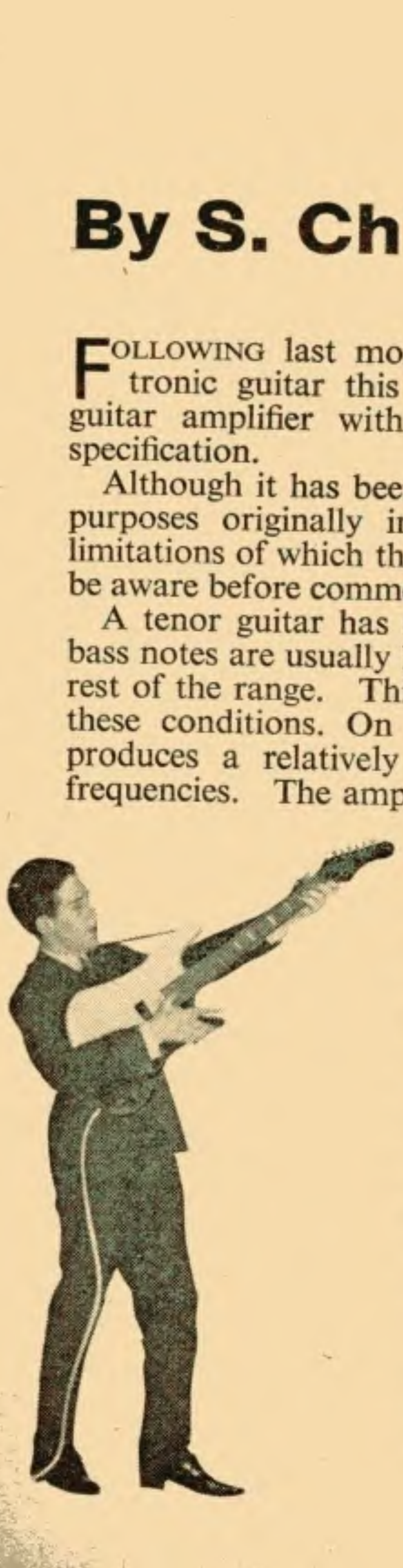


By S. Chisholm

Following last month's article on the tenor electronic guitar this article describes an integrated guitar amplifier with the facilities outlined in the specification.

Although it has been proved to be adequate for the purposes originally intended there are one or two limitations of which the prospective constructor should be aware before commencing the construction.

A tenor guitar has a wide frequency range but the bass notes are usually low level in comparison with the rest of the range. This amplifier copes very well with these conditions. On the other hand a bass guitar produces a relatively high amplitude at its lowest frequencies. The amplifier will handle this but if they are played strongly there is a risk of overloading the first stage. It was *not* intended to use the amplifier in a guitar group played before a large audience, but if the constructor wishes to do so he should be aware of the above limitations and use the channel volume controls, bearing in mind the power available at the output. It can give sufficient power to fill a large living room even when there is some room noise present.



Good earthing is essential to reduce hum to a minimum and provide a clean bass response.

SPECIFICATION

Although designed originally for use with the tenor electronic guitar described last month, this amplifier can be used with other musical instruments.

Input
Two channel input with independent volume controls.

Controls
Overall volume, tone and vibrato controls for local or remote operation.

Tone
Two alternative circuits described:
(a) Three position control with volume compensation simulating a three pickup guitar.
(b) Two position control uncompensated.

Vibrato
Optional two-speed constant depth.

Output
$3\frac{1}{2}$ watts driving one 8in energised and one 6in permanent magnet loudspeaker.

Frequency range
No audible loss over the entire range of a piano using a crystal microphone placed inside the piano cabinet.

Power Consumption
240 volts a.c. 70 watts (self-contained power unit).

Dimensions
18in wide, 14in high, $7\frac{1}{2}$in deep. Wooden case with detachable lid containing the second loudspeaker and connecting cables.

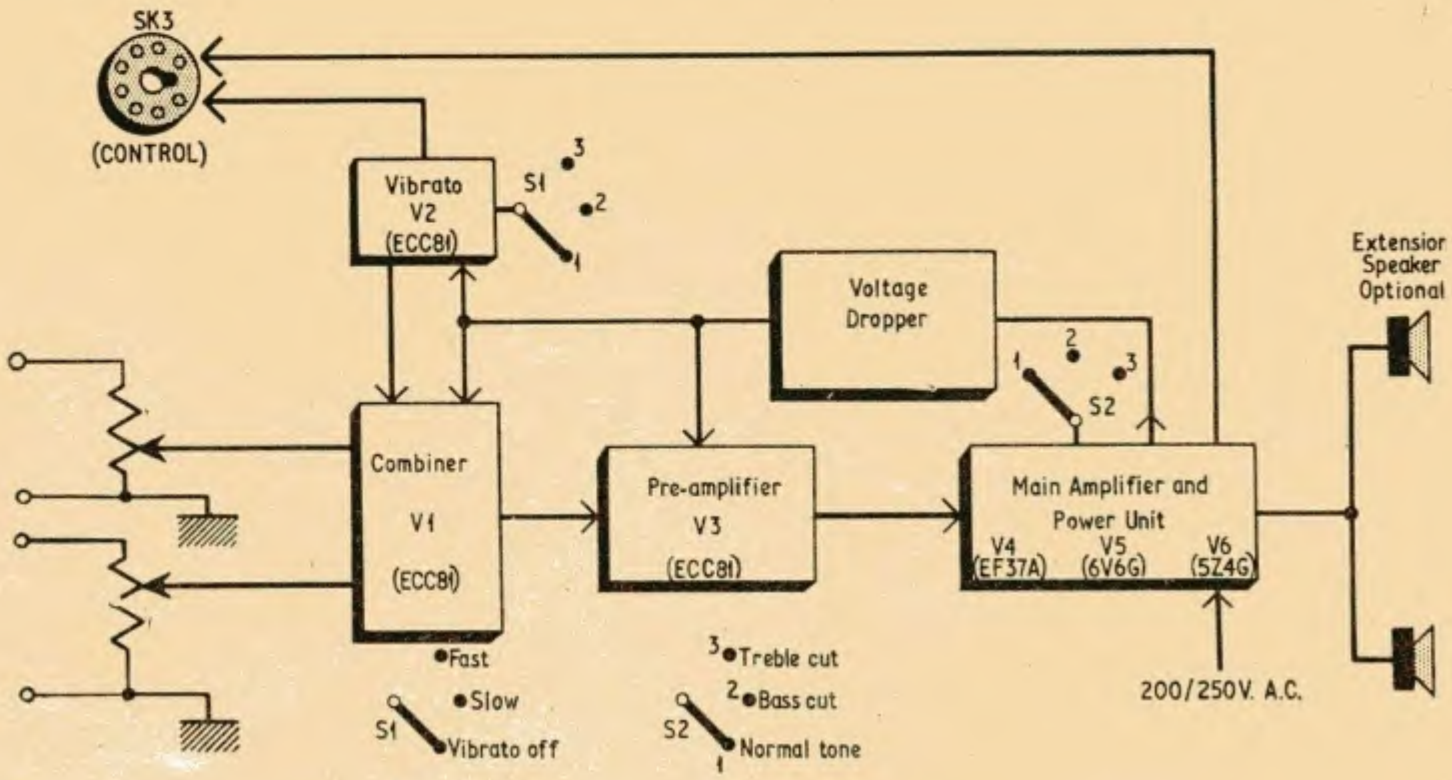


Fig. 1. Block diagram of the complete amplifier

CIRCUIT

The block digram of the complete amplifier is shown in Fig. 1. The two input sockets are suitable for high impedance signals from a microphone and pick-up. Each channel has its own volume control to match the two signals and prevent possible overloading of the first stage. Vibrato effect can be switched to channel 1 signal before the two signals are mixed and fed to V3a (see Fig. 3). V3 and V4 amplify the combined signal. RLA1 in the cathode of V4 is normally closed. Switch S2 (situated on the guitar itself) can operate the relay to bring the cathode bypass capacitor into circuit to increase the bass response. A certain degree of top cut is provided by R26 and C17 across the primary of the output transformer.

Although an 8in energised loudspeaker is specified (part of the winding being used as a smoothing choke), there is no reason why this should not be replaced by a moving coil loudspeaker and separate choke as shown in Fig. 3.

The power unit is designed for a.c. operation only. Universal (a.c./d.c.) operation is unsuitable because of shock risks on the instrument. The amplifier should be earthed.

TONE CONTROL

One of two systems can be adopted; both provide instantaneous preset change of tone. The first (R24 and C16 in Fig. 3) will give a slight drop in volume. The second (Fig. 4) provides a more flexible arrangement controlling both treble and bass.

In the simple circuit the guitar switch S2 supplies a d.c. voltage to relay RLA from the h.t. line. The

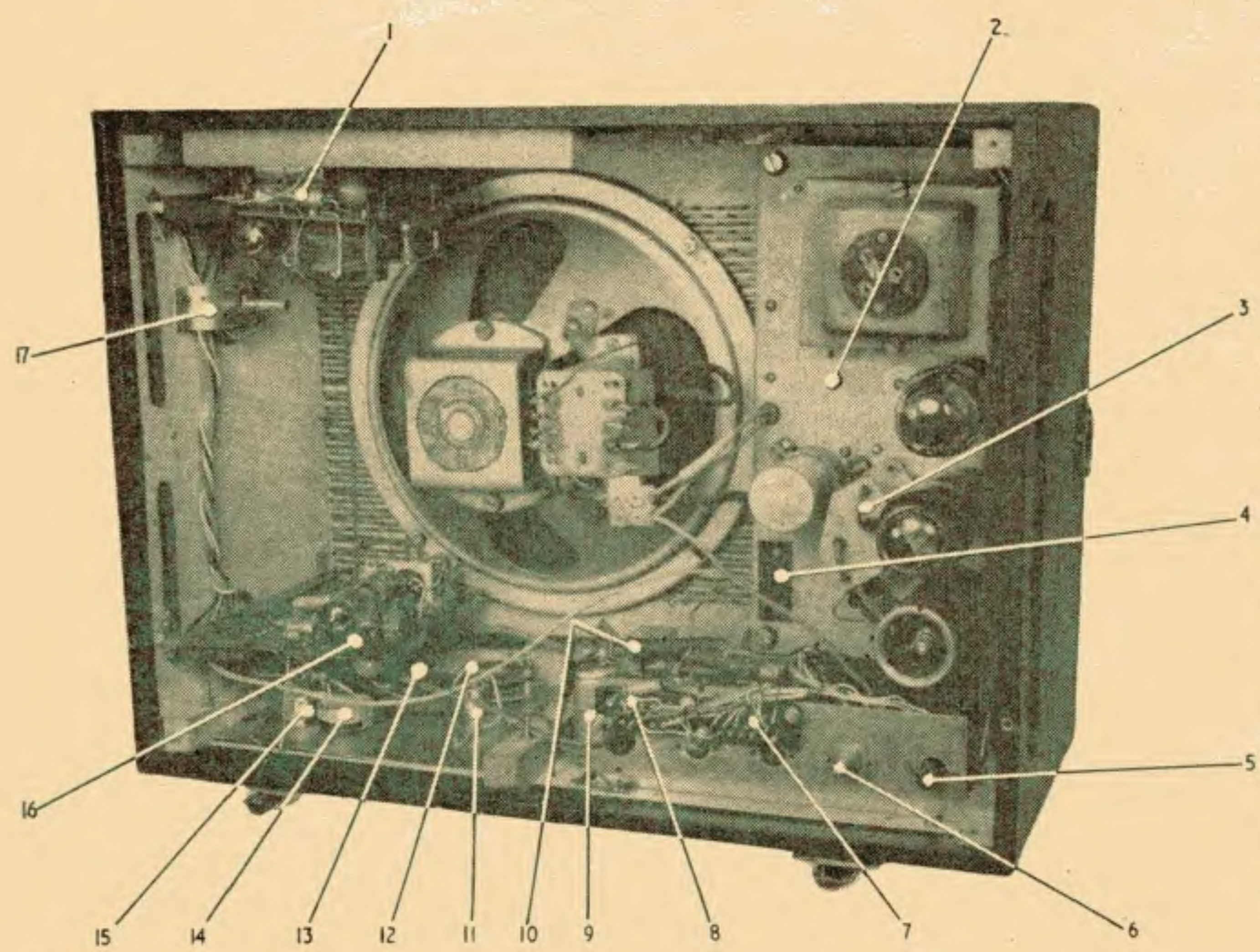
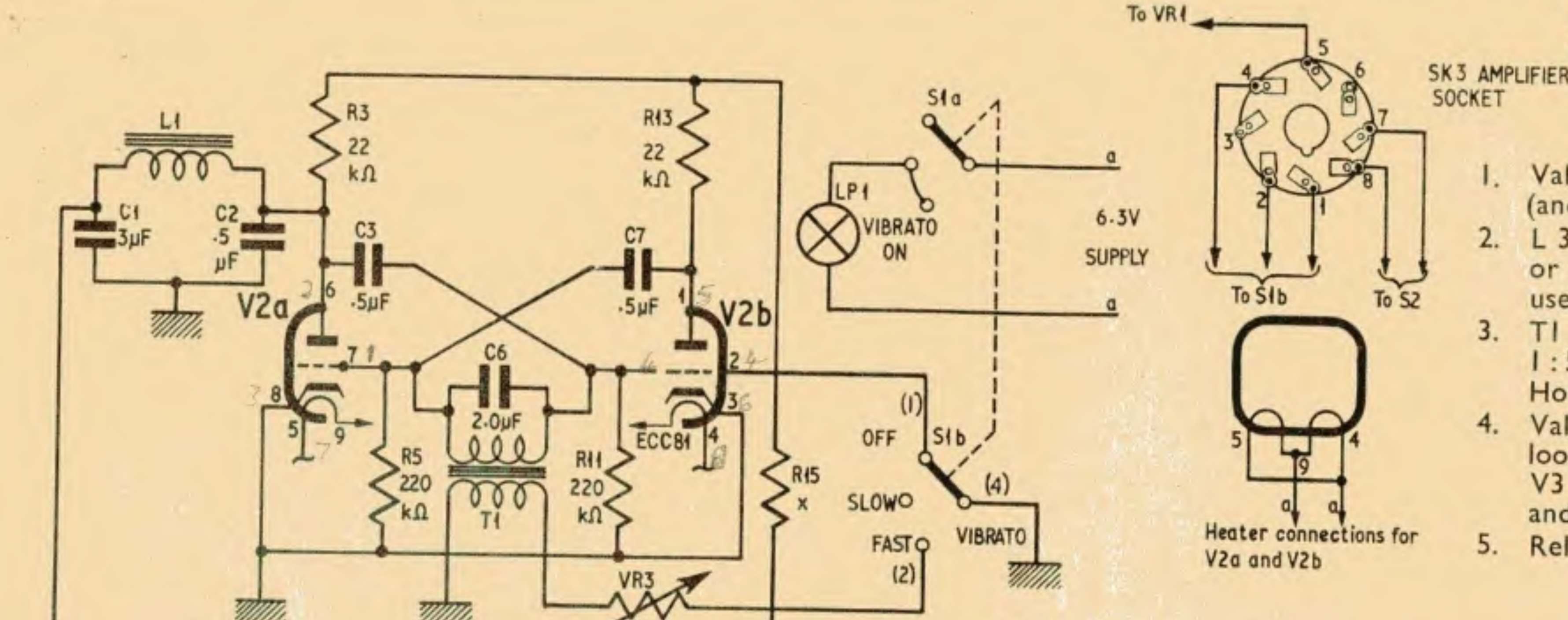
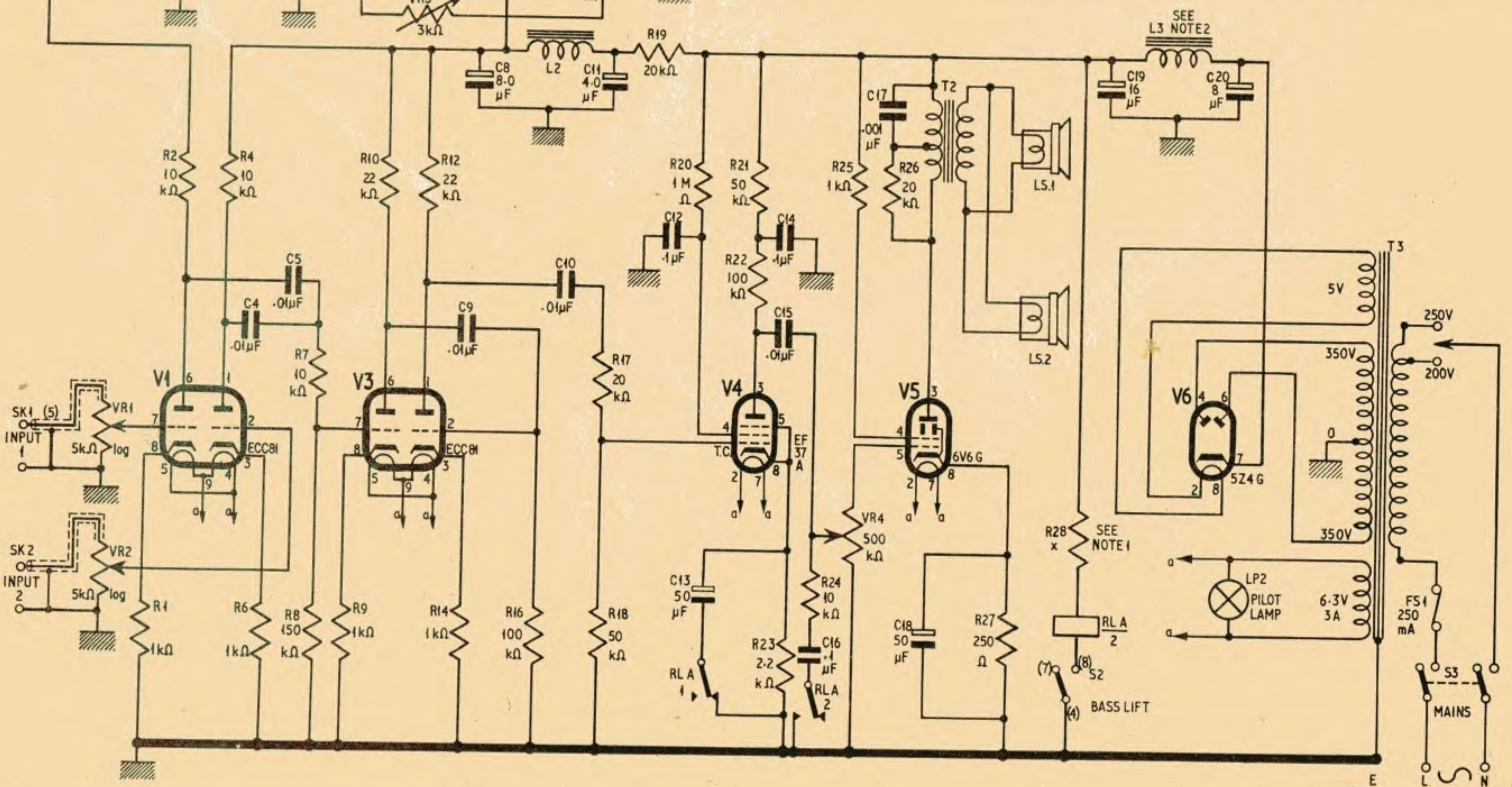


Fig. 2. Interior of the prototype model

1. Vibrato unit
2. Main amplifier
3. Bass inductor L4
4. Input to main amplifier
5. Treble volume control VR5
6. Bass volume control VR4
7. Relay RLB
8. Relay RLA
9. Smoothing capacitor C8
10. Smoothing choke L2
11. Vibrato indicator lamp LP1
12. Vibrato control switch S1
13. Input volume control VR2
14. Input volume control VR1
15. Input socket SK1
16. Preamplifier unit
17. Vibrato speed control VR3

Fig. 3. Complete circuit diagram of the amplifier and vibrato unit





SK3 AMPLIFIER SOCKET

Notes:

1. Value of R28 is determined by the current requirements or RLA (and RLB if used see Fig. 4).
2. L 3 may be the field winding of the 8in energised loudspeaker or a 10H 80mA choke if a permanent magnet loudspeaker is used.
3. T1 may be an intervalve transformer of step-up ratio 1 : 4 or 1 : 5. A ready made item such as the type T1V4 (available from Home Radio of Mitcham) can be used.
4. Valve pin connections are numbered in clockwise notation looking at the underneath of the valveholders. In V1, V2, and V3 the heater 6·3V supply is connected to pins 4 and 9 ; pins 4 and 5 are shorted.
5. Relay contacts are shown in the normal non-operated condition.

value of Rx is arranged to suit the current required to operate RLA (see a later paragraph). Contacts RLA1 disconnect C13 from the cathode of V4 and RLA2 introduces the top cut circuit (R24 and C16) across the output of V4.

