John Madd

# Practical Electronics

OCTOBER 1965

PRICE 2'6

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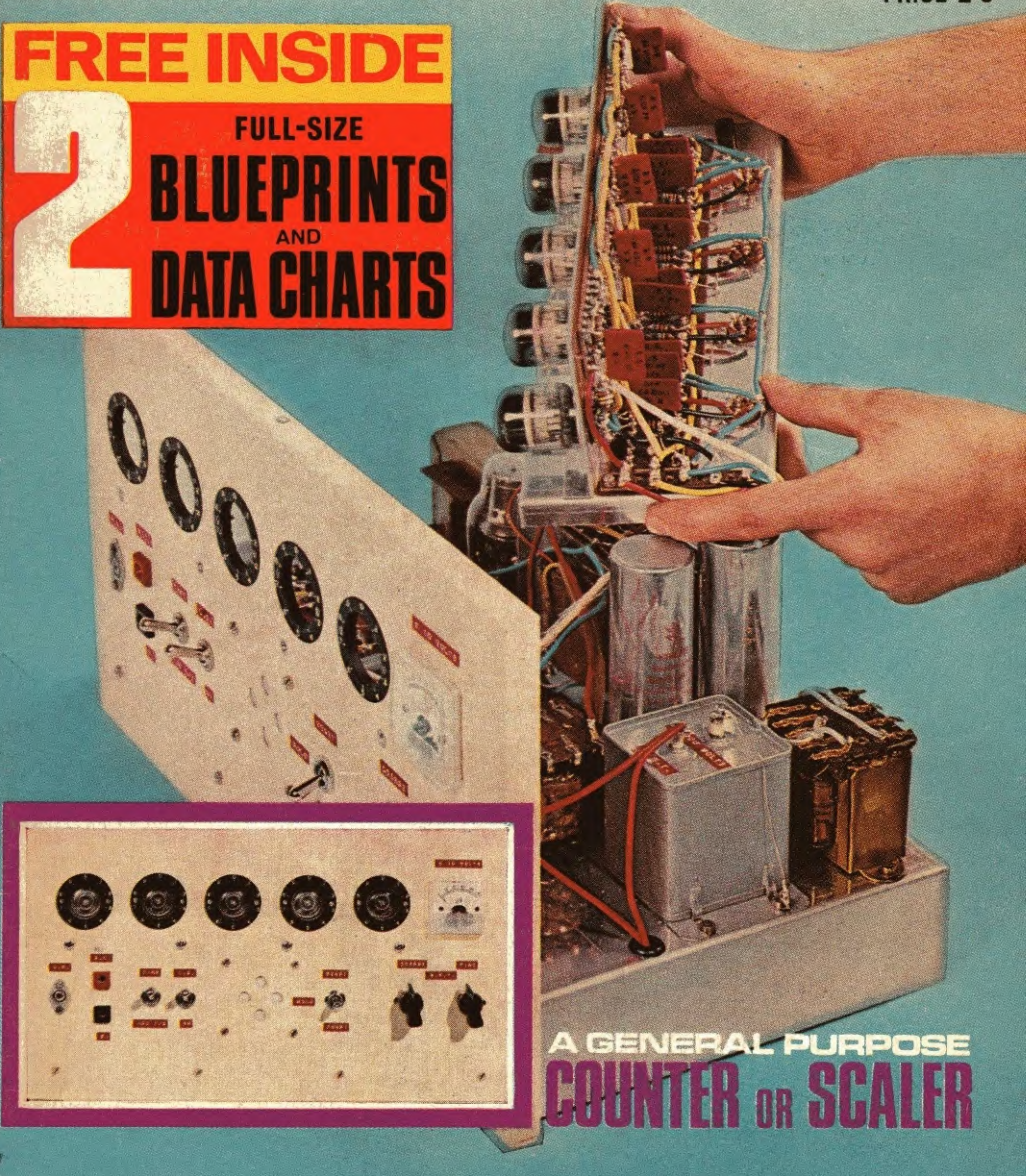
**2 FULL-SIZE BLUEPRINTS AND DATA CHARTS**



**A GENERAL PURPOSE COUNTER OR SCALER**

VOL. 1 No. 12
OCTOBER 1965

# Practical Electronics

## TAKING STOCK

WITH this issue we complete our first year of publication.

As we explained in our inaugural number, our aim is to serve the amateur electronics enthusiast by offering him a varied range of projects which in conception, design, and method of execution reflect the current developments and trends in electronics. Now, some fifty constructional projects later, it may be instructive to take a look at the ground covered so far.