The complex circuit (Fig. 4) involves more components but it is well worth adopting. A second relay is connected in the h.t. circuit as shown, with S2 changed to a three-way switch to give bass lift, treble lift or neither. We now have two sets of relay contacts RLA and RLB. The positions of the contacts shown in the circuit indicate their function in the non-operated condition.

Operation of the tone switch S2 to the bass lift position operates RLA. RLA1 disconnects the cathode bypass capacitor C13 from earth and inserts the top cut circuit R24 and C16 and the bass control VR5. The volume control VR4 and treble control VR5 are not in use. The values of R24 and C16 can be adjusted to provide top cut to suit the user.

When S2 is set to treble lift, RLB operates and RLA releases. All circuits associated with RLA are now restored to normal. RLB1 and RLB2 connect the treble control VR5 and disconnect VR4. RLB3 inserts C21 and L4 in the grid circuit of V5. The values of C21 and L4 may be chosen to suit the user's preference, and may be determined from published nomograms to give a bass cut below about middle C (256c/s). VR5 can be adjusted to compensate for the general loss of volume due to C21 and L4.

In the prototype a 60 : 1 microphone transformer was used for L4. The primary (low impedance) winding was left open circuit. C21 was initially 150pF, then by experimenting a suitable value was found to give the required amount of bass cut. Too small a value for C21 can cause a.f. oscillation when VR5 is adjusted. Relays RLA and RLB should be capable of operating at about 10mA, the lower the current demand the better. They should have at least three changeover sets of contacts.

VIBRATO

The vibrato circuit (V2a and V2b in Fig. 3) is basically a multivibrator. The operating frequency is governed by T1, C6 and VR3. The LC circuit (L1, C1, C2) rounds off the spiky waveform of the multivibrator. The value of C6 is chosen in conjunction with the inductance of T1 by connecting a preset potentiometer VR3 across the primary when required. Depth of vibrato is preset by R15.

The h.t. supply to V1a anode is taken from the anode load resistor R3 via a low-pass filter L1, C1 and C2. This filter removes practically all trace of multivibrator waveform and provides a smoothly alternating waveform to V1. Inductor L1 is a Mullard ferroxcube (type LA7) filled with 30 s.w.g. enamelled wire but any form of a.f. choke should be suitable provided it can be mounted on Veroboard.

Vibrato is introduced to the guitar signal by operating S1 which also switches on the vibrato indicating lamp. When S1 is switched off V2B grid is earthed, thus preventing modulation of the h.t. supply to V1a. The "slow" setting releases the grid; vibrato frequency is then determined by the LC circuit only.

The "fast" setting introduces preset VR3 effectively reducing the inductance of T1 primary. Vibrato tends to affect V1b, but to a lesser degree than in V1a, and is not considered to be objectionable. Socket SK3 provides connection to remote controls on the guitar.

GUITAR WIRING NOTE

In last month's article on the "Electronic Guitar" (see Fig. 6) the connections of terminals 4 and 5 on the guitar plug, amplifier plug and jack plug were incorrect. The screen should be connected to pins 4 on both 8-pin plugs and to the sleeve of the jack plug; the centre conductor should be connected to pins 5 and the tip of the jack plug.

Next month: Full constructional details will be given with a few details on maintenance and use of the amplifier and guitar.

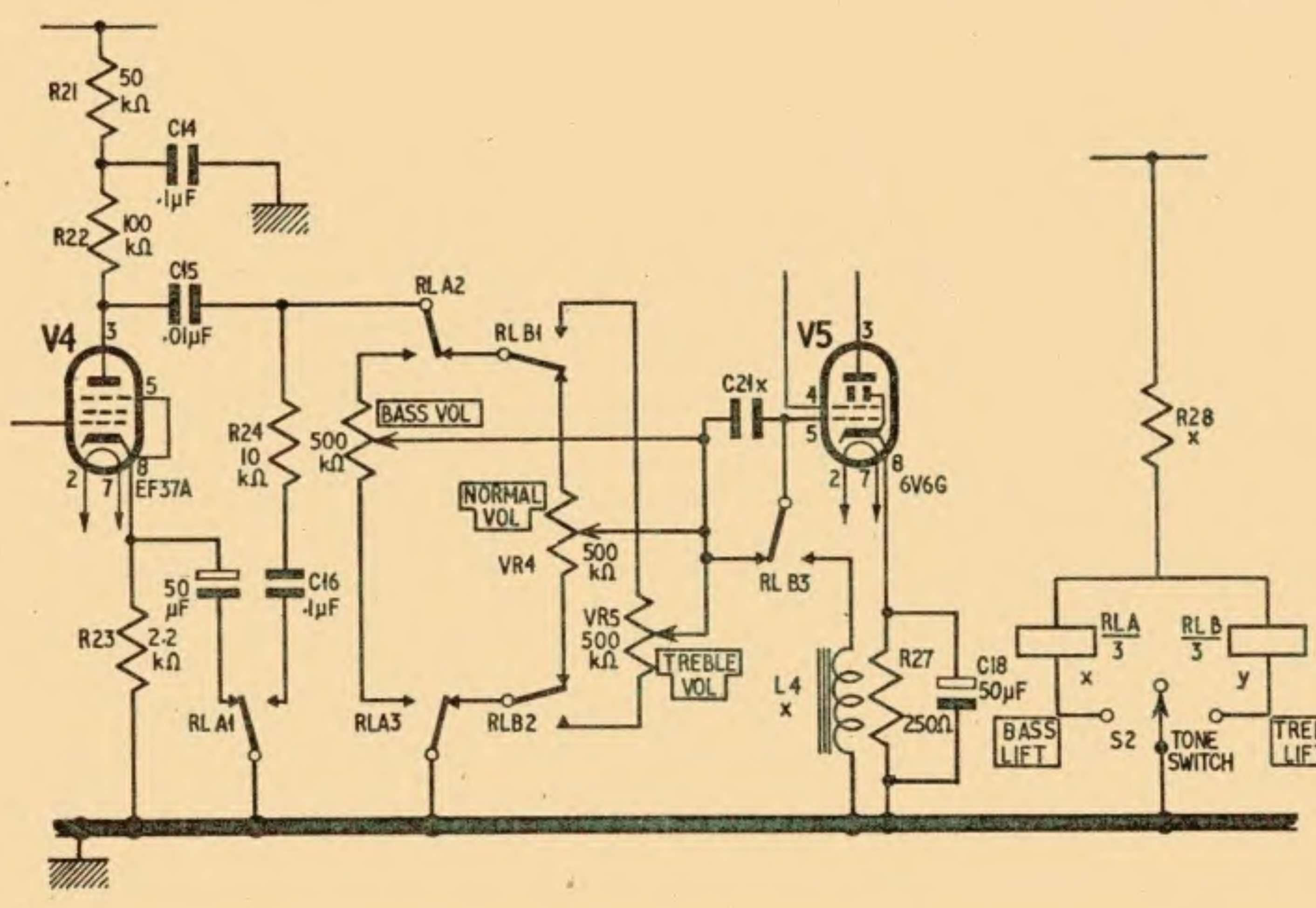


Fig. 4. Alternative complex tone control circuit between V4 and V5

COMPONENTS . . .

INPUT CONTROL PANEL

Potentiometers

VR1 and VR2 5kΩ log.

Sockets

SK1 and SK2 Two-terminal jacks
SK3 International octal valveholder

Switch

S1 2-pole, 3-way, centre off, toggle switch

Lamp

LP1 Indicator lampholder and 6·3V 0·05A m.e.s. bulb.

Note: VR1 and VR2 are connected to the pre-amplifier S1 and LP1 are connected to the vibrato circuit

MIXER AND PRE-AMPLIFIER UNIT

Resistors

R1	1kΩ	1W	R9	1kΩ	1W
R2	10kΩ	1W	R10	22kΩ	1W
R4	10kΩ	1W	R12	22kΩ	1W
R6	1kΩ	1W	R14	1kΩ	1W
R7	10kΩ	$\frac{1}{4}$W	R19	20kΩ	3W
R8	150kΩ	$\frac{1}{4}$W			

Capacitors

C4	0·01μF	350V paper	C9	0·01μF	350V paper
C5	0·01μF	350V paper	C10	0·01μF	350V paper
C8	8μF	350V elect.	C11	4μF	350V elect.

Valves

V1 ECC81 V2 ECC81

Choke

L2 10H 30mA

VIBRATO UNIT

Resistors

R3	22kΩ	1W	R11	220kΩ	$\frac{1}{4}$W
R5	220kΩ	$\frac{1}{4}$W	R13	22kΩ	1W

R15 3W resistor (resistance determined by vibrato depth required)

Potentiometer

VR3 3kΩ log

Capacitors

C1	3μF	150V paper (can be 2 + 1μF in parallel)
C2	0·5μF	150V paper
C3	0·5μF	150V paper
C6	2μF	150V paper
C7	0·5μF	150V paper

Choke

L1 Ferroxcube type LA7 filled with 30 s.w.g. enamelled wire, or any a.f. choke

Transformer

T1 Type T1V4 (Home Radio)

Valve

V2 ECC81

MAIN AMPLIFIER

Resistors

R17	20kΩ	$\frac{1}{4}$W	R23	2·2kΩ	1W
R18	50kΩ	$\frac{1}{4}$W	R24	10kΩ	$\frac{1}{2}$W
R20	1MΩ	$\frac{1}{2}$W	R25	1kΩ	1W
R21	50kΩ	1W	R26	20kΩ	$\frac{1}{2}$W
R22	100kΩ	1W	R27	250Ω	1W

R28 to suit current through RLA (see text)

Potentiometer

VR4 500kΩ log. carbon

Capacitors

C12	0·1μF	350V paper
C13	50μF	25V elect.
C14	0·1μF	350V paper
C15	0·01μF	350V paper
C16	0·1μF	150V paper
C17	0·001μF	350V paper
C18	50μF	50V elect.
C19, 20	16μF + 8μF	350V elect.

Valves

V4 EF37A V5 6V6G V6 5Z4G

Switches

S2 Single-pole, on-off toggle switch
S3 Double-pole, on-off toggle switch

Transformer

T2 Output transformer to match 6V6 to two loudspeakers in parallel
T3 Primary 200-250V a.c.
Secondary 350-0-350V 70mA, 6·3V 3A, 5V 2A

Choke

L3 L.F. choke 10H 80mA (required only if p.m. loudspeaker is used)

Miscellaneous

FS1 Fuseholder and 250mA fuse
LP2 Indicator lampholder and 6·3V 0·3A bulb
RLA Relay (see text)

COMPENSATED TONE CONTROL

The following is a list of additional or replacement components. See text and Fig. 4 for details.

Potentiometers

VR5 and VR6 500 kΩ log. (additional)

Switch

S2 single-pole, 3-way, centre off, toggle switch replaces the single-pole, on-off switch given in main amplifier components list

Miscellaneous

L4 Choke
C21 Capacitor
RLB Relay
} additional (see text)

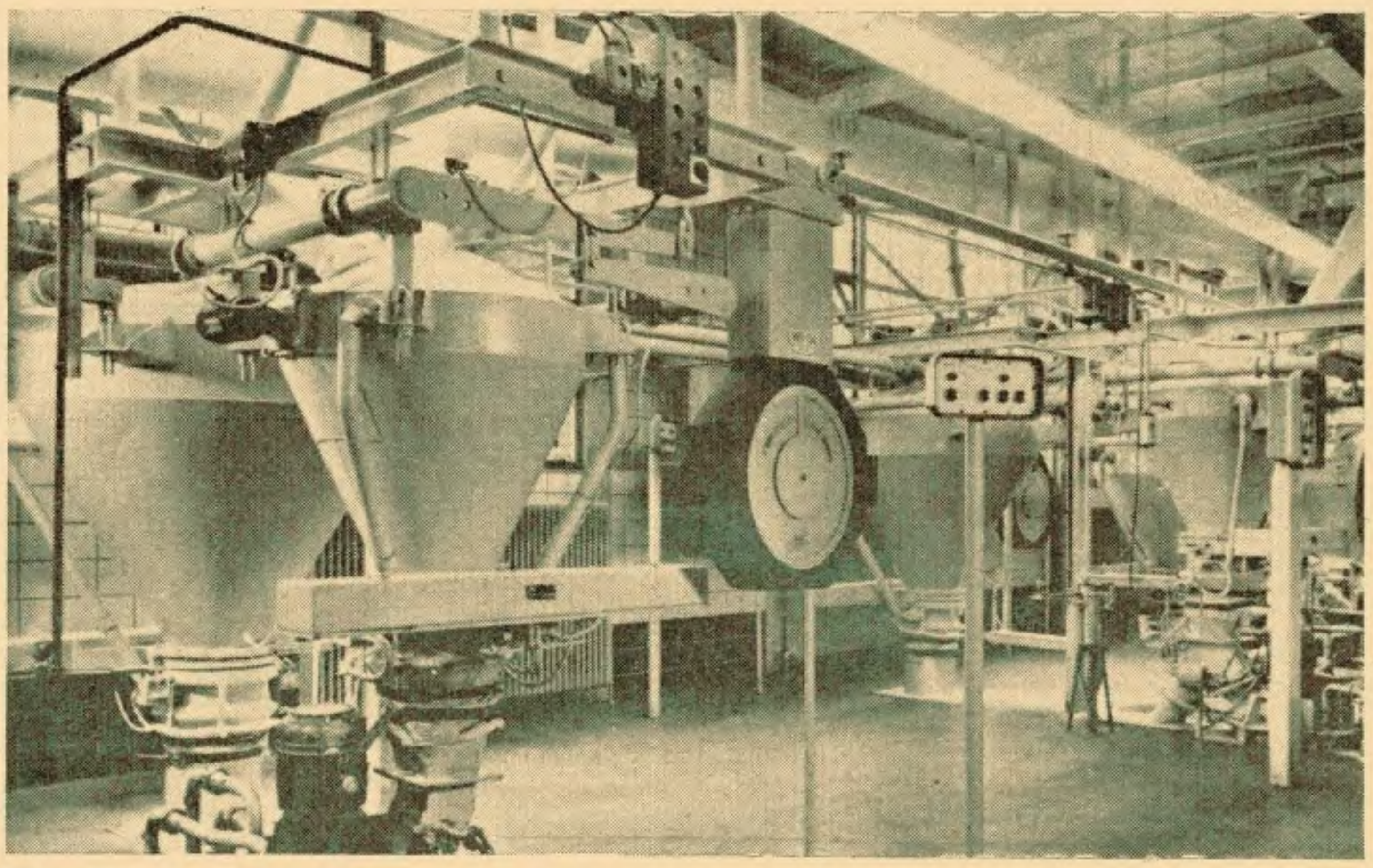
OTHER MISCELLANEOUS ITEMS

2 Veroboard panels
1 8in loudspeaker, permanent magnet (if an energised loudspeaker is used, the field winding should withstand 80mA at 350V and take the place of L3)
1 6½in permanent magnet loudspeaker
Screened wire, connecting wire, cleats, nuts, bolts, wood screws, sheet aluminium (see next month's article)

ELECTRONORAMA

HIGHLIGHTS FROM THE CONTEMPORARY SCENE

Mass Produced Dough Using Computers



AUTOMATIC control of manufacturing processes has been applied to biscuit making in Holland where E.M.I. Electronics equipment measures and weighs the various ingredients prior to mixing and cooking.

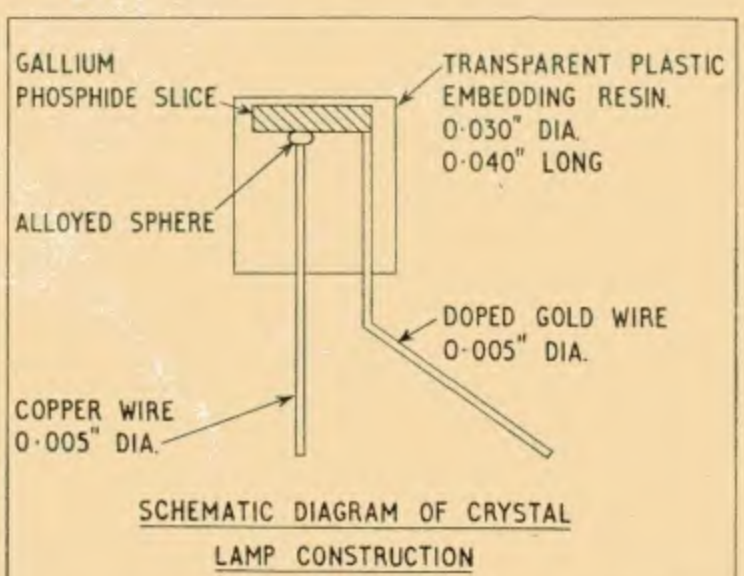
The only human assistance is provided by a programme controller, who can see at a glance from a chart in front of him which of the many processes is being carried out. The master computer, which can just be seen on the right hand side of the photograph, controls the entire operation of preparing the biscuit dough. The racks on the left contain stand-by equipment for manual operation.

Semiconductor Lamp

A DEVICE, which is believed to be the first of its kind produced commercially in the U.K., will produce light based on radiative recombination at a *pn* junction. The crystal lamp, as it is called, is in effect a forward biased gallium phosphide diode suitably treated to produce a radiation of 7,000Å (wavelength) in the infra-red region. At a forward current of 20mA the red lamp has a voltage drop of approximately 2½ volts. The average brightness is 10 to 40 foot lamberts.

Operating in the reverse biased mode it can be used as a fast light source, light output rise times of less than three nanoseconds being obtained.

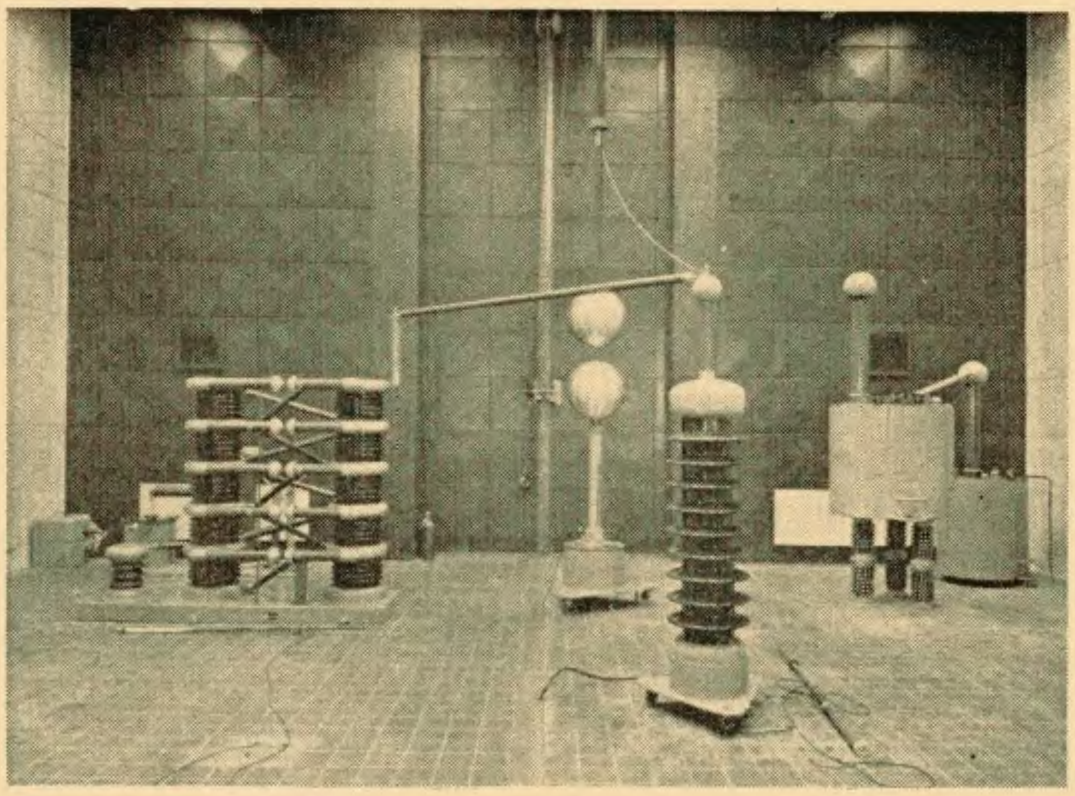
The development of the crystal lamp has been carried out by the Electronics Department of Ferranti.



SCHEMATIC DIAGRAM OF CRYSTAL LAMP CONSTRUCTION

Bang !

A NEW "high voltage" laboratory at the University of Leeds was recently equipped with a 500 kilovolt impulse generator (left), a 50cm sphere arc gap (centre) and a combined surge potentiometer and a.c. resistance voltmeter column. On the right the 300 kilovolt testing transformers can be seen. The equipment has been provided by Ferranti. ▶



Sizing up the Wafers ▲

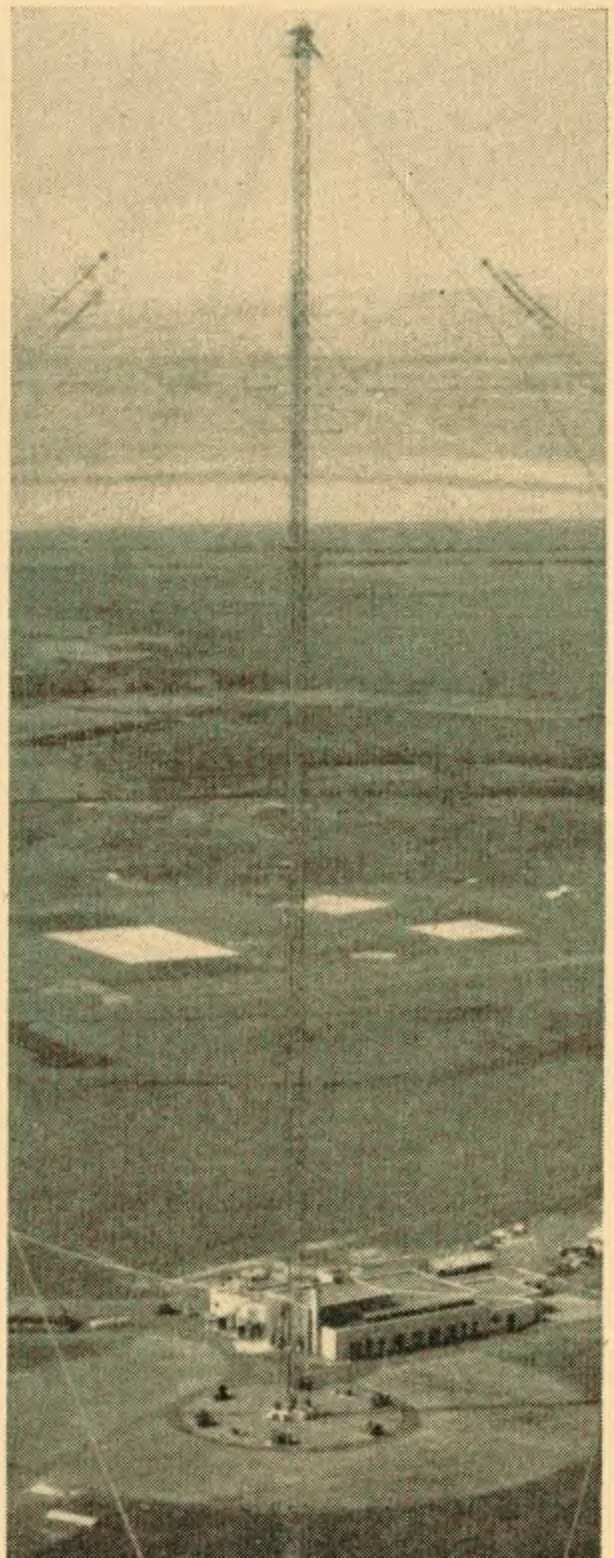
MINUTE particles of germanium have to be sorted according to size for the manufacture of semiconductors. This machine sorts 3,000 pieces (or wafers) an hour into 10 thickness grades for the transistor division of Standard Telephones and Cables. Each grade differs in thickness by only one ten thousandth of an inch.

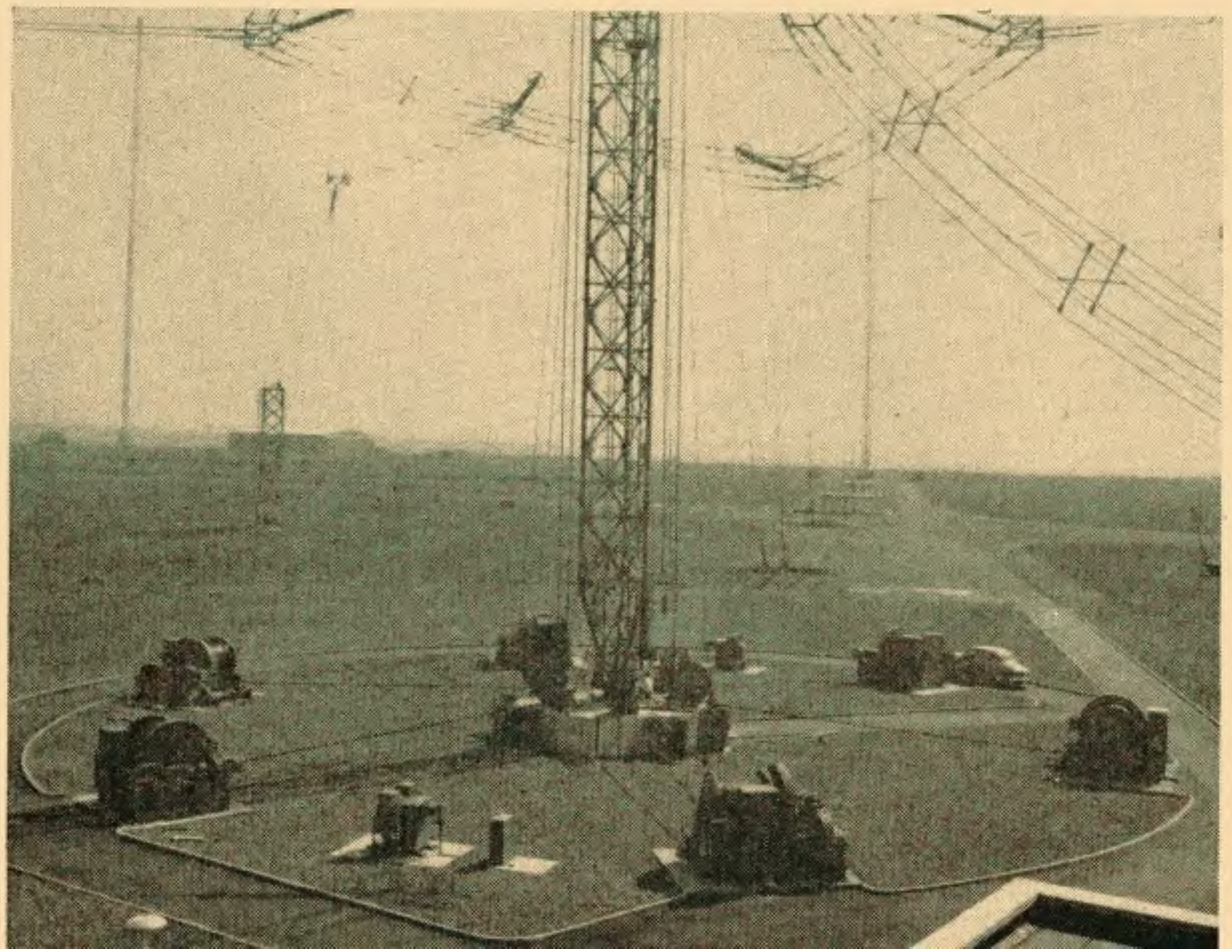
Keep the Mast Upright !

THE 748ft high centre mast of the new N.A.T.O. V.L.F. Radio Station, recently completed by British Insulated Callender's Construction Company near Carlisle, is fitted with six halyard winches. They can adjust the tension cables on the mast to withstand wind speeds of up to 130 m.p.h. at the top and ice on the conductors up to 3in in diameter.

The tensions involved are measured at the mast heads by electronic load cells. The signals from these cells (about 10mV) are carried down the mast to the winch, where they are amplified and registered as tension readings on the winch dials and on slave dials in the control tower. Under extreme weather conditions the aerial can be lowered to any position and the winches can be adjusted by remote control in the tower.

Calculations of stresses under 30 sets of loading conditions were performed on the EDSAC 2 computer at Cambridge University.

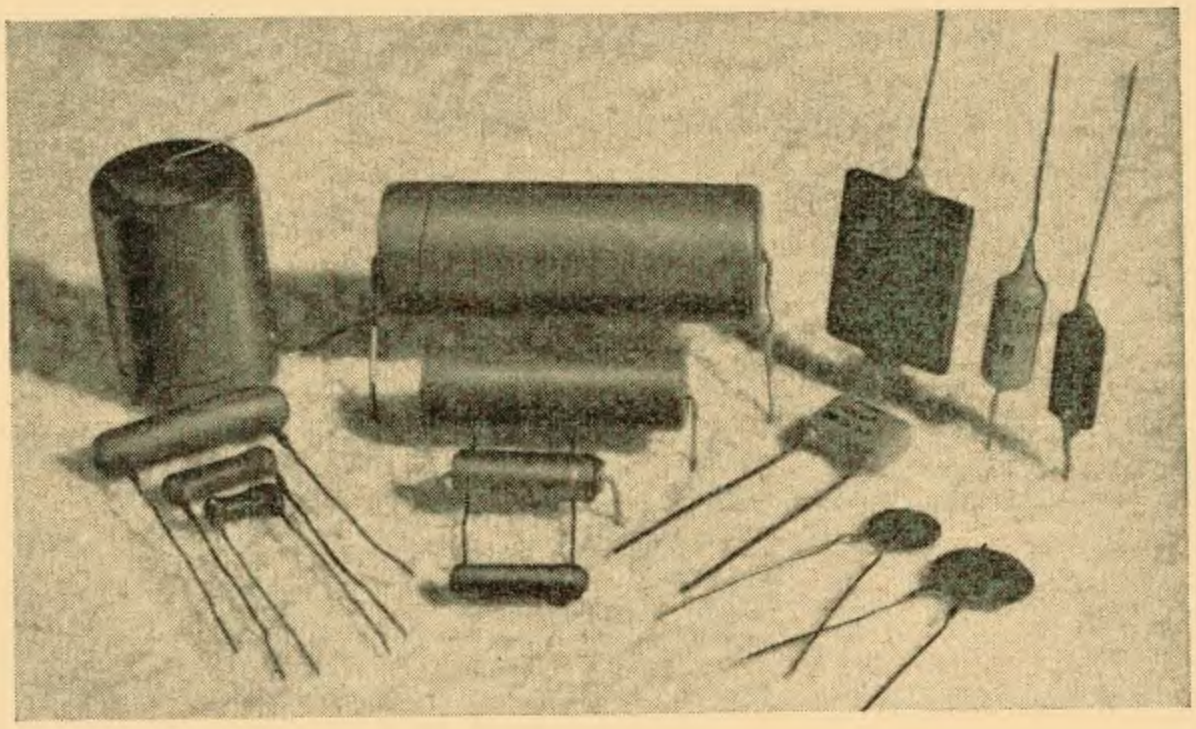




BEGINNERS start here... 4

An Instructional Series for the Newcomer to Electronics

C



FIXED CAPACITORS

A selection of the more common types of fixed capacitors. In the centre and left rear are paper dielectric; three tubular ceramic capacitors are in the left foreground; the flat rectangular components in the right of the photograph are mica types, and in front of these are two disc ceramic capacitors

It is now time to consider the capacitor. This is a most important component and it is used in electronic circuits almost as extensively as the resistor.

Basically, the capacitor (or condenser as it was more commonly called at one time) consists of a pair of metal plates, in close proximity to each other but separated by air or some other electrically insulating material.

It is important not to lose sight of this basic structure —even though many and varied types of capacitors will be encountered in everyday electronics. We will have more to say about these different types of capacitors and their particular uses later on. But first we must familiarise ourselves with the basic component and the properties it possesses.

CHARGING ACTION

Let us suppose a capacitor is connected to a battery as shown in Fig. 4.1. When the switch is set to position 2 there will be a momentary flow of current in the circuit as indicated by a sudden deflection of the meter needle; then the needle will rather slowly fall back to zero. Why is this so?

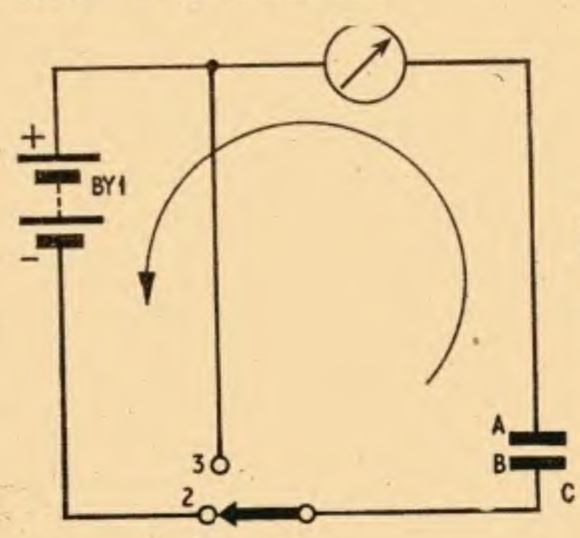
Let us look closer at this circuit and especially at the capacitor C. Initially, with the switch open (position 1) there is no voltage or potential on either plate of the capacitor. Thus the capacitor is as we say, discharged.

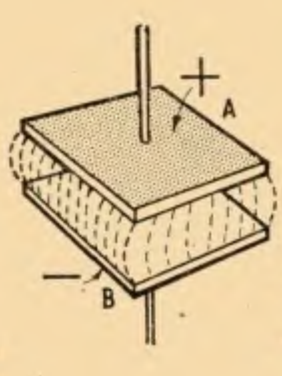
Immediately the switch is closed, electrons move from the negative side of the battery and accumulate on plate B of the capacitor, while at the same time electrons are drawn from plate A to the positive side of BY1.

An electrostatic field is now created by the opposite polarities on these two facing plates, and lines of force pass through the insulating medium or dielectric, as it is generally called (Fig. 4.2). Electrons flow through this dielectric from the negatively charged plate B to plate A, and produce the current we would see indicated by the sudden upward rise of the meter needle.

The meter used in this experiment, it should be explained, is of the centre-zero type. Note that the meter needle deflects to the right—which is normal for conventional current flow, whereas the arrow indicates the direction of *electron flow* in the circuit.

This current flowing into the capacitor is stored as an electrical charge. As this charge accumulates, the





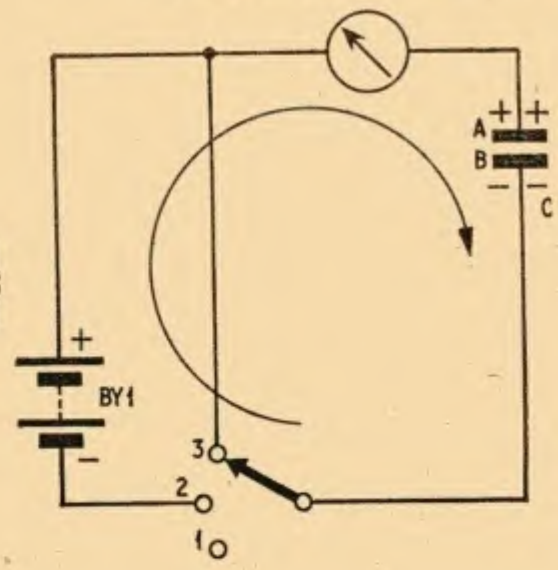


Fig. 4.1 (far left). This illustrates charging of a capacitor C by the battery BY1

Fig. 4.2 (centre). An electrostatic field is created between the two plates, as indicated by the broken lines

Fig. 4.3 (left). The capacitor is now discharged, the current flowing in the opposite direction to that of Fig. 4.1 voltage on the two plates builds up until eventually it is equal to that of the battery. In this condition no more current can flow—since there is now no potential difference between either side of the battery and the capacitor plate to which it is connected—and the capacitor is said to be fully charged.

The amount of this stored charge is determined by three factors:

(1) The distance between the two plates
(2) The area of overlapping surface
(3) The nature of the dielectric

The capacitance (C) of a capacitor is measured in farads, and is obtained by dividing
The charge measured in coulombs (Q)
by the potential difference between the plates (V)

DISCHARGE OF CAPACITOR

We can remove the capacitor from the circuit, and it will hold its charge for a considerable time. But suppose we deliberately short circuit the two plates of the capacitor, the stored charge will be dissipated through the external circuit and the capacitor will once again be in a discharge state.

This discharging operation can be performed with the original circuit. If the switch is set to position 3 (Fig. 4.3) the meter needle will swing over in the opposite direction and then slowly return to zero. This shows very graphically that after an initial heavy discharge current, the electrostatic field gradually collapses, with a resultant decline in current as the capacitor becomes discharged.