* * *

To date, our designs has taken cognisance of several fields of interest: audio, radio, ultrasonics, nucleonics, and instrumentation. The latter is a convenient term for describing a miscellany of detecting, measuring, and timing devices; it would be far too exhaustive a task to attempt to designate their multifarious applications.

An analysis of the published designs will reveal that the transistor has a five-to-one preponderance over the valve. Few of our readers are likely to quarrel with this, we suspect, for this seems to represent a realistic balance in light of present day progress in electronics. Nevertheless we do feel it would be wrong to suppose that the valve is all but vanquished. There still remain a variety of functions that only the thermionic valve can perform satisfactorily and we must certainly not overlook the important gas filled cold cathode devices—ranging from the simple voltage stabiliser to the more complex counting tube such as used in the scaler described in this present issue.

* * *

Considering now the essentially *practical* aspect, it will be noted that the projects have illustrated a number of constructional methods.

Basically, all that one requires for many transistorised projects is a piece of laminated plastics board. However there are several different approaches to the problem of wiring up the individual components. The traditional method of making each point-to-point connection with wire is losing favour to the "wire-less" technique of the individually etched printed circuit and to the versatile printed wiring board marketed under well-known trade names. Among other advantages, these new methods permit close packing of components, thus reducing the overall dimensions of a complete assembly to the minimum.

This leads us to a final thought, directed particularly to our beginner friends: While much labour has been eliminated by these modern constructional methods, considerable adroitness in handling a small lightweight soldering iron has become essential. This, like all skills, can be acquired only by practice.

## THIS MONTH

### CONSTRUCTIONAL PROJECTS



### SPECIAL SERIES



### GENERAL FEATURES



### NEWS AND COMMENT



***Our November issue will be published on Thursday, October 14***

All correspondence intended for the Editor should be addressed to: The Editor, PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Editorial and Advertisement Offices: PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Phone: Temple Bar 4363. Telegrams: Newnes Rand London. Subscription Rates including postage for one year, to any part of the world, 35s. 

# ELECTRONIC SOUNDS AND MUSIC

BY F. C. JUDD. A. INST. E.

Electronics and magnetic tape have become very prominent in the creation of new sounds used in modern but otherwise conventional music and in the actual making of so called "electronic music", which is of somewhat abstract nature. It is not intended to discuss here electronic musical instruments, neither should the reader confuse music produced by electronic organs and electric guitars with that created on or with the aid of magnetic tape and electronic devices.

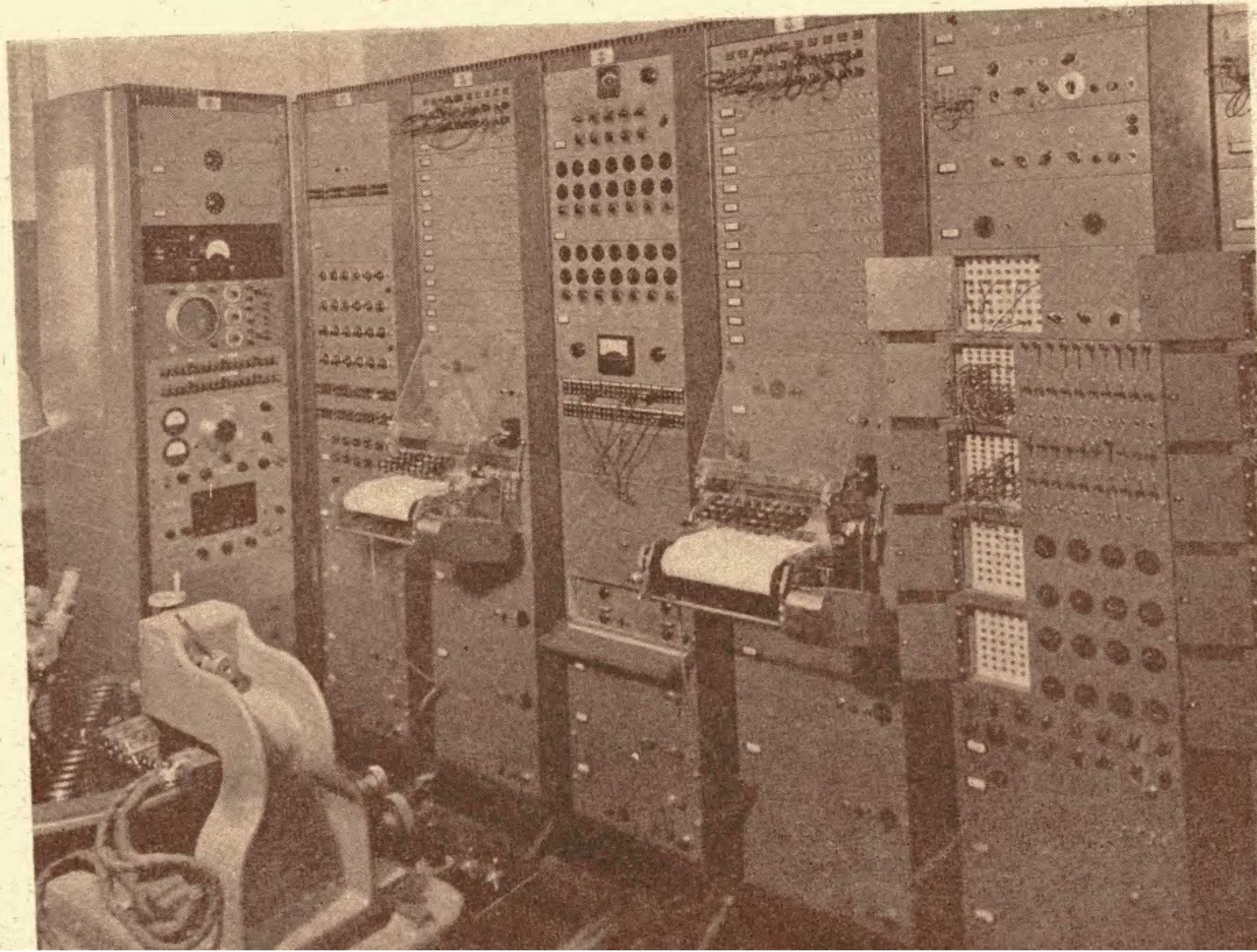
Electronic music is derived from basic tone and noise generators; magnetic tape features very prominently in the composition and actual making. There is, however, another and similar form of music which can be created out of tape recorded natural sounds and this is the more surrealistic "Musique Concrête".