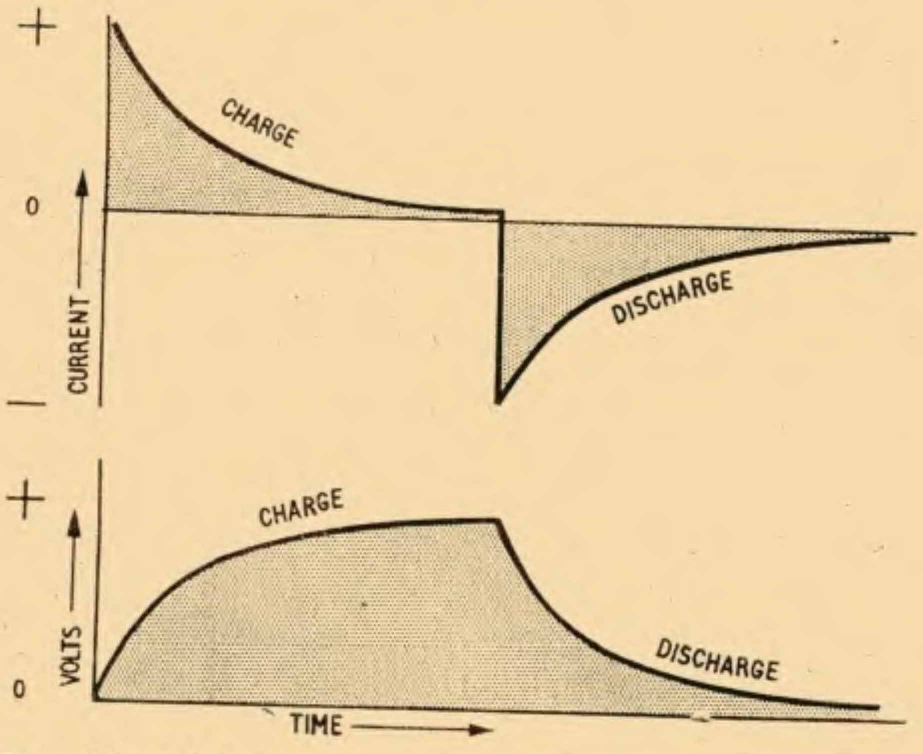


Fig. 4.4. The charging and discharging action of a capacitor is made clear by these curves

The curves in Fig. 4.4 show how the current through a capacitor falls as it becomes charged, while at the same time the voltage across the capacitor rises. During discharge a large negative-going current flows initially but then falls off; this causes a steady decline in voltage across the capacitor.

One very significant fact should have emerged from these investigations. The capacitor acts momentarily as a short circuit to an applied voltage, but immediately afterwards, when the capacitor has become charged to this same value, it then acts as a barrier or open circuit. In other words the capacitor responses to *sudden changes* of voltage but not to *steady levels* of voltage.

For all d.c. purposes we can consider the capacitor as an open-circuit (apart from the initial charging current upon application of the voltage). But to an alternating current (a.c.) the capacitor offers little resistance at all—it is virtually a short circuit. This a.c. resistance (properly called *reactance*) does though vary according to the *frequency* of the alternating current. More about this later.

This characteristic makes the capacitor a very important component in electronic circuits, where it is often necessary to separate d.c. signals from a.c. signals, or to discriminate between a.c. signals of different frequencies.

A fuller discussion of the action of capacitors with a.c. supplies must wait until we have progressed a little further with our practical work. Very soon now we shall be describing a simple electronic device that will produce a.c. (at low voltage) when powered by a small battery. Once this device has been built, you will be able to conduct interesting experiments in electronics.

In the meanwhile, familarise yourself with the general features of normal everyday capacitors.

UNIT OF CAPACITANCE

The farad represents the capacitance whose potential would be raised by one volt by one coulomb of electricity. One coulomb is that quantity of electricity which is delivered by a current of one ampere flowing for one second.

As the farad is far too large a unit for practical purposes (the earth itself has a capacitance of only about one-seventh of a farad) fractions of a farad are used.

The units we will meet in electronic work are the microfarad (a millionth, abbreviated to μF), and the picofarad (a billionth, pF for short).

TABLE 4.1

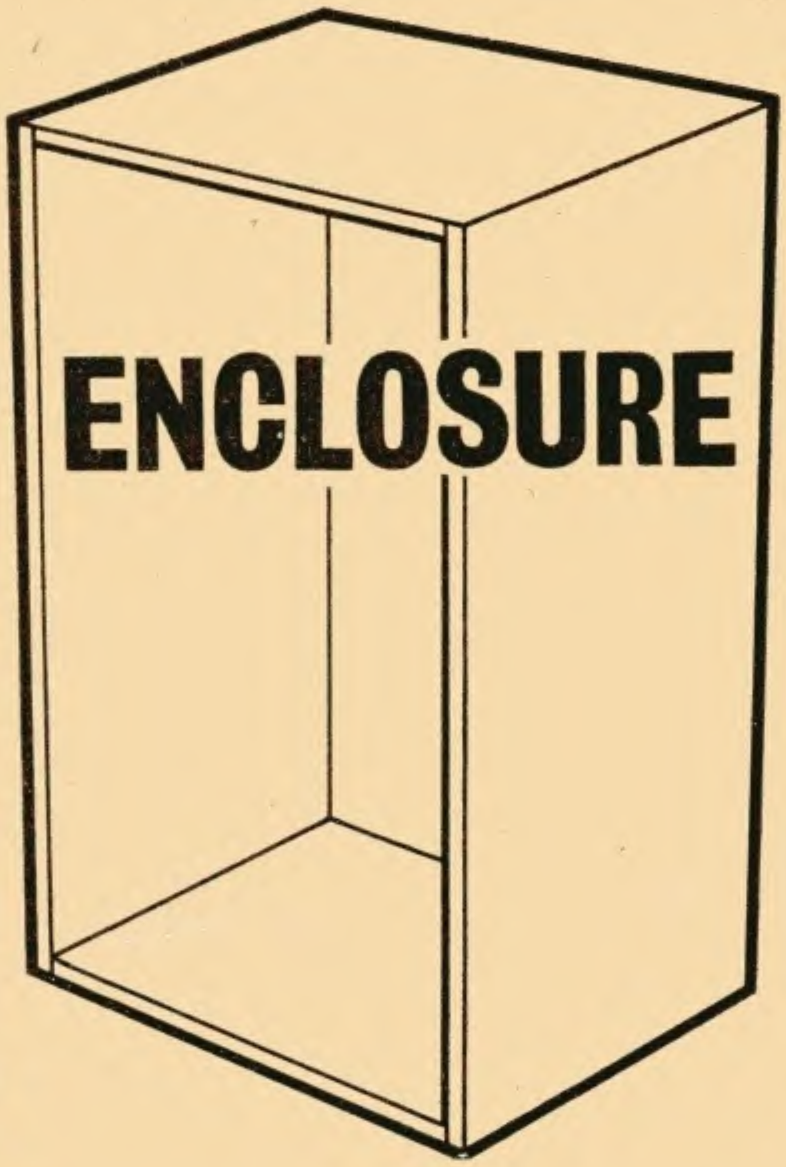
Micromicrofarad ($\mu\mu$F) or Picofarad (pF)		Microfarad (μF)
1	equal to	0·000001
10	,,	0·00001
100	,,	0·0001
1,000	,,	0·001
10,000	,,	0·01
100,000	,,	0·1
1,000,000	,,	1·0

PRACTICAL CAPACITORS

In our photograph on page 276 you will see a variety of commonly used capacitors. These are all of the non-polarised, fixed value type.

These components differ from each other mainly in the kind of material used as dielectric. If you look at the component lists in other articles in this magazine, you will notice that capacitors are frequently described as "paper", "ceramic", "mica" etc. This refers to the kind of material employed as the dielectric. Brief details of the construction of such capacitors, their normal range of values, and some indication of their applications will be given next month.

COMPACT LOUDSPEAKER ENCLOSURE



By K. F. RUSSELL A.M.I.E.E.

PART TWO... CONSTRUCTION

With 1 cu ft chosen as the most desirable size of the enclosure, we next have to decide on the proportions. There are some restrictions in the choice of dimensions as these determine the length of the standing waves set up inside the enclosure. If the wall-to-wall dimension in two directions is similar, the standing waves set up between the parallel surfaces in both these directions will be similar in wavelength and frequency, and there will be appreciable colouration in the response of the enclosure at this frequency. An even worse condition would arise if the box were cubic in shape.

Two further shapes are to be avoided. First, the enclosure must not be very long compared with its cross section, as it will then try to operate as an organ pipe; and second, the front-to-back dimension must not be made very short unless the loudspeaker can be specially designed to suit a shallow enclosure. It is extremely difficult to make very shallow enclosures with strong colouration of the sound in the mid frequency range, and the shallow enclosures which are available commercially at the present time have all been carefully developed alongside the loudspeakers which they employ. Careful design of the tuning and internal treatment is also necessary to give a smooth performance with such an enclosure.

FINAL DIMENSIONS

With these restrictions in mind, we have to arrive at a set of dimensions which will make the box fairly unobtrusive, and also give pleasing proportions from the point of view of appearance. Suitable dimensions are suggested in Fig. 6. These are external dimensions using ½in plywood. Solid timber is not recommended because slight distortion of the panels would cause the joints to open. Plywood is quite suitable from the acoustic point of view, as the changes in grain direction help in damping out resonance. Chipboard is also suitable, but rather more difficult to work. As the panels are comparatively small, it is not necessary to add internal bracing.

The 7in cut-out is suitable for loudspeakers of 8in diameter, and this dimension can, of course, be modified to suit the loudspeaker finally chosen. The position of the loudspeaker close to one end of the cabinet gives the loudspeaker itself maximum height above the floor if the cabinet is to be floor mounted. There is an advantage in this because the treble frequencies tend to be emitted in a fairly narrow beam, which is rapidly absorbed by the carpet if the loudspeaker is close to the floor. The cabinet can be mounted either vertical or horizontal.

Air resonances set up within the enclosure must be absorbed as far as possible, and this is usually done by including an absorbent material within the cabinet. There is a fairly wide choice here, and the most satisfactory materials are those of the kind having loosely packed fibres, such as glass fibre wadding, bonded acetate fibre or cotton wool. Carpet felt and similar materials tend to be rather severe in small cabinets.

The most effective position within the enclosure for the absorbent material is at the point of highest air velocity, i.e. mid-way between each pair of parallel walls. This is difficult to achieve in practice, but it can be done by hanging a curtain of the material from top to bottom of the cabinet, and twisting this through 90° or thereabouts. Fig. 7 gives the idea. This works very well with material such as bonded acetate fibre, which is fairly cohesive, but cotton wool might have a tendency to fall apart. In any case, the idea is not practical if the enclosure is to be used in alternative positions, which might involve turning it on its side. As a compromise, the absorbent material is fastened to the walls of the enclosure and, to compensate for the inefficiency of the absorbent in this position, more of it is used.

The whole of the interior of the enclosure should be lined with absorbent, except for the rear panel and the area round the loudspeaker cut-out. It can be stuck into position with dabs of adhesive, or pinned with staples. A thickness of ¾in to 1in is suitable. In the cabinet shown in Fig. 10, a layer of bonded acetate fibre has been stapled in place, and then partly rolled back to reveal the construction details.

The lining for the rear panel consists of a single thickness of soft woollen cloth, with a weight of 10–14 oz per sq yd. Sufficient cloth is required to cover the whole of the rear panel, and it is best fixed by spreading the panel with adhesive round the edge and between the slots.

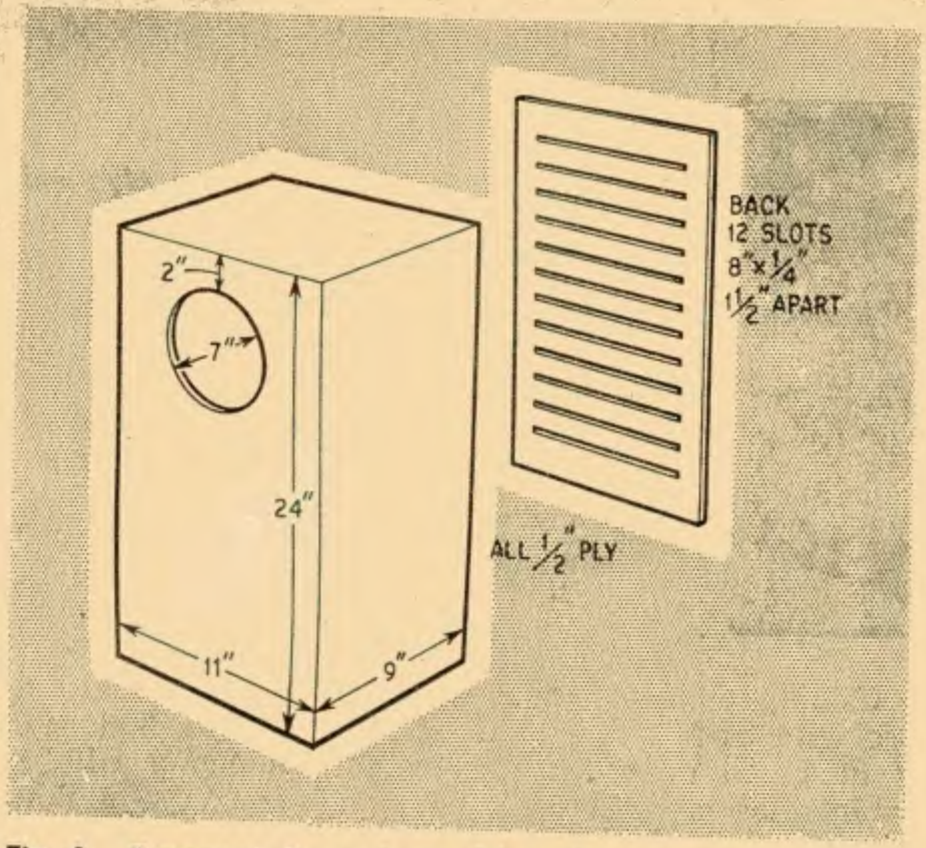


Fig. 6. External dimensions of 1 cu ft enclosure

CONSTRUCTION OF ENCLOSURE

The two side panels and the top and bottom panels must first be cut and assembled. The most difficult part of this is cutting joints for the corners. Mitred joints are neat if cut properly and have the advantage that veneered board can be used, but as this joint has to be cut with a locking tongue and groove, it is best left to the professionals with suitable machinery.

The most practical joint for the home constructor is the flat rebate, which is shown in Fig. 8. Layers of ply are removed corresponding to the width of the panel to be fitted, leaving a flange about ⅛in thick—usually two layers of ply. The easiest way to do this is to scribe the required width (the thickness of the panel), pin a strip of wood along the mark to act as a guide, and then saw through the plywood with a tenon saw to the required depth. The strips of plywood are removed one by one with a chisel.

The joints can then be secured with a hot glue or p.v.a. cold adhesive, using panel pins and glue blocks on the inside of the joints to hold them together. The pins should be driven below the surface with a fine punch, and the small holes filled with a stopper.

Unfortunately, the pin holes tend to show up after polishing, and the best way of avoiding this is to cover the cabinet after assembly, using wood veneer, plastics covering material of the p.v.c. type, or rigid sheet in melamine or similar material. This type of covering also has the advantage of disguising the plywood edges of the rebates, although the rigid covering materials do, of course, leave a thin edge visible.

THE FRONT PANEL

Fitting the front panel to the enclosure can be tackled in several ways. Probably the easiest method is to rebate the edges so that it slots easily into the cabinet, and to screw it in place. The front surface can then be covered almost to the edges with the grille cloth, and the edges finished with strips of plastic trim, mitred at the corners and held in place by impact adhesive. If the veneering or alternative covering on the side panels is left until the front panel is in position, a very neat finish to the cabinet can be achieved.

A second method is to make up a hardwood picture-frame with mitred corners using a suitable wooden moulding, the width of which is rather greater than the ½in thickness of the side panels. If the external dimensions of the cabinet are 24in × 11in, internal dimensions of the frame would be 22½in × 9½in. This picture-frame is glued into place and the front panel is introduced from the rear. In this case, the grille cloth can be fixed to the front panel before assembly, bringing it round the edges of the panel where it is glued or stapled. The front panel will need to be made slightly smaller than the internal dimensions of the cabinet to allow for this. The front panel is then held in place by means of triangular blocks screwed into the sides of the cabinet and also into the front panel. These can be seen in the photograph of Fig. 10.

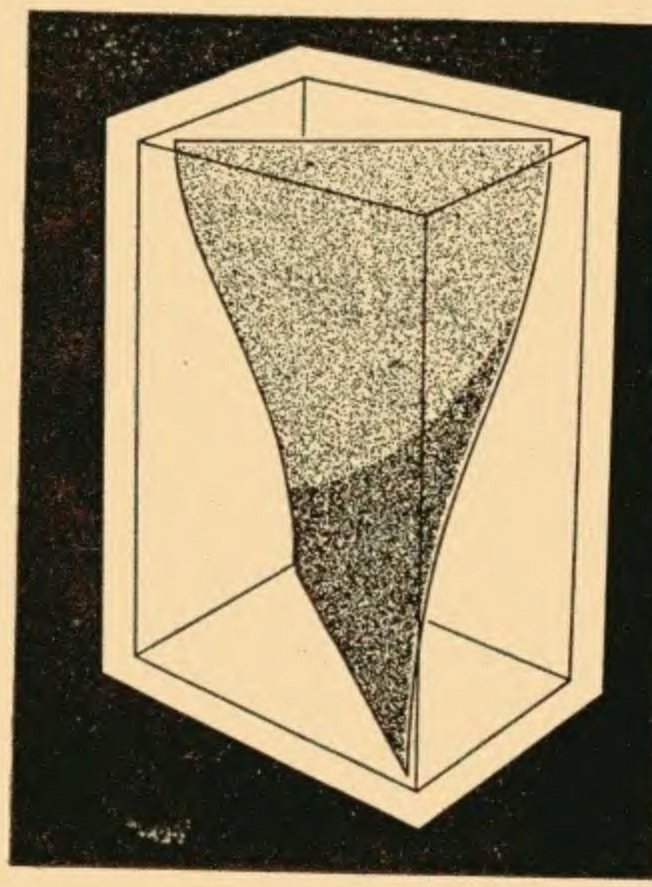
A third possible method is to use rails for fixing the front panel. Softwood rails of 1in square section are screwed to the insides of the cabinet, spaced from the front edge by the thickness of the front panel plus the grille cloth, or perhaps ⅛in more. Rails of this type, used for fitting the rear panel, can be seen in Fig. 10. If this method is adopted, the front panel is introduced from the front and screwed to the rails from the rear. If the grille cloth is taken round the sides of the front panel, this solves the problem of treating the raw edges of cloth. The disadvantage of this method is that the edges of the side panels are left visible, and will need some treatment.

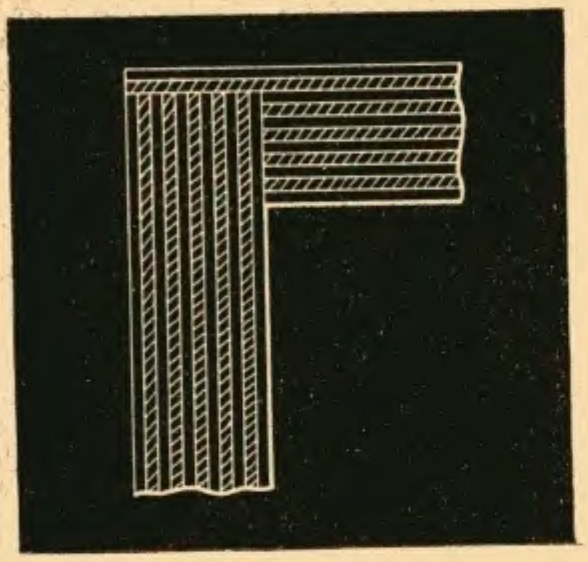
SPEAKER FIXING

Whichever method is used to fix the front panel, the circular cut-out for the loudspeaker must always be made first, and bolts should be inserted from the front of the panel to take the loudspeaker chassis. The holes for these bolts should be rather smaller than the bolt diameter so that the latter have to be screwed through the wood. If this is not done and the bolts are left slack, it becomes extremely difficult to get the nuts on to the bolts after the loudspeaker has been placed in position. After the bolts are inserted, the grille cloth can be fitted.

The rear panel is a comparatively easy matter, since this is readily fixed by using rails, as shown in Fig. 10. Softwood rails of ⅝in square section are screwed in place, spaced the width of the rear panel from the rear of the cabinet frame, and the back of the cabinet is merely screwed to these. It is important that the back of the cabinet is made detachable, as access to the loudspeaker may be needed.

Fig. 7. Sketch showing method of hanging curtain of absorbent material





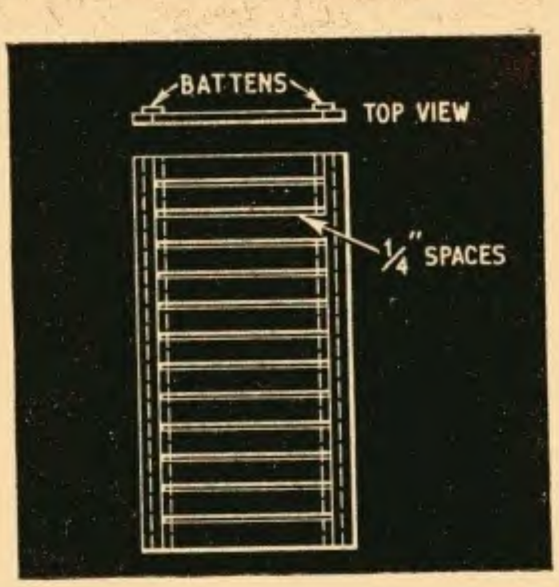


Fig. 8 (left). Flat rebate joint in plywood

Fig. 9 (right). Alternative method of making rear panel

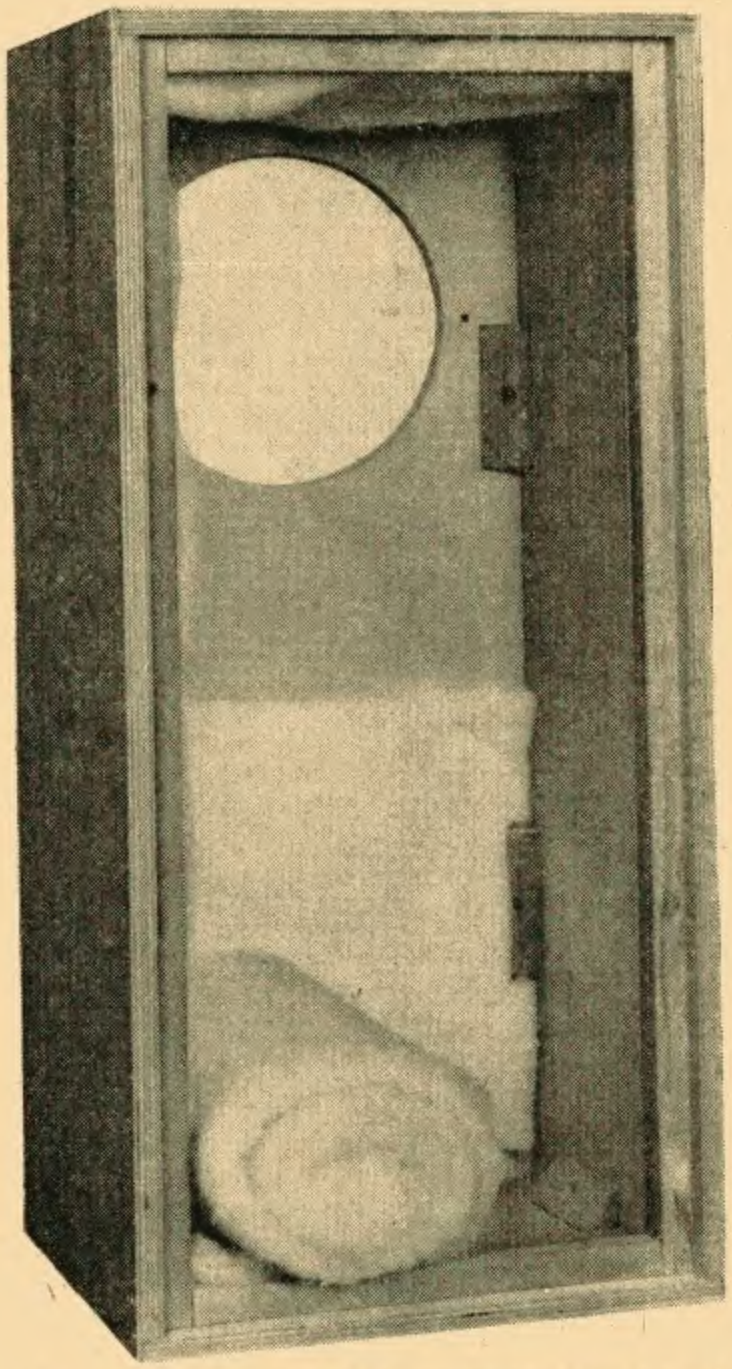


Fig. 10. Rear view of 1 cu ft enclosure with rear panel removed, and absorbent material rolled back to show triangular blocks and fixing rail

Cutting the slots in the rear panel may present a problem, and tackling 12 of these with a pad saw is likely to damp the enthusiasm of the would-be cabinetmaker. The back can be made up using 1½in width strips of plywood, and assembling these ¼in apart on to side battens, 1in wide. Fig. 9 shows the way of doing this. Pinning and glueing is a satisfactory form of assembly.

A further alternative is to use ½in diameter holes instead of slots. The equivalent of an 8in slot ¼in wide would be 10 holes of ½in diameter.

GRILLE CLOTH

The choice of material to cover the front panel of the cabinet is fairly wide, but certain materials are quite unsuitable and some care must be taken in the choice. Ideally, the material should be as transparent as possible acoustically, and as opaque as possible visually. Obviously the material must be of fairly open weave to suit the acoustic requirements, but this in itself is not always sufficient to decide whether it is satisfactory.

Fig. 11 shows the transmission characteristics of three different materials, all of which look attractive, and apparently have a sufficiently open quality to allow the sound to emerge. The height of the oscillogram in each case represents the sound pressure on the side of the material opposite the loudspeaker. The oscillograms in line A relate to specially designed acoustic material used by most manufacturers of high quality loudspeaker cabinets. The very slight attenuation in the mid-frequency range is not audible. Similar materials are usually available through dealers in sound reproducing equipment, typical ones being Vynair, Tygan and Somic.

Line B relates to a cloth taken from a commercial loudspeaker enclosure, and shows marked attenuation throughout the frequency spectrum. This material was of attractive appearance, and we can only assume that the manufacturer was relying on visual rather than acoustic quality to sell his product. The effect is typical of closely woven materials.

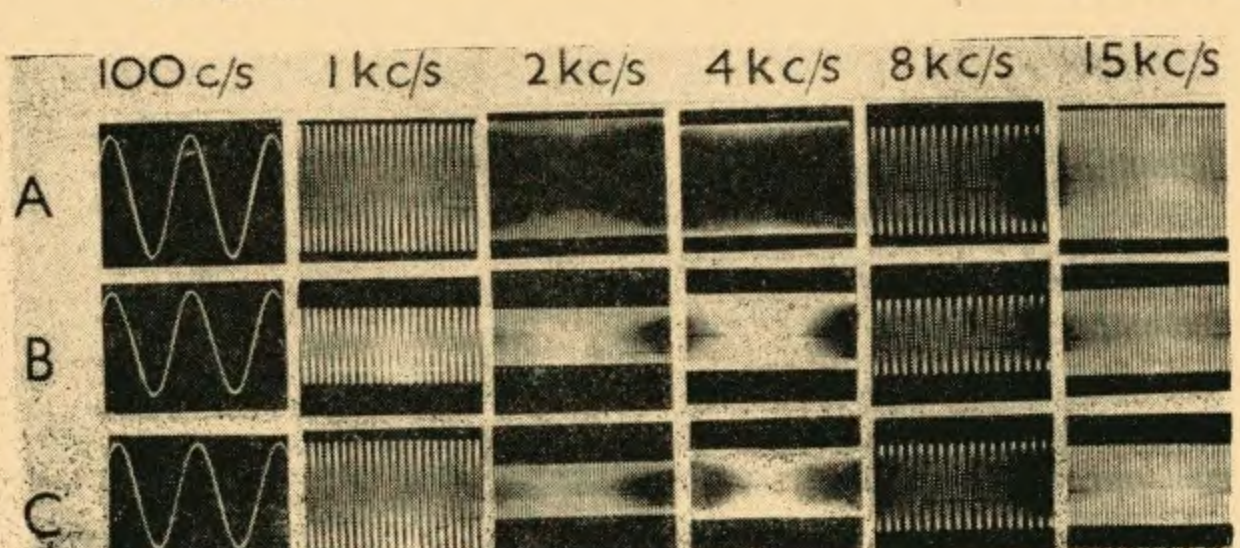


Fig. 11. Attenuation of loudspeaker output due to different covering materials

A — commercial loudspeaker grille cloth

B — unsuitable cloth on commercial cabinet

C — bamboo table mat

Expanded metal sheet with fairly large openings is usually satisfactory, but one cannot always be guided by appearances. For example, table mats made up of strips of bamboo would appear to have plenty of air space between the strips, and they would also look quite decorative on the front of a cabinet. Line C of the oscillograms, however, shows fairly severe attenuation by this type of material in the middle and upper frequency ranges, and listening tests soon determined that it was quite unsatisfactory.

If in doubt about the suitability of a material, the best course of action is to stretch a sheet of it temporarily over the loudspeaker opening, and while listening to the loudspeaker, get an accomplice to remove the material quickly so that an instant comparison can be obtained. If there is the slightest difference between the two conditions, the material should be discarded.

FINISHES

Reference has already been made to covering with rigid laminates of the melamine surfaced type, decorative p.v.c. sheeting, and veneering. The two plastics materials need no further explanation, and the neatness of the finished product depends entirely on the skill of the worker. Adhesives, where necessary, will be supplied with the material. It is important that the cabinet is well rubbed down, finishing with a damp cloth, before the plastics material is applied.

Whether the wood is left plain or is veneered, it must be well rubbed down with fine glass paper before any further finish is applied. Any tape used to hold leaves of veneer together will be removed during this operation. After sanding, the grain is filled with a proprietary filler applied across the grain, and the surface is left to dry for about 12 hours. A further rub down with fine glass paper is then carried out.

If the panels have been left plain for painting, the paint can be applied on this surface. If a veneer has been applied, the next operation is staining with a suitable wood dye. This should be put on with a wide brush, working along the grain and starting with a colour lighter than the final colour required. The panel is then finished with two coats of lacquer and a final rub over with glass paper leaves it ready for wax polishing.

The application of trim and grille cloth are comparatively easy. If a plastics trim is being used, an impact adhesive will secure this adequately. Before the grille cloth is put in position, the front panel should be covered with black cotton voile, which is a very thin, open weave material, as this helps to disguise the loudspeaker opening. A clear adhesive with medium drying time is suitable. If the grille cloth contains a very large percentage of plastics material, it is only necessary to fix this to the front panel round the edges, and the gentle application of heat will shrink the fabric to give a smooth, taut finish. Other fabrics containing natural fibres or paper should be laid as flat as possible and glued all over with a clear adhesive. It is particularly important that the fabric is well secured in the region of the speaker opening because the large air vent movement at low frequencies tends to cause the fabric to flap.

ACKNOWLEDGEMENTS

The author would like to thank Mr G. A. Briggs, chairman of Wharfedale Wireless Works Limited, for permission to publish the material contained in this article, and also Mr W. A. Jamieson for help in the various tests and measurements required in the development of this loudspeaker system. ★

Guide to SEMICONDUCTOR CIRCUIT DESIGN

A pull-out booklet on semiconductor data is included as a supplement in this month's issue of PRACTICAL ELECTRONICS.

The main parameters are briefly explained and characteristics of some of the most commonly used signal diodes and Zener diodes are given. Next month the centre pull-out pages will deal mainly with transistor characteristics.

When the pages have been carefully removed from the wire staples they can be folded in half and cut along the top edges. The second part (next month) will drop into the centre of the first part.

Contributed Articles

The Editor will be pleased to consider for publication articles of a theoretical or practical nature. Constructional articles are particularly welcome, and the projects described should be of proven design, feasible for amateur constructors and use currently available components.

Intending contributors are requested to observe the style in our published articles with regard to component references on circuit diagrams and the arrangement of the components list.

The text should be written on one side of the paper only with double spacing between lines. If the manuscript is handwritten, ruled paper should be used, and care taken to ensure clarity, especially where figures and signs are concerned.

Diagrams should be drawn on separate sheets and not incorporated in the text. Photographic prints should be of a high quality suitable for reproduction; but wherever possible, negatives should be forwarded.

The Editor cannot hold himself responsible for manuscripts, but every effort will be made to return them if a stamped and addressed envelope is enclosed.

the HALL effect....

by P. D. FORSHAW, B.Sc.

PART ONE

WHILE some of our readers may be relatively unaware of the *Hall effect*, let us put their minds at rest by stating here and now that the subject is not at all difficult to understand and does not require an advanced knowledge of electronics or mathematics. Indeed, an elementary appreciation of high school physics and a smattering of Ohm's Law are all that is required as a starting-off point.

It was over 80 years ago that the Hall effect was initially discovered by E. H. Hall, but it was not until recent years when semiconductor technology came into its own that Hall's discovery could be fully exploited. Simply stated, if an exitation current is caused to flow through a conductor, insulator or semiconductor in the presence of a magnetic field then a *Hall voltage* will be set up in a direction perpendicular to both the direction of current and magnetic field.

Referring to Fig. 1, we see that when an exitation current I_E is flowing horizontally through the material in the presence of a magnetic field of flux density B then a Hall voltage of magnitude V_H appears in a direction perpendicular to both current and field. Moreover, we can equate these values of B, I_E and V_H by means of the Hall relationship:

$$V_H = K_H I_E B \qquad \ldots (1)$$

Where K_H is a constant (the Hall constant).

M.K.S. SYSTEM OF UNITS

Before we discuss how and why this effect arises—just a word about units. The rationalised M.K.S. system of units is being strongly advocated in academic circles these days, and to avoid possible confusion, wherever units appear in this article they will be based upon this system. This gives "I" in amps, "B" in webers per square metre, V_H in volts and K in volts metre² per amp weber.

Essentially, the basic principles underlying the Hall Effect account also for the deflection of cathode ray beams in magnetically deflected cathode ray tubes, the rotation of motor armatures and even the deflection of the pointer in moving coil meters. In all cases we find that whenever an electric current is passed through a conductor in the presence of a magnetic field, a mechanical force is exerted upon the current carrying conductor. In the Hall effect and the cathode ray tube, however, we go one step further because it is the charge carrying particles themselves which experience this force. Let us explain in more detail by referring to Fig. 2.

In Fig. 2a we see that the application of an electromotive force from an accumulator connected across the conducting material causes an electric current to flow which is indicated on the ammeter. This current is caused by the movement of minute charge carrying particles called electrons, each carrying a negative charge of $1{\cdot}6 \times 10^{-19}$ coulombs, which flow from the negative to the positive plates of the accumulator in the direction of the arrows.

However, the presence of a magnetic field influences the relatively smooth flow of electrons as shown in

Fig. 1 (below). The passage of an electric current (I_E) through a material in the presence of a magnetic field (B) causes the Hall voltage (V_H)

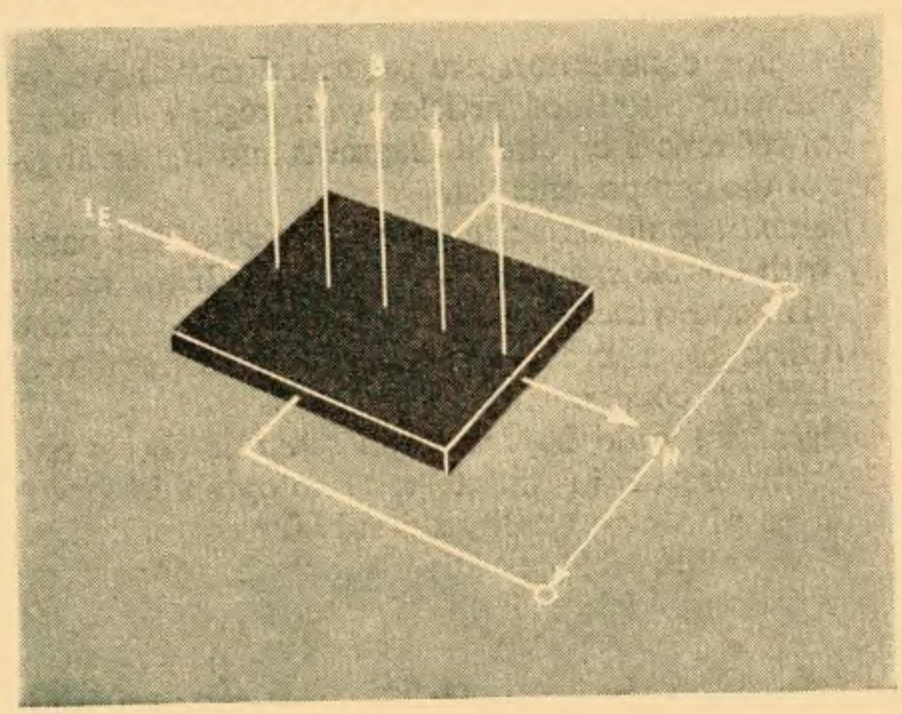


Fig. 2a (top). Current flow is composed of charge carrying particles moving in the direction of the arrows

Fig. 2b (bottom). The presence of a magnetic field (into page) affects the flow of electrons as shown

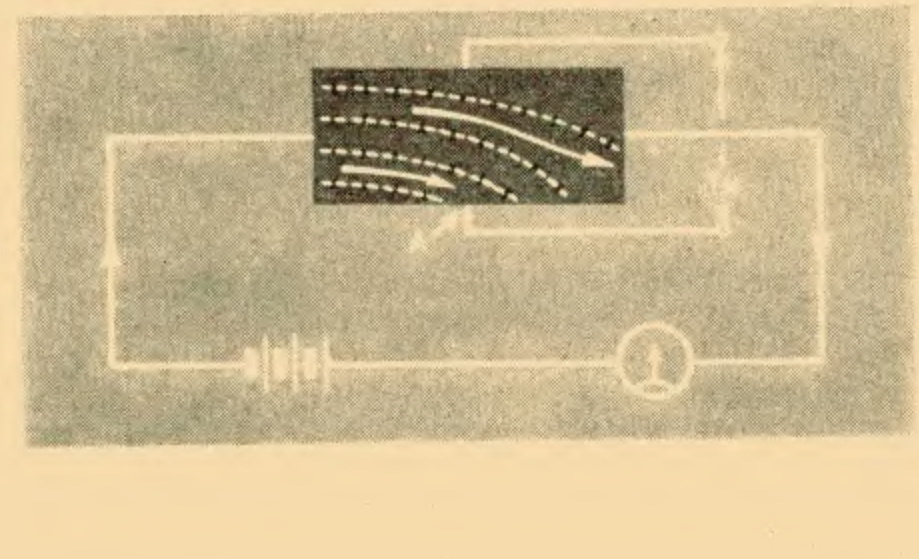


Fig. 2b. Here the field is in a direction into the page. Just as the charged particles comprising the cathode ray beam in a cathode ray tube are deflected, so also the negatively charged electrons in the conducting material are deflected to one edge of the material. Although they all eventually leak away along normal conduction paths, the electrons tend to collect along this edge (at A) causing a negative charge to build up which in turn gives rise to an electric field across the material. A high impedance voltmeter of sufficient sensitivity will be able to detect the presence of this electric field and will measure what we have termed the *Hall voltage*.

STATE OF EQUILIBRIUM

The Hall voltage will not, however, build up indefinitely as more and more electrons collect at A. As we know, like charges repel, and the negative charge already at A will tend to oppose the flow of further electrons towards this charged area. When the mechanical force arising from the presence of the magnetic field exactly equals the force of repulsion between the electrons, a state of equilibrium is established. This state is reached in fractions of a microsecond, and thus the Hall voltage is able to follow changes in either field or excitation current that occur at rates up to hundreds of megacycles.