Here basic sounds are treated and manipulated in various ways and re-recorded into a whole composition. The techniques are too numerous to discuss here and could in fact become the subject of a complete article.[1] On the other hand many of the methods applied to electronic music and musique concrête can be adapted by the amateur in the making of interesting electronic sounds and with a little skill and practice, complete electronic music compositions.

## SYNTHETIC SOUNDS

The idea of applying electronics in the creation of new sounds and music is not new and even completely synthetic music and voices have been produced with the equipment such as that shown in Fig. 1. Computers have also been put into operation to compose

*Fig. 1. The R.C.A. music and voice synthesiser*



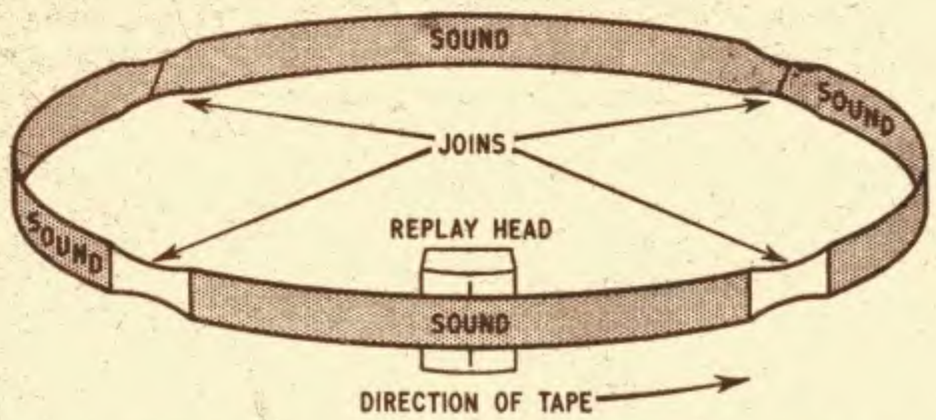



*Fig. 2. Tape loop rhythm. Each sound on equal length of tape*

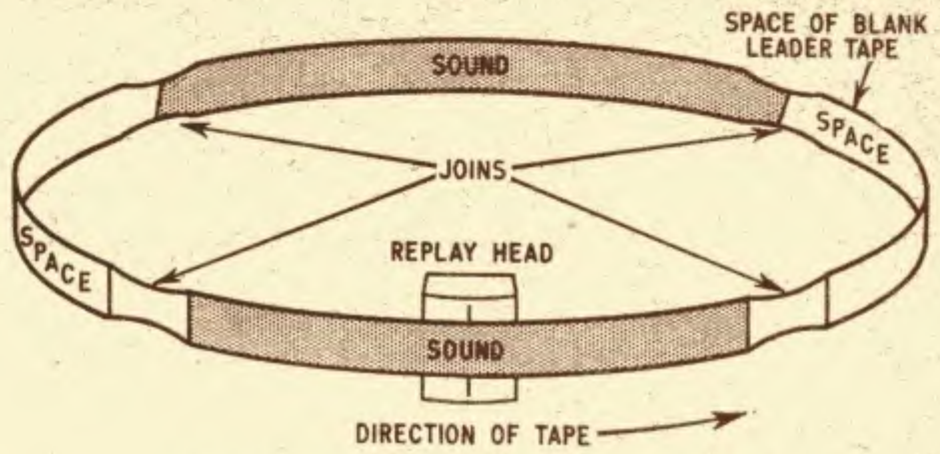



*Fig. 3. Two-sound, four-beat rhythm*

and actually produce music and some workers in this field have integrated the various techniques to produce music which has a popular appeal music-wise, but with new sounds to the "instruments". Even "pop" record groups and recording studios are employing electronics and tape to produce new musical sounds and unusual, though not always elegant effects known otherwise as "gimmicks".

New techniques however, generally call for specialised equipment, but with a tape recorder plus a few simple electronic circuits any enthusiast can indulge in the making of fascinating new sounds and if by nature he happens to be something of a musician, some quite unorthodox kinds of music too.

## TAPE RECORDER AS A MUSICAL INSTRUMENT

The use of "tape loops" is fairly well known and a small loop of recorded sounds can be repeated over and over again so long as the tape recorder is left running. This simple technique can be used to provide a perfectly timed rhythm against which to play a musical instrument or set a melodic line from a tone generator.

Here is a simple exercise to show what can be done. Record four different sounds on tape at 7½ inches per second and cut out about three inches of each sound. Join these together with splicing tape to form a loop as shown in Fig. 2 and replay at 7½ inches per second. This will demonstrate the basic method and you will find it quite easy to count four beats to a bar with this simple rhythm. Now try a two piece loop by recording some percussive sounds and selecting from these two of different pitch, they should be cut and jointed as shown in Fig. 3 with lengths of leader tape in between. The pieces of recorded tape and leader tape must each be of the same length, say three inches.

If you make the pieces shorter the rhythm will be faster and vice versa. When this "sound-space-sound-space" loop is played you can again count four beats to the bar, i.e. 1(sound)-2(space)-3(sound)-4(space). The loop can then be re-recorded on to another tape and at the same time you record more sounds in tempo and with accent on the second and fourth beats (spaces in the loop). This does of course require a second tape recorder and a means of mixing the output from the loop replay recorder and a microphone. The BBC Radiophonic Workshop have produced two records which employ this technique (Fig. 4). Details of the records are given at the end of this article.

Once you have tried these simple exercises the use and making of loop rhythms should be quite easy. If you have "echo" facilities on your tape recorder then the rhythms might be enhanced by this also. Alternatively, the effect of different speeds might be found interesting. Incidentally, in making loops one can of course operate at a much slower rate during the first process, i.e. by running the primary loop at half speed. Re-recording and the addition of new sounds is done at the same speed. The final result is replayed at the original speed. The second batch of sounds will of course be raised in pitch by one octave and sound completely different from the original.

## EXPERIMENTAL EQUIPMENT

The photograph of Fig. 5 shows part of the author's studio for recording and creating special electronic effects. The central "rack" contains two tone generators (sine wave and square wave), a ring modulator, electrical audio filters, pre-amplifiers with variable frequency characteristics, provision for mixing up to 12 signal channels, a level meter, and an oscilloscope.

*Fig. 4 (left). Corner of the BBC Radiophonic Workshop*

To the left of the picture can be seen a keyboard, which operates a series of tone generators in tempered scale and which has provision for controlled "attack" and "decay" of any sound fed through or produced by the system. Another item frequently used in the studio is a "Theremin", which is an electronic musical instrument operated by the "hand capacitance" effect. The remainder of the equipment consists of various tape recorders and amplifiers, not all of which are shown in the photograph. This is of course a quite ambitious studio since it has to produce music for television and films.

Simple equipment is quite capable of producing excellent results; Fig. 6 shows a typical circuit of a simple transistor tone generator for keyboard operation. Ordinary tone generators can be used for specific sounds, most of which can be altered by means of a "ring modulator". This device can be constructed from a pair of audio transformers with centre-tapped secondary windings; a circuit is given in Fig. 7. It has two inputs and one output. Sounds fed into the two inputs will be "ring modulated" and appear at the output with two extra tones, the frequencies of which will be the sum and difference of those at the input. When two sine waves of different frequency are passed through a ring modulator the resultant output is a chord of unusual timbre; an effect greatly favoured by composers of electronic music.

Another useful circuit is the vibrato oscillator shown in Fig. 9. Tones and sounds applied to this may be given a tremolo (trembling) effect which can sound very pleasing. The keyed tone circuit shown in Fig. 7 has its own vibrato oscillator. Incidentally the vibrato device consists of a low frequency phase-shift oscillator which controls the gain of the pre-amplifier (V2). The control VR2 effects the amplitude of the sine wave applied to the suppressor grid of V2 and if turned too high can result in an unpleasant "thumping" sound. Of course if you require a "thumping" noise then the device will produce it (electronic "heart beats" effect).

Control over "attack" (beginning of a sound) and "decay" (end of a sound) can be produced with the circuit shown in Fig. 10. It is not difficult to construct, but since it has a high gain pre-amplifier like that in the vibrato circuit, precautions must be taken against hum pick-up. These circuits should be constructed like any high gain audio amplifier and completely screened. The "attack" time is controlled by VR2 and C5, although in practice it is better to leave C5 at a suitable value and modify VR1 and R5 for the required delay, i.e. the time needed for the sound to commence. A few trials with different component values will soon produce the desired effects.

With the help of electronic circuits such as those described, plus a tape recorder, quite fascinating sounds can be created. If the tape recorder has "echo" facilities, i.e. a separate replay head that will pick up the recorded signals and feed them back through the recording amplifier, so much the better. A signal mixer of some kind is also advantageous especially