As the strength of the magnetic field is increased so also is the force experienced by the electrons. It is thus quite logical that V_H should be directly proportional to the magnitude of B. Similarly, as the current is increased a greater number of electrons are introduced into the conducting material, hence more are deflected and the magnitude of V_H again increases. Both these facts are, of course, borne out by equation (1).

PRACTICAL CONSIDERATIONS

The value of the constant K_H in the Hall relationship depends entirely upon the type of material chosen. With normal materials such as conductors and insulators the value of K is found to be extremely small and consequently the Hall voltage is minute for all practical values of flux density and excitation current. With these materials we may expect to encounter Hall voltages of the order of millimicrovolts (10^{-9} volt) or less—often well below the level of *Johnson* (Thermal) *noise*.

Semiconductor materials, due to their relatively low mobility, show values of K_H of a fairly high order.

Before the advent of semiconductors the Hall effect was looked upon as a scientific curiosity and could certainly not be put to any great practical use. Over the last few years, however, much work has been done to determine the most effective semiconductor materials; instruments such as gaussmeters (equipment used for the measurement of flux density), wattmeters and modulators are now commercially available which rely upon the Hall effect for their operation. Hall voltages of 0·3 volts are typical with currents of the order of 100mA and with flux density of about 0·1Wb/m².

GAUSSMETERS

One of the main uses of the Hall device is, of course, in the manufacture of gaussmeters (Fig. 3) and other magnetic field sensing equipment. Today the gaussmeter has numerous applications, some of the more obvious ones being the measurement of the flux density of permanent magnets in loudspeakers, motors, and travelling wave tubes, and the investigation of the remanent magnetism in recording tapes, non-magnetic alloys, solenoids, etc.

More conventional flux measuring methods have their limitations—none have all the advantages of the Hall Effect gaussmeter, viz. extreme sensitivity, accuracy, portability and the ability to measure flux density in air-gaps of 0·02in or less. Gaussmeter elements of 0·019in are now being manufactured and investigations are currently being carried out, both in this country and in the United States, on thin film (deposited) semiconductors to even further reduce the size of these unique devices.

Hall kits are already available for home construction and demonstration purposes in schools and technical colleges at reasonable prices. Using these kits it is possible to perform elementary experiments in the measurement and detection of magnetic fields. One such kit is illustrated in Fig. 4. This inexpensive kit requires two 6 volt batteries or power supplies and a voltmeter, in order to carry out elementary field measurement and plotting.

This then is the Hall effect. We have seen what it is and how and why it arises. Next month we shall explain the operation of the Hall multiplier, a unique device capable of performing variously as a modulator, detector, wattmeter and a computing element.

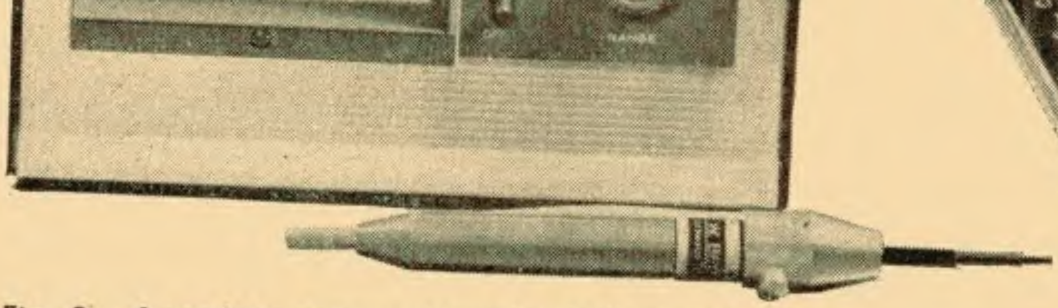


Fig. 3. A modern gaussmeter using indium arsenide as the Hall device

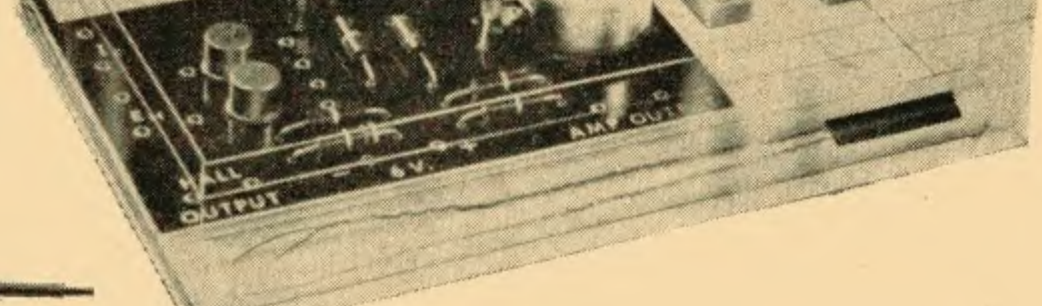
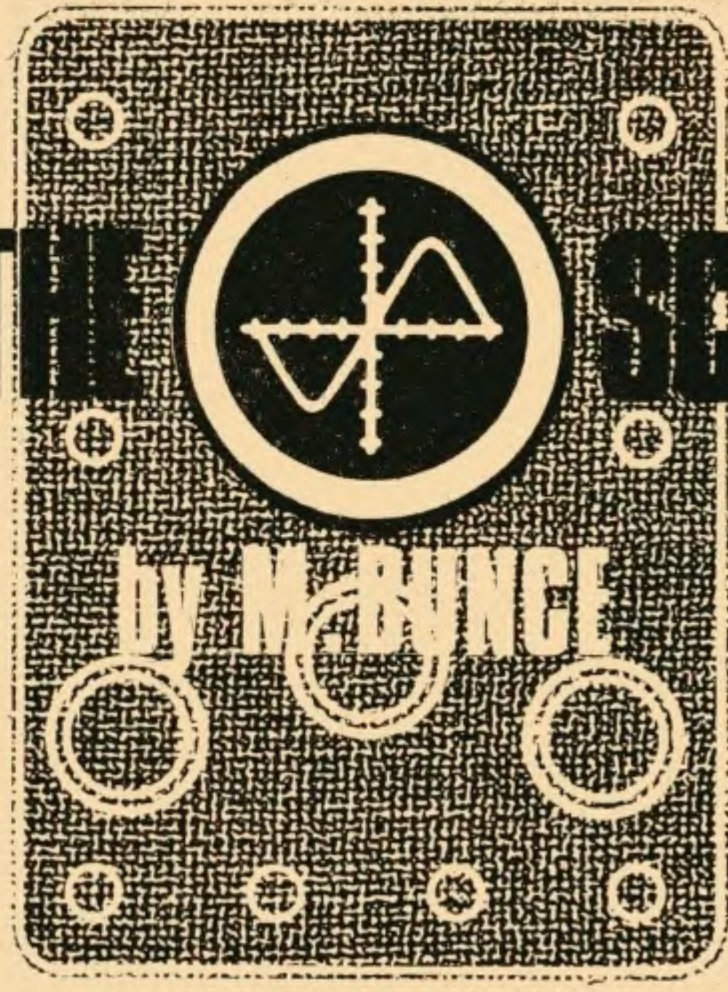


Fig. 4. Hall effect kit suitable for experimental use

USING THE OSCILLOSCOPE



by M. BUNCE

A brief survey of some of the measurements which can be carried out with a cathode ray oscilloscope

MANY amateur constructors use specialised items of test equipment, but in many cases the oscilloscope is one item which is not used to its full advantage. Apart from the obvious application of displaying an a.c. waveform it can be used as an a.c. voltmeter, frequency meter, signal generator, resonance indicator for adjusting tuned circuits and even as a wide-band amplifier. In some cases an oscilloscope is essential and indeed can be more accurate than the conventional meters mentioned above.

It need not be an expensive model; a simple 2½in single beam, wide-band 'scope can be obtained for as little as £20. Double beam models can also be obtained just as cheaply on the second-hand market.

OPERATION

Fig. 1 shows diagrammatically the construction of an electrostatic cathode ray tube. The principle of operation in simple terms depends on the application of a sawtooth waveform to the *x*-plates to cause the electron beam to deflect across the phosphorous screen. This action produces a visible line on the screen running from left to right. At the end of its travel the voltage applied to the *x*-plates drops rapidly, causing the spot to return to the left-hand side. This is known as "flyback".

If an alternating voltage is applied to the *y*-plates the beam will be attracted towards them in sympathy with the applied voltage. Hence when the *y*-plate voltage is positive the beam will be deflected upward; conversely when it is negative the beam will be deflected down. This takes place at the same time that the beam is moving from left to right. The beam will therefore trace out a picture or graph in two dimensions on the screen corresponding to the original applied waveform in voltage and time. Some typical waveforms are shown in Fig. 2.

Fig. 1. Diagrammatic layout of electrodes in the electrostatic cathode ray tube

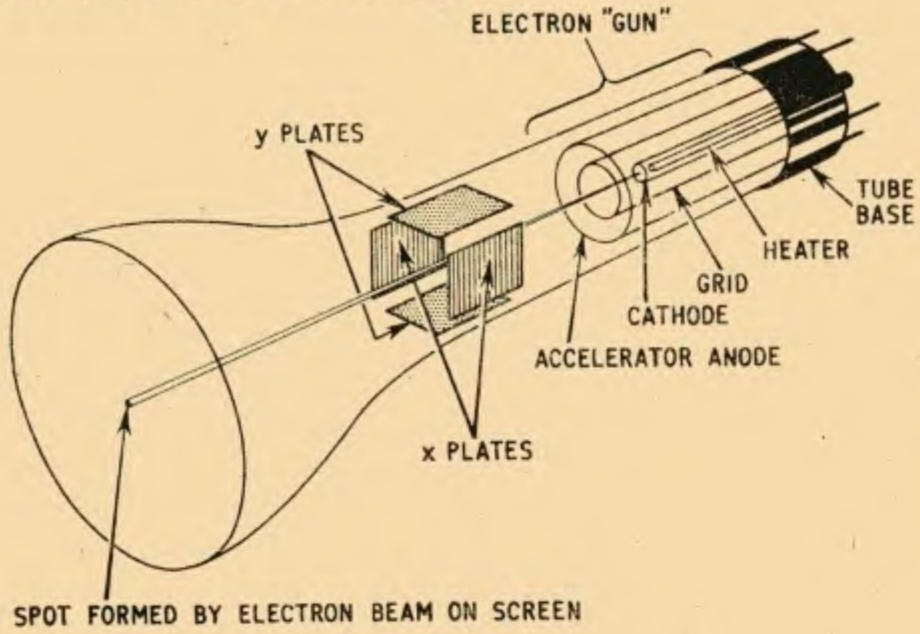
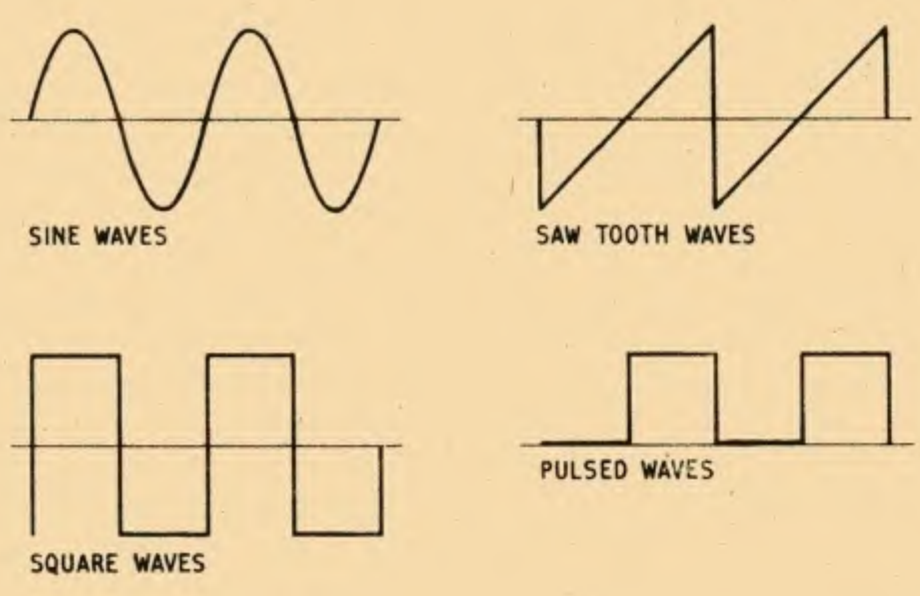


Fig. 2. Some typical waveforms which can be displayed on an oscilloscope



Facilities are usually provided on the 'scope for the viewer to "see" the applied waveform in a convenient manner. Wide-band amplifiers are incorporated and in some cases trigger circuits. By suitable adjustment of the controls one can display the waveform in varying heights, widths and time scales. The trigger circuit is used to delay the scanning of the beam until a predetermined instant when it can be triggered into operation simultaneously with a pulse. Very accurate time measurement can be achieved by using this facility.

Good quality 'scopes incorporate flyback suppression which dims the flyback trace to avoid confusion with the signal waveform. This can be achieved by making the flyback stroke as rapid as possible as depicted by the steep drop on the sawtooth waveform (see Fig. 2).

FREQUENCY METER

Most oscilloscopes are provided with a graticule (i.e. a calibrated scale) which fits over the front of the screen. This is used to measure the time and voltage (x and y) of the waveform in conjunction with the calibrated control knobs. By measuring the time between one cycle and the next on the screen, one can calculate the frequency of this waveform in cycles per second as being the reciprocal of time measured in seconds. For example, if this time interval is measured to be two milliseconds, the frequency would be one divided by 2/1000, which is 500c/s.

It is worthwhile to measure the time over several cycles on the screen and so determine the time for one cycle. A more accurate measurement can be achieved this way.

Double beam 'scopes are often provided with a "sync" control. By careful adjustment the waveforms of both traces can be arranged to coincide and appear to be of the same frequency. By reading the timebase control scales the time, and hence the frequency, can be compared with respect to a known input reference.

LISSAJOUS FIGURES

Many readers may have seen the fascinating shapes which can be displayed on the screen. These are quite simple to produce if you have a signal generator which provides a sine wave output.

"Lissajous" figures, as they are called, provide an excellent method of frequency calibration. Instead of feeding the timebase waveform to the x-plates a sine wave is used. On many scopes the timebase can be disconnected simply by means of a switch on the control panel. The unmodulated sine wave is then connected direct to the x-amplifier or x-plate terminal. The unknown sine wave can be connected to the y-plate amplifier in the usual way. By careful adjustment of the signal generator frequency a condition will occur when the trace will be circular and stationary. The signal generator is now providing a sine wave at the same frequency as that of the unknown waveform. The unknown frequency can then be read direct from the signal generator dial. Alternative figures can be displayed for harmonics and hence the frequency can be determined from the expressions given in Fig. 3.

The phase difference between two signals of the same frequency can be determined as follows:

Connect the timebase output to the y-amplifier and determine the phase difference between the x and y amplifiers. Now remove this connection and connect one signal source to the x-amplifier and the other to the y-amplifier. The resulting trace should be similar to one of those shown in Fig. 4.

SIGNAL GENERATOR

The sawtooth waveform from the timebase circuit can be used as a signal tracer for a.f. amplifiers. A capacitor of about 0·01μF should be connected in series with the timebase output to block any d.c. which may be present. This can usually be done by connecting the capacitor directly on the x-plate terminal found on many 'scopes.

TV SERVICING

One field in which the oscilloscope will be found to be indispensable is in television servicing. This is because many television sets use pulse waveforms and synchronisation circuits. The 'scope is the only instrument which can monitor the pulse shape. It is essential that it has a very wide bandwidth. Some manufacturers are now making 'scopes which will cope with these requirements. ★

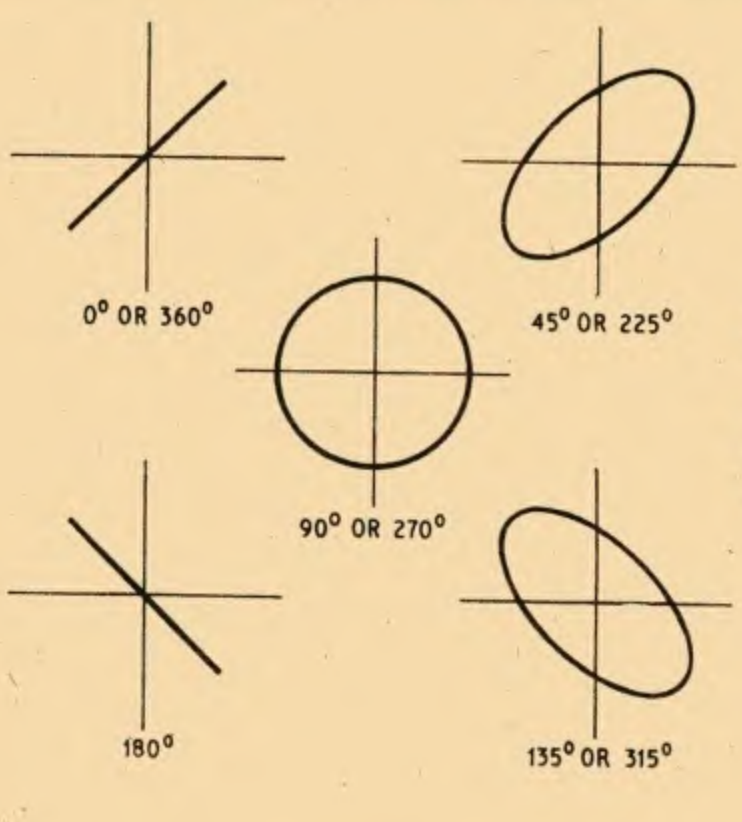
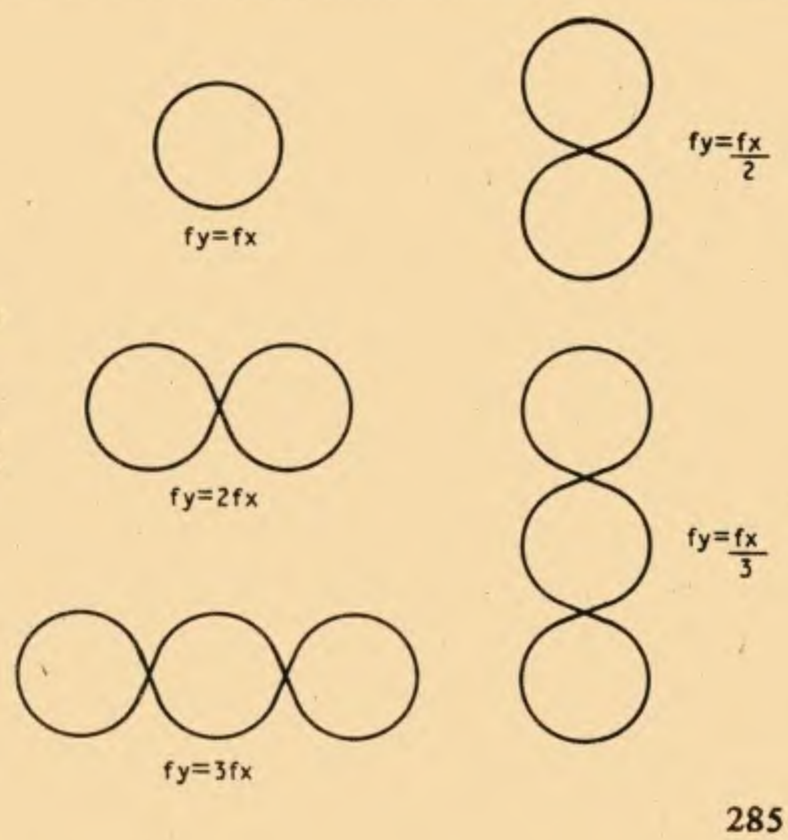


Fig. 3 (left). Lissajous figures

Fig. 4 (right). Measuring phase difference using Lissajous figures



DETACHED PARTICLES
By John Valence

NEW IMAGE, PLEASE!