*Fig. 5. The author's equipment for producing electronic sounds and music*

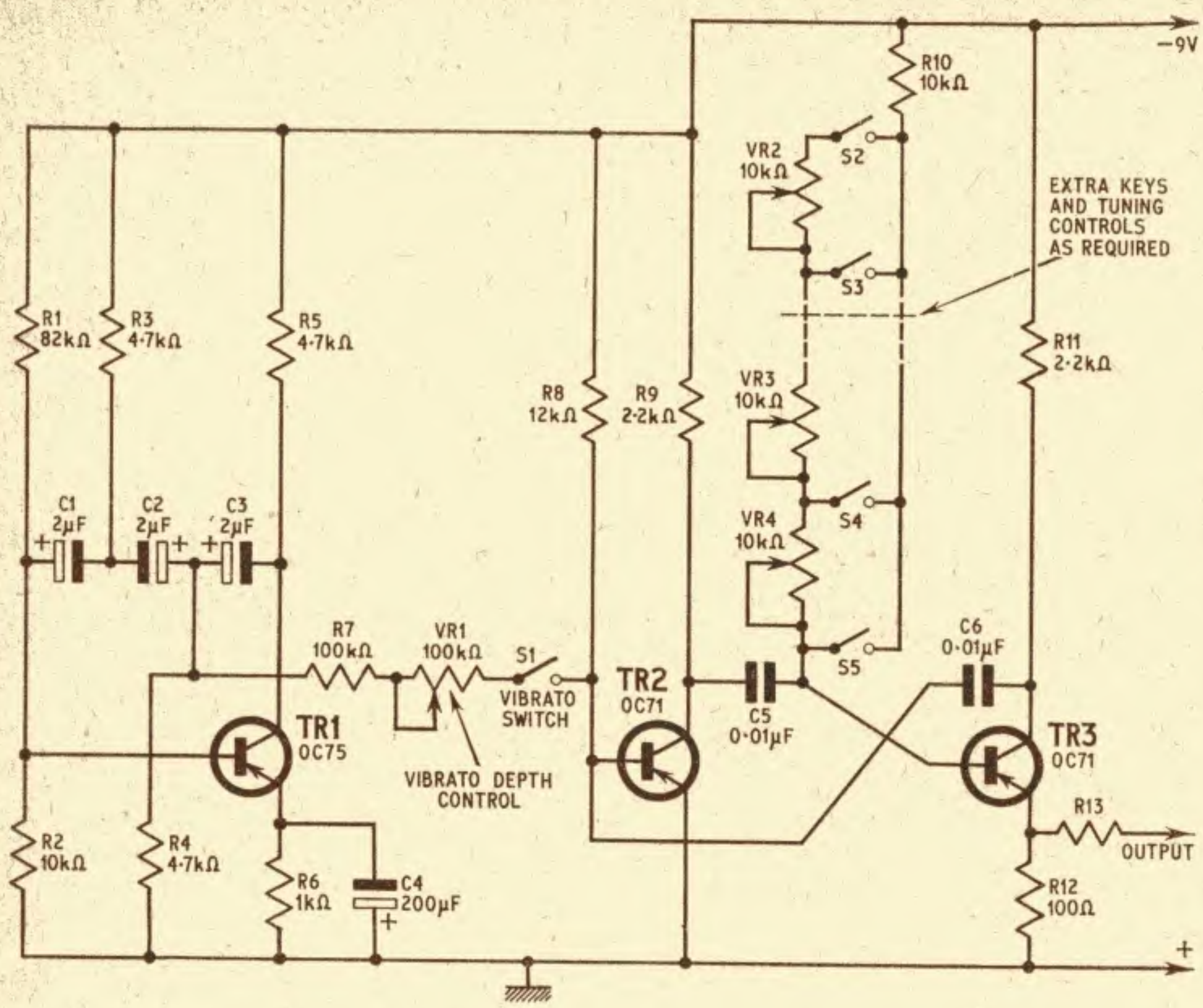



*Fig. 6. Single note keyboard oscillator with vibrato oscillator, designed by Mullard Limited*

when working with two tape recorders and other signal sources. Assuming one has these facilities, here are some of the techniques that can be applied:

## SOUND SOURCES

1. Tone mixing from one or more generators;
2. Ring modulation of tones;
3. Use of sine or square wave tones;
4. Tone shaping circuits (simple differentiation or integration);
5. Use of keyed tone systems to tempered scale;
6. Sounds produced through a microphone.

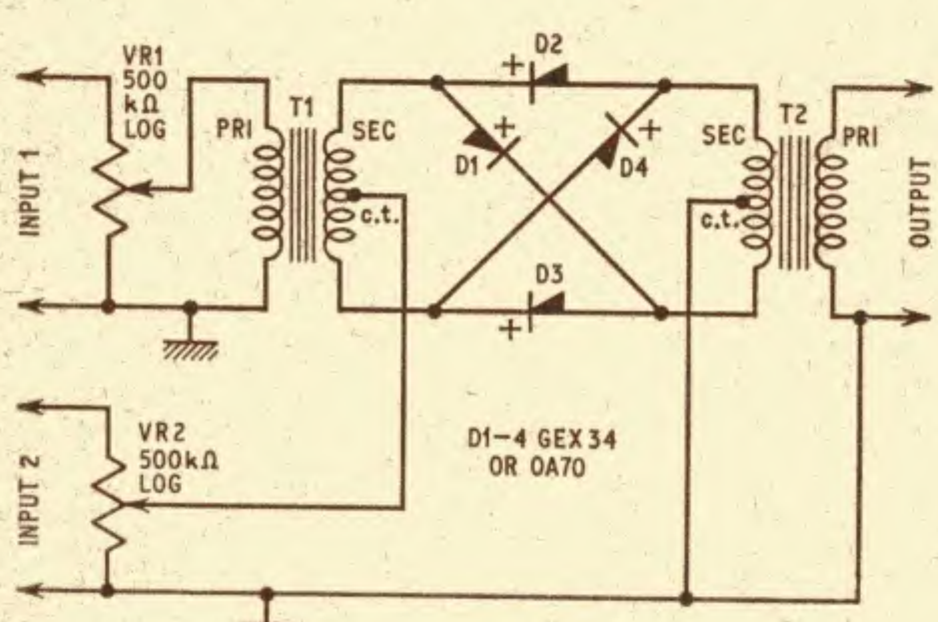



*Fig. 7. A typical ring modulator circuit*

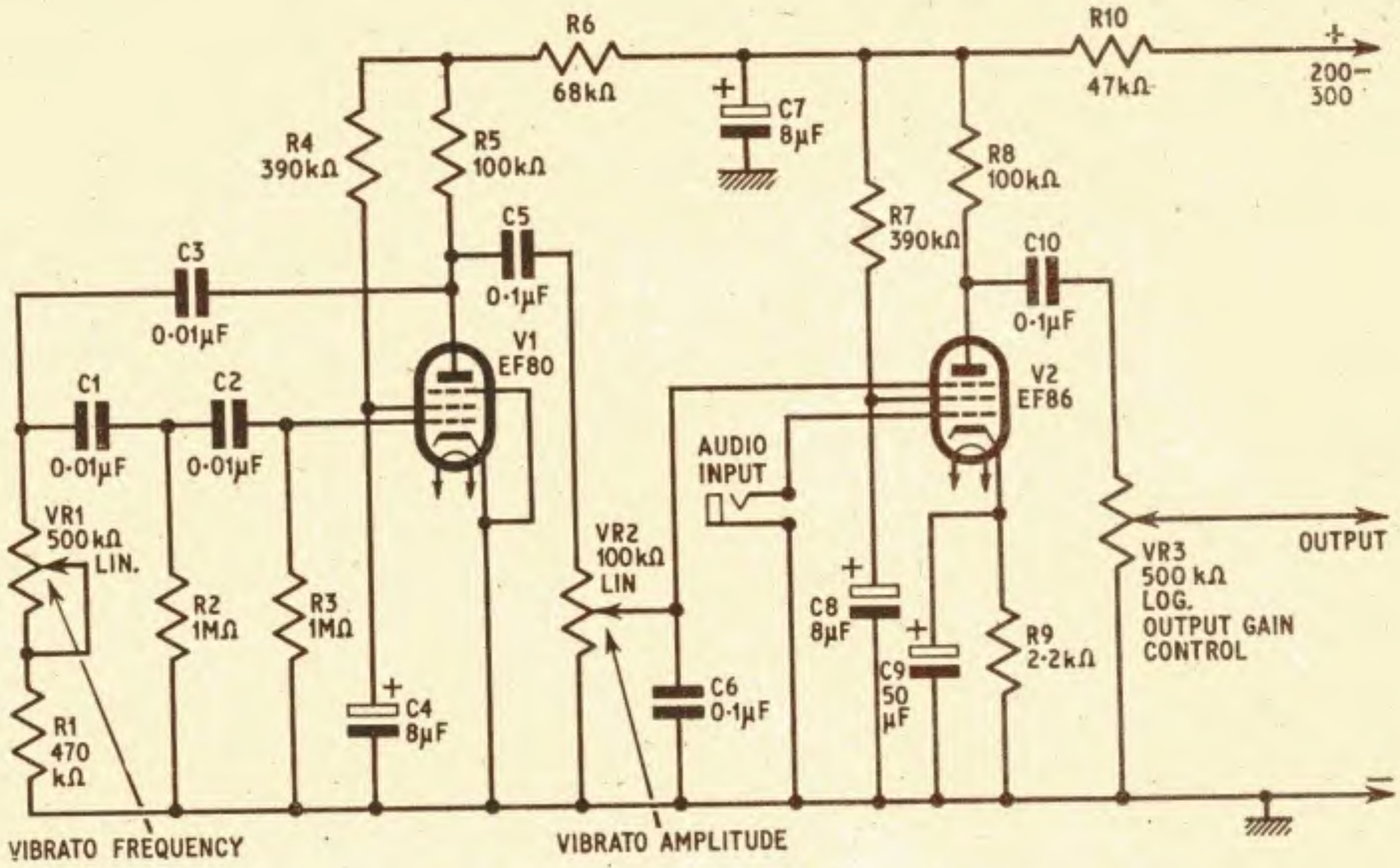
## TAPE RECORDING TECHNIQUES

1. Tape editing (cutting sounds from tape and rejoining them);
2. Change of tape speed (during recording or playback);
3. Ring modulation of recorded sounds and pure tones;
4. Tape loops (rhythms and repeating sound sequences);
5. Tapes and loops running in reverse;
6. Tape "echo" (feedback from extra replay head);
7. Reverse echo (tape replayed in reverse after being echoed);
8. Cutting of tape at beginning of sound to produce new "attack";
9. Cutting of tape at end of sound to produce new "decay";
10. Stereophonic effects by employing two or more tracks;
11. Artificial stereo effect (movement of sound by panning);
12. Panning technique (fading one sound from one stereo channel to another).

## ELECTRONIC TREATMENT

1. Ring modulation of any two groups of sounds;
2. Electrical filtering (altering the frequency response of amplifiers);

Fig. 8. *Vibrato oscillator and pre-amplifier circuit*




3. Linear mixing of any group of sounds;
4. Mechanical reverberation (with spring delay echo unit);
5. Electronic vibrato.

The above represent a few of the possibilities that electronics and magnetic tape have to offer in the creation of new sounds and most of these can be combined in various ways. For instance, *sound movement* is an interesting effect. One could make a rhythm track from a loop which is then re-recorded equally on two tracks of a stereo recorder (rhythm central). Melodic lines can be added from a keyboard tone generator and "panned" (faded from track to track) so that the melody appears to "wander" about in space. This effect was recently demonstrated to an audience who found it quite fascinating although a little disconcerting.