WESTMINSTER bestirs with heroic talk of modernisation and the importance of technology. The earnest hopes and plans of our legislators for a more dynamic economy we must all certainly applaud. But all this brave talk of automation, computers and electronics seems slightly odd coming from the cloister-like, old world atmosphere of the neo-Gothic Parliament buildings.

Some of the quaint and time honoured practices dutifully carried out in its daily business routine do not help the outsider to visualise Parliament as the power house behind the national drive. Having lectured industry on the need to abandon old fashioned methods in the interests of greater productivity, our elected representatives then stroll out of the debating chamber into a lobby to be counted one by one in a manner reminiscent of the cattle or sheep market.

Modernisation should start at home. After all, in many other countries the supreme legislature employs electric or electronic aids for vote casting and counting. Gentlemen, automate your own House first, and thereby set a good example for others to follow!

ELECTRONIC BATH

WE seem to be going through a period when the adjective "electronic" is eagerly seized upon, often with but the slightest justification, to impart glamour or sense of modernity into some gadget or piece of fairly ordinary electrical apparatus. In this connection, I recall an exhibition of "Bathrooms Through History" that formed part of the Bath (Somerset) Festival held last summer. Inevitably the exhibition had to peep into the future with an (so called) Electronic Bath.

It would seem that one day we shall be able to lay in bed for those precious extra minutes and turn the bath water on, adjust the temperature, fit or remove the waste plug—all by remote control.

Agreeable though the vision may be, I feel a little perturbed at the thought of electronic (or is it in this case just *electric*?) apparatus, fed presumably from the a.c. mains, being so directly associated with bathroom plumbing.

Quite obviously any equipment of this nature marketed commercially would be built to rigid standards and the installation carried out by competent engineers. But in case any comfort seeking amateur is thinking of tackling this along private enterprise lines, my counsel is an emphatic *don't*.

Quite seriously, remember always to seek expert advice before undertaking any electrical installation work in such potentially dangerous places as bathrooms.

WHICH A'WAY

IN his early days, every student of electronics comes up against the puzzling question: which way does the current flow.

Many presumably surmount this obstacle with little difficulty; they quickly acquire the ability to perform mental acrobatics and to read a circuit in terms of either conventional or electronic current, according to whichever may be the more helpful in a given circumstance.

I have sympathy for those others who find this a continually perplexing business. Indeed, I confess to having to stop and think whenever the symbol for a metal rectifier or semiconductor diode comes into view. Now, does the bar represent the "cathode"—or is it the arrow-head? It is of course, as you are no doubt saying to yourself at this moment, the former. Yes, this is so because the arrow-head of the symbol indicates the direction of conventional current flow, that is positive to negative. (Quickly now, what does the coloured spot on a semiconductor diode signify?)

Suggestions have been made from time to time that the terms positive and negative should be switched to agree with electron flow. But this is obviously one of those things we shall have to continue to live with. And come to think of it, Benjamin Franklin may indeed have guessed wrong as regards current flowing in a conductor, but today he would be able to make out a case for his positive to negative idea when considering hole current in semiconductors, wouldn't he?

Anyhow, some of us may suspect that our own contemporary geniuses haven't made life easier for the beginner with their choice of *that* particular word for a positive current carrier.

AIRCRAFT CARRIER

THE Royal Navy does not intend to play second fiddle to anyone else so far as the utilisation of electronics is concerned. The aircraft carrier H.M.S. *Eagle* has just completed an extensive refit in dock—five years in fact—during which time over £30 million has been spent on modernisation. Just half of this bill is attributed to electronics which includes three large computers in addition to the telecommunications and radar equipment. One wonders, however, if even the marvels of electronic techniques applied to defensive measures can successfully overcome the basic vulnerability of these gigantic ships under modern warfare conditions.

Have you lost your key again?

NEWS BRIEFS

Change of Face!

THE National Radio Show has been confined, in the past, to radio and television sets produced by British manufacturers. Then pianos were introduced (a little out of place in the circumstances) followed by electronic organs, tape recorders, record players and sundry other items. It became apparent a few years ago that this show was losing popularity and little wonder that such titles as Cabinet Show, Pop Record Show, Startime, and "Bring-the-kiddies-along-for-a-knob-twiddling-session" Show were appended when various publicity gimmicks were used to attract patrons.

It is with pleasure that we learn of the abolition of this much abused form of exhibition. However, this is not the complete end! Industrial and Trade Fairs Limited have taken over the promotion and organisation of annual exhibitions at Earls Court, London, devoted to radio, television and other forms of home entertainment.

The scope of the new Radio Shows will be broadened to international status which may well put the British manufacturers on their toes in the face of stiffer competition and—dare we mention—exports. The first of these will open from 25 August to 4 September 1965.

Let us hope that the new Shows will be of real value to both sellers and buyers and not an excuse for live or recorded beat shows.

So Small!

THREE new radio sets have also been developed in Russia which makes miniaturisation seem microscopic. One of them is designed to be worn behind the ear, like a hearing aid; another is clipped to the breast pocket and looks like a badge.

All three can be held in the hand together and are smaller than a wrist watch.

Stereophonic Broadcasting

FOLLOWING the cessation of experimental stereophonic sound broadcasting, the BBC is collaborating with broadcasting organisations in other European countries in the investigation of a common compatible stereophonic system. The next meeting of the C.C.I.R. Study Groups will be held in Vienna at the end of March. Meanwhile pilot tone test transmissions will continue from Wrotham 91·3 Mc/s on Tuesday, Wednesday and Thursday afternoons.

In the Picture

A TWO channel stereophonic three dimensional television receiver was on show at the U.S.S.R. Economic Exhibition recently in Moscow. The illusion of presence is created by using polaroids which orientate light waves in a definite plane. The set can be converted for colour viewing by adding kinescopes with colour images.

Components Show

THE next Radio and Electronic Component Show sponsored by the R.E.C.M.F. will be held at Olympia from 18–21 May 1965. Inquiries regarding the exhibition should be addressed to the organisers, Industrial Exhibitions Limited, 9 Argyll Street, London, W.1.

Electronic Journalist

THE U.S. Census Bureau is using a computer which will both write and address its news stories for distribution to the Press. The first hand-out, which was untouched by human hand, was compiled and typed by the computer. The hand-out concerned figures on the retail trade for each county in two states.

A mass produced form with blank spaces is fed into the computer, which scans the appropriate statistical reports, picks out the required figures, types them with the address on the forms and despatches the forms in the post.

NEW PRODUCTS

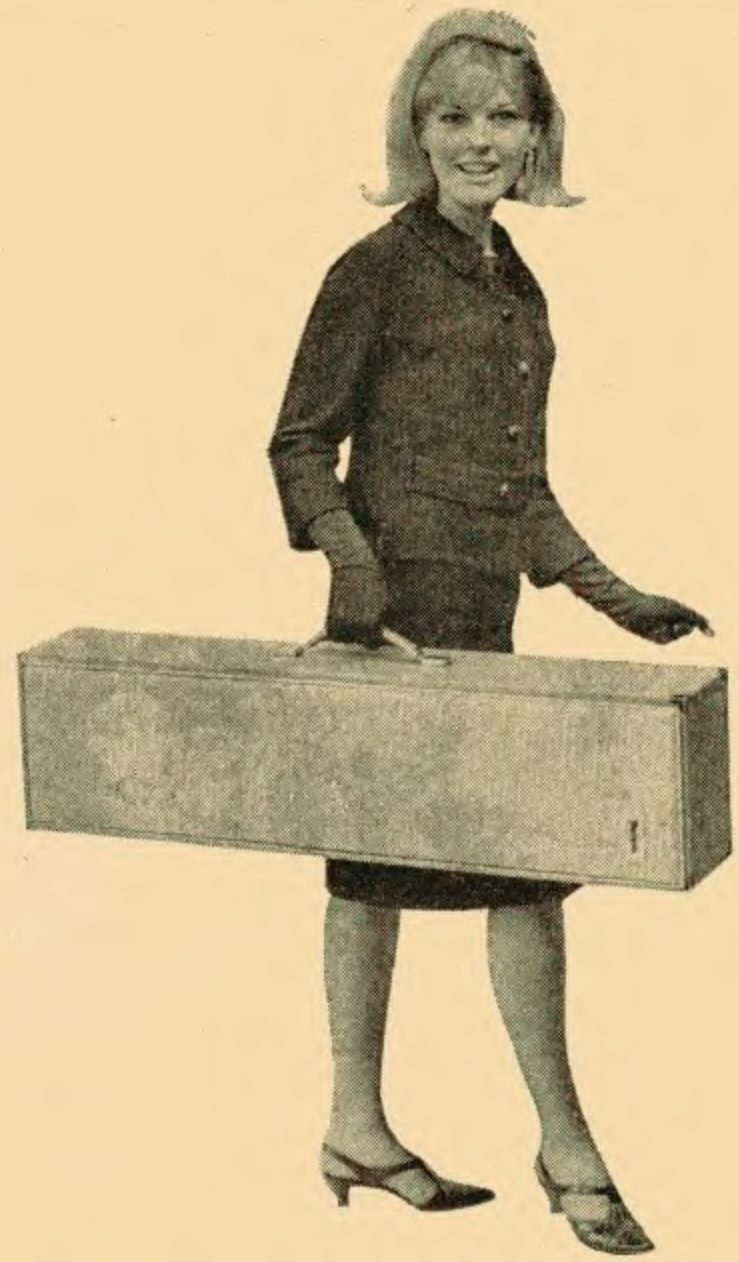
Send-A-Message

MSS Recording Co. Ltd., Poyle Trading Estate, Colnbrook, Slough, Bucks.

The triple play recording tape mentioned in this magazine recently has now been added to the send-a-message packs by the above firm.

The complete pack weighs less than $\frac{1}{2}$oz and a playing time of 10 minutes is provided. The price of this pack is 3s.

The tape is packed in a specially designed box measuring 2in × 2in with two address labels for posting. The unbreakable polypropylene spool is only $1\frac{3}{4}$in diameter but has the standard hub centre. The extra light weight enable the tapes to be sent by airmail to America for only 1s 3d and Australia for 1s 6d.



Portable P.A. System

Wharfdale Wireless Works Ltd., Kershaw Works, Harehills Lane, Leeds 8.

Suitable for schools, churches, social events, yacht clubs, harbours, auction sales, crowd control, etc. is a new entirely portable public address system from Wharfedale.

The complete equipment, comprising an amplifier, six speakers and microphone (with full size floor stand), is housed in a portable case. The amplifier is built on an aluminium chassis and powered by 12 heavy duty flashlight batteries or a built-in mains unit for 110–250V a.c. 40–60c/s as preferred.

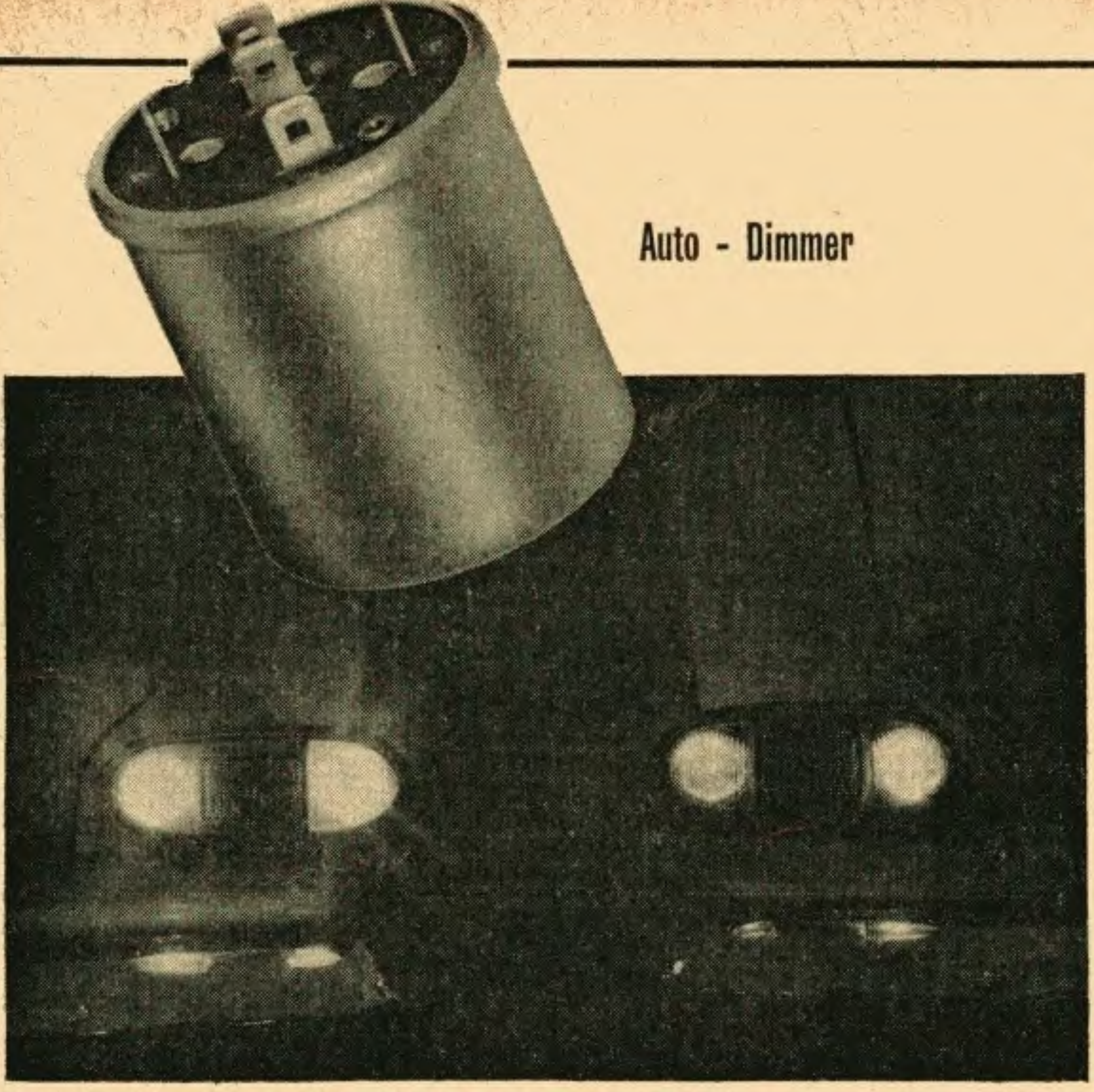
The p.a. system has inputs for microphone (low impedance), auxiliary (high impedance for tuner, tape or crystal pick-up), a frequency response within 2dB 100 to 8,000c/s and a maximum peak power output of 30 watts.

The six 5in speakers are of the latest neoprene flexible surround design and the microphone is an omni-directional high grade dynamic type with on/off switch.

The portable case is finished in tan leatherette with satin aluminium fittings and matching grille cloth. The case dimensions are $36\frac{3}{4}$in × $7\frac{3}{4}$in × $9\frac{7}{8}$in. The equipment weighs less than 42lb.

The complete p.a. system is priced at £69 10s 0d U.K.

Auto - Dimmer



Thorn Electrical Industries Ltd., Special Products Division, 105-109, Judd Street, W.C.1.

The latest product to be announced by the Thorn Group is called the "Auto-Dimmer" and is designed to help increase the safety on the roads. Our photographs show the complete unit (inset) and two cars one with the dimmer fitted and one without.

Designed to limit night time dazzle from motor vehicle brake lights and flashing indicators, the dimming unit only becomes operative when either the side or headlights are switched on.

The components are sealed in an aluminium can and connections to existing car wiring is by press-fit tags, solder or a specially designed socket.

Two separate solenoid operated units, incorporating a changeover switch and voltage dropping resistors, maintain the independent circuits to brake and flasher lights. In the event of component failure a "fail-safe" circuit ensures that the whole system reverts to full brightness.

The dimmer is available in 6V, 12V or 24V versions.

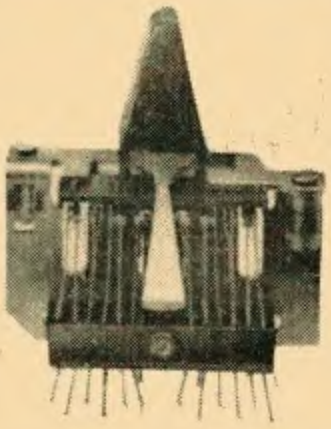
Miniature Lever Keyswitch

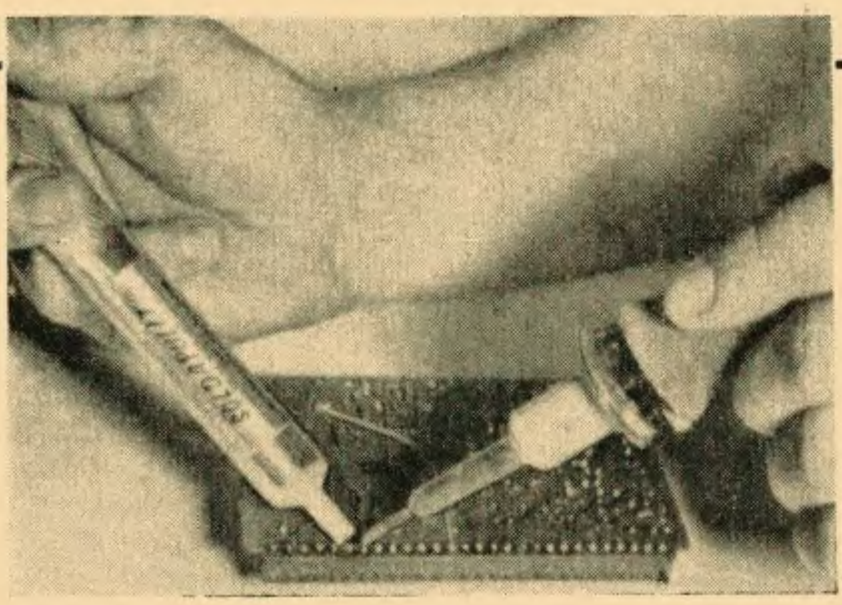
Keyswitch Relays Ltd.
120-132 Cricklewood Lane,
London, N.W.2.

Readers having any difficulty in obtaining the switch for the intercom unit published in the December 1964 issue of P.E. should contact Keyswitch Relays. Our photograph shows the miniature lever keyswitch type B.P.1000, 4CN, 4CL used in this article.

Key handles are available in Red, Green, Yellow, Grey, Ivory or Black; the colour required should be stated when ordering. The switch has five silver twin contacts rated at 0·1A at 250V d.c., 0·3A at 100V d.c./250V a.c., or 1A at 12V d.c./100V a.c.

The price of the switch is 17s 4d, plus 3d extra per handle.





Desoldering Tool

Systems Engineering Services Ltd., 35-39 South Ealing Road, London, W.5.

A new product manufactured by Edsyn Co. of America and now being introduced to the British market by the above firm should prove of interest to both industry and the keen amateur constructor.

Known as the "Soldapullt" it is a completely portable desoldering tool and is ideal for printed circuit work as well as for orthodox wiring. The tool is used in conjunction with a soldering iron and by releasing a spring loaded piston which creates a high impulse vacuum the molten solder is drawn into its cylinder. The tool is automatically cleaned when resetting the plunger by ejecting the surplus solder from the tip.

When one considers the time and expense saving factors involved plus stopping frayed tempers from shaking and/or blowing unwanted solder from joints (which usually land on one's clothes, hands or, as in some cases where the living room is the only place available for constructing, carpet) the outlay for this tool will prove a good investment.

The tool comes in three models; the standard tip, the long tip, and the standard tip model with a 45° extension for hard to reach places. The Soldapullt retails at £4 10s.

Our photograph shows a 28 pin connector being desoldered from a printed circuit board.

IMMERSION HEATER ECONOMY CIRCUIT

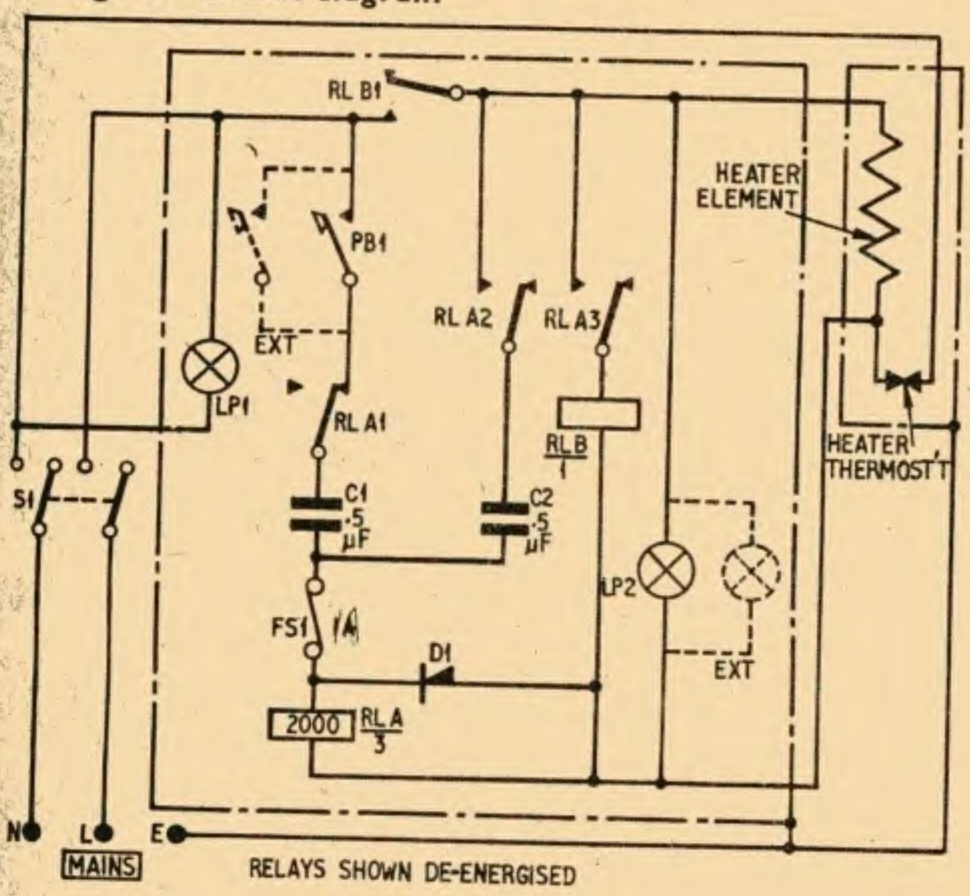
by ALAN N. LEVETT

THIS single shot circuit was designed to ease the financial burden of the forgetful immersion heater owner. The heater thermostat is set to maximum temperature, and when it opens, the current is switched off and stays off until the control is reset.

In operation from cold the push button switch PB1 is closed, this energising relay A. Contacts A1 are adjusted to break after A2 and A3 make. As A3 makes, relay B becomes energised, closing contact B1, so supplying current to the element of the immersion heater, and allowing relay A to be held on through its own contact, A2. The indicator lamp LP2 will now be illuminated and stay so until the circuit is broken either by the thermostat, by S1, or by a failure in the supply.

As a safety measure, should C1 or C2 become short circuited the fuse FS1 will blow, making the circuit inoperative. Should either capacitor become open circuited the circuit will still not operate.

Fig. 1. Circuit diagram



The function of diode D1 is to develop a d.c. voltage across the relay A. Capacitors C1 and C2 act as voltage droppers. Resistors could of course be used for this purpose, but arrangements for adequate cooling of the unit would then have to be made.

S1 is the switch normally used to control the heater.

RELAY CONTACTS

Relay A should have the contact used as A1 (n.c.) adjusted so that it breaks *after* A2 and A3 (n.o.) have made, but still breaks when the armature is hard over. Relay B should be a 250 volts energised type, with contacts rated at 15A d.c.

The components should be mounted on a thick plastics board, and the unit mounted in a metal box which *must be connected to earth,* or to the earth wire in the cable.

If required, additional control points can be set up by wiring further push buttons and lamps in parallel with PB1 and LP2.

IMPORTANT NOTE

Before working on the heater, turn off at the mains and remove the appropriate fuses. ★

COMPONENTS ....

C1, 2	0·5µF 500V paper capacitor (2 off)
D1	BY100 silicon rectifier (Mullard)
FS1	1A fuse in holder
LP1, 2	Mains neon indicator lamp (2 off)
PB1	Push button switch 250V a.c.
RLA	Relay with 2,000Ω coil. 4 changeover heavy duty contacts
RLB	Relay with 250V a.c. coil. Single make-break contact, 15A rating
S1	D.P.S.T. switch, 15A 250V a.c. (normally already in position as heater control switch)

ELECTRONIC "DOOR BELL" FOR THE DEAF-BLIND

TO THOSE who are both deaf and blind—and especially to those who live alone—one of the most worrying features of day-to-day life is the inability to know when there is a caller at the front door. Failure to do so could, in the case of a relative, friend or tradesman, prove unfortunate; should the visitor be the doctor, the consequences might prove serious.

The Royal National Institute for the Blind has found one solution in the field of electronics, which is claimed to be the first of its kind in the world.

DEVELOPMENT AND FUNCTION

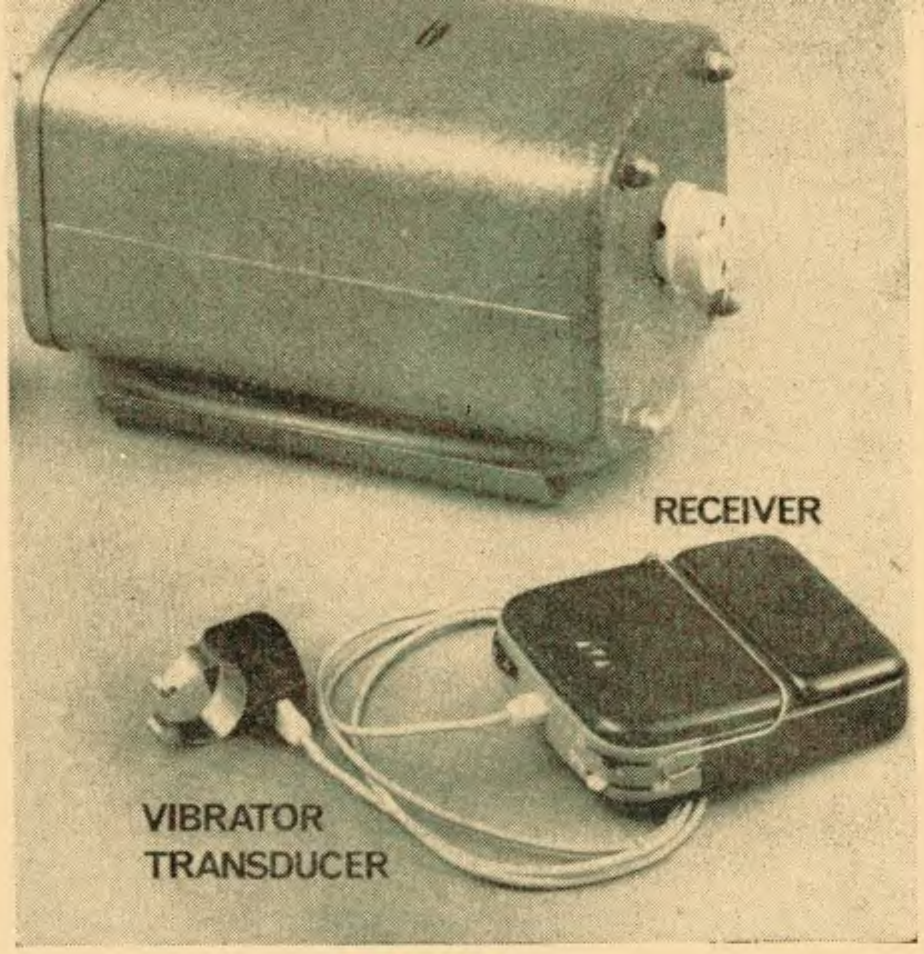
The system is based on an idea put forward by the G.P.O. Research Branch, Dollis Hill, where a demonstration of its possibilities was given some 18 months ago, and which has now been developed by the R.N.I.B. into a practical, working proposition.

The equipment consists of two separate parts, a transmitter and receiver. A series of loops of wire or copper strip is installed in the home and completely encircles the living area. These loops are charged with a small current (2 amps at 1 volt) when the bell-push is operated. The current is, in fact, a 250c/s tone which is supplied by a tuned saturable core transformer in the transmitter.

A pocket size transistor hearing aid receiver, which is made sensitive to this field, operates a small vibrator worn on the finger. The vibrator is basically a bone conduction transducer using a standard G.P.O. 20 ohm coil suspended on three "spider" legs, which have been modified so that resonance occurs at 250c/s giving maximum response.

The minimum operating power required to give acceptable tactile vibrations is considered to be 15mA at 1·25 volts at 250c/s.

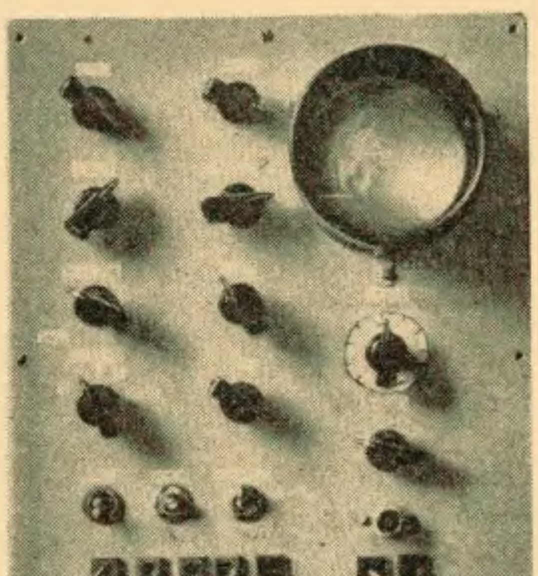
The Ministry of Health has agreed to supply sufficient receivers to permit a wide-scale field trial to be carried



out early this year and has invited a number of local authorities in England and Wales to participate in this. Information received will be used for evaluation purposes to ensure that the device meets all operational requirements before it is made nationally available.

CODE TRANSMISSION

It is technically feasible that the use of this system could ultimately be extended to include the transmission of additional information by means of a code such as Morse, utilising vibrations of different frequency or duration. Whether this would prove a practical proposition—bearing in mind the difficulty which elderly deaf-blind users might encounter in memorising such a code—is but one of the problems of tactile communication which the R.N.I.B. is currently considering.



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The March Edition of PRACTICAL ELECTRONICS on sale February 11

Readout—
A SELECTION FROM OUR POSTBAG

Down with printed circuits?

Sir—May I question why you advocate the use of printed circuits on some projects. There is no one among my friends in this hobby who likes them, and although the prints are no doubt ideally suitable for mass production, I cannot think that the amateur is keen on messing about with chemicals for the purpose of producing "one off" circuits. I feel that a good indication of the unpopularity of printed circuits for amateur use is reflected in their lack of availability on the market.

J. E. Brown,
Weeping Cross,
Stafford.

We are sure many readers will disagree with your comments. However, if you do not wish to use printed circuits it is quite easy to translate the diagram for orthodox wiring purposes.

Light-operated switches

Sir—I have read with great interest your article on LIGHT-OPERATED SWITCHES, especially the concluding paragraph employing the idea of using this type of device for starting and stopping a timed race or competition.

Over the past year I have been experimenting with the same idea, to register time taken to complete a set Fire Service Competition. The timer is started by the competing team running through a ray of light, directed onto a photo-cell, the stopping is accomplished when the team have knocked over the required number of targets with the water delivered via the branch-pipes. The time is registered in 1/10 parts of a second on an electro-magnetical counter.

It became apparent that locking actions were necessary in the start and stop circuits, this I was able to do with the aid of relay contacts. The timer contains a Mullard ORP60 cell. I am unable to obtain satisfactory results in supplying sufficient light to the cell from a light source situated 20 feet away from the cell. Can you give any guidance on what type of light to use, and how to shield the cell from ambient light or sunlight?

P. G. Smith,
Berkhamsted,
Herts.

For your application the cell should be mounted at the end of a light trap. This can take the form of a 12in. tube of 1in diameter, divided into four segments internally by lengths of card. A very concentrated light beam is necessary. A focused spotlamp is suitable (about 36 watts) employing an ordinary headlamp bulb.—G.J.K.

Japanese multimeters

Sir—A wide variety of attractively priced Japanese multimeters have appeared on the market.

Some contain capacitance and inductance scales, these quantities being read by placing the component and the multimeter in series across an a.c. supply. However, many of these meters have been made in Japan for the American market and often carry an American distributors name.

Not only are the scales concerned likely to be calibrated for use with the U.S. domestic supply voltage (110–120V a.c.) but also for the American standard a.c. frequency, i.e. 60c/s.

Therefore, if these scales are to be used in this country, it is necessary firstly to obtain the required a.c. voltage (by a transformer) and secondly to make a correction for our own mains frequency, i.e. 50c/s.

Electronic Constructors,
Sutton Montis,
Yeovil, Som.

Calling all clubs and societies

Sir—At the school where I am a member of the physics teaching staff we recently started a Radio and Electronics Construction Society.

Your magazine appeared eminently suited to our needs and I accordingly placed an order for two back numbers of the first issue, which had been published before the society had started, to obtain a complete series.

D. Bloomer,
Halesowen,
Birmingham.

We are very interested to learn of your recently formed Society and would like to hear from any other similar organisations devoted to electronics and allied subjects.

Variable d.c. supply

Sir—I intended constructing the Variable Low Voltage D.C. Supply Unit described in the December 1964 issue.

As I am in possession of a transformer rated at 17V 8A I would like to construct this unit with a higher output, i.e. 0–20V and as near 8A as practically possible, the voltage being the most important as I sometimes work with transistor sets of 18V.

I would be much obliged if you would let me know what changes in components would be necessary. Any other information would of course be gratefully received.

F. Sommerville,
Belfast 6,
N. Ireland.

We would not recommend operating this power unit at a higher voltage than that specified. This is rather important, since the transistors will suffer damage due to over-heating if any attempt is made to operate this unit at higher power levels.

Metal detector

Sir—I wish to construct a simple device for detecting metal (wrecks, etc.) on the sea bottom. The device must be portable, battery operated and preferably using headphones rather than any form of cathode ray tube. It should have a maximum range of at least 100ft. The device is of course to be operated from a boat, and used for detecting metal objects that may be of interest to skin divers.

Readout— A SELECTION FROM OUR POSTBAG

continued

If you can suggest any obtainable circuit, or methods of converting ex-government mine detectors I would be more than obliged. I have searched all the local electronics shops in vain for information on this subject.

P. WILLIAMSON,
Roath Park,
Cardiff, Glam.

Sorry we have no details of any ex-government equipment. But we will gladly forward any details supplied by readers to Mr. Williamson.

. . . in medicine, too

Sir—Electronics is being used in medicine increasingly and your journal should help keep the doctor in touch with the meaning and working of the apparatus he is using, i.e. electrocardiograms, electroencephalograms, closed circuit television etc.

Your article on ultrasonics was interesting but for completeness its use on surgery could have been mentioned, i.e. brain and ear surgery especially.

I try and attend lectures and exhibitions held in Glasgow on electronics but find great difficulty in finding a "practical" definition of the term especially as to what is the difference between "electricity" and "electronics".

R. H. FREEDMAN (DR.),
Newlands,
Glasgow S.3.

The internationally accepted definition of electronics is: that branch of science and technology which deals with the study of the phenomena of conduction of electricity in a vacuum, in a gas, and in semiconductors, and with the utilisation of devices based on these phenomena.

The in-betweens

Sir—I have much enjoyed the first two copies of PRACTICAL ELECTRONICS.

However, I have one suggestion. You provide well for the beginner and the knowledgeable but not so well for the person in between. Can you give a more detailed description of how your circuits work, particularly the blueprint circuits and how their correct working may be tested on meters c.r.o., etc. For example, I am going to make the variable constant voltage d.c. supply unit described in the December issue. I expect it will work well but my understanding—and I particularly want to learn more—will be limited to your brief description. You explain the function of the parts of the circuit as far as the Zener diodes but give no indication—to me at any rate—of the function of four transistors. In brief, more explanation please.

R. V. WALLEY, M.D.,
Abbots Leigh,
Bristol.

Articles dealing with the theoretical aspects of electronic circuitry will appear regularly. To give a full and detailed circuit description for all constructional projects would of course mean a considerable amount of repetition. Anyhow, your point has been duly noted.

Radioactive sources

Sir—I am disturbed to find it suggested, in the article on Radioactivity, that experimenters use radioactive luminous paint as a source and that they might obtain this from a wholesaler in watchmakers' goods. Such a source would be unsealed and there is the danger that spillage might occur.

It is worth noting that the Departments of Education and Science (Ministry of Education) include the following in their notes regarding the use of Radioactive Substances in Schools:

"Luminous Paints. Hazards can arise from the ingestion or inhalation of some luminous paints which may contain radioactive substances. In no circumstances should attempts be made to recover these materials from luminous dials or to obtain the paints in any other manner."

". . . These unsealed sources must not include any long-lived radio isotopes, which are selectively concentrated in living bone, such as Radium and Strontium 90."

G. E. FOXCROFT,
Rugby.

While the source is unsealed, the only likely danger due to mis-handling is from breakage of the tube, as spillage by knocking the tube over is impossible because of the viscosity of the paint and the minute quantity present. To safeguard against breakage, the tube could be wrapped in cotton wool and then inserted into an aluminium container with a screw top (such as a cigar tube), and the screw top sealed on with pitch. This would then prevent any danger of leakage. It might be wise to label the container "Poison—Not To Be Taken."—J. F. Rowles.

We regret that the original suggestion concerning luminous paint (p. 130 December issue) did not emphasise that only a minute amount of this substance should be used. In view of the possible misuse of this substance, we strongly advise all persons not experienced in handling radioactive materials to use only those radioactive sources which have been officially approved for use in schools and which can be obtained from the usual suppliers of laboratory equipment.

Flash gun

Sir—I wonder if you could tell me if you have any article of a practical nature on transistorised photographic flash units.

A really "do it yourself" article would have, I am sure, a wide appeal to many interested in either electronics or photography or both.

J. W. HARVEY,
Stratford-upon-Avon,
Warwicks.

It seems from our correspondence that there is a genuine demand for a transistorised flash gun. We have put this subject in hand and it is hoped to publish details as soon as design and component availability is finalised.

Walkie talkies

Sir—I have been reading about Japanese walkie talkie sets. Can you let me know where I can get information about these sets.

D. M. EVANS,
Crawley,
Sussex.

We regret being unable to help in this connection. This opportunity is taken to draw attention to the necessity of obtaining the appropriate transmitting licence from the G.P.O. before attempting to use any radio transmitting equipment.

REWARD
TWO GUINEAS
will be paid for the first correct solution with circuit of the MAGIC BOXES problem ON PAGE 264
The editor's decision is final