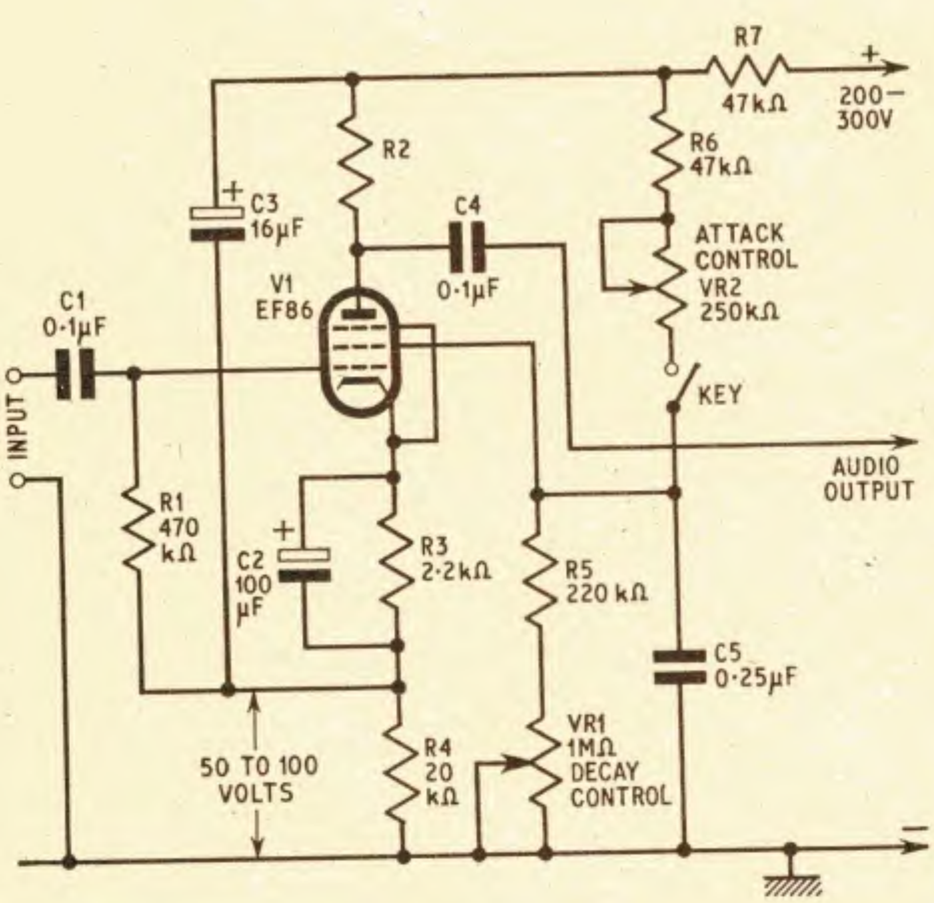



Fig. 9. *"Attack" and "decay" control circuit*

Finally for those who feel they would at least like to hear what electronics have contributed to music, here are details of records now available, each of which features many of the techniques outlined in this article:

1. Music from Mathematics (music composed and played by a computor).
   Brunswick STA. 8523 (stereo) available in mono.
2. Varêse. Poême Electronique (electronic music) classical.
   Philips ABL 3392 (mono).
3. The Synthesis of Music, by the R.C.A. Music Synthesiser.
   R.C.A. LM.1922 (available only from R.C.A. New York, U.S.A.).
4. Dr. Who (BBC recording of rhythmic electronic music by the Radiophonic Workshop).
   Decca F.11837 (mono).
5. Time Beat (BBC recording of rhythmic electronic music by the Radiophonic Workshop).
   Parlophone 45-R-4901 (mono).
6. Electronic Sounds and Music. F. C. Judd (for special effects).
   Castle EFX-1 and EFX-2 (mono).
7. Electronic Sound Patterns. Daphne Oram.
   H.M.V. 7EG-8762 (mono).
8. Electronic Movements. Tom Dissavelt (rhythmic electronic music).
   Philips 430 736PE.
9. Study 1 and 2. Karlheinz Stockhausen (modern classical electronic music).
   Deutsche Grammophon LP.16133 (mono).
   (one of three records of similar composition.)

REFERENCE


1. "Electronic Music and Musique Concrête" (techniques). Published by Neville Spearman Limited.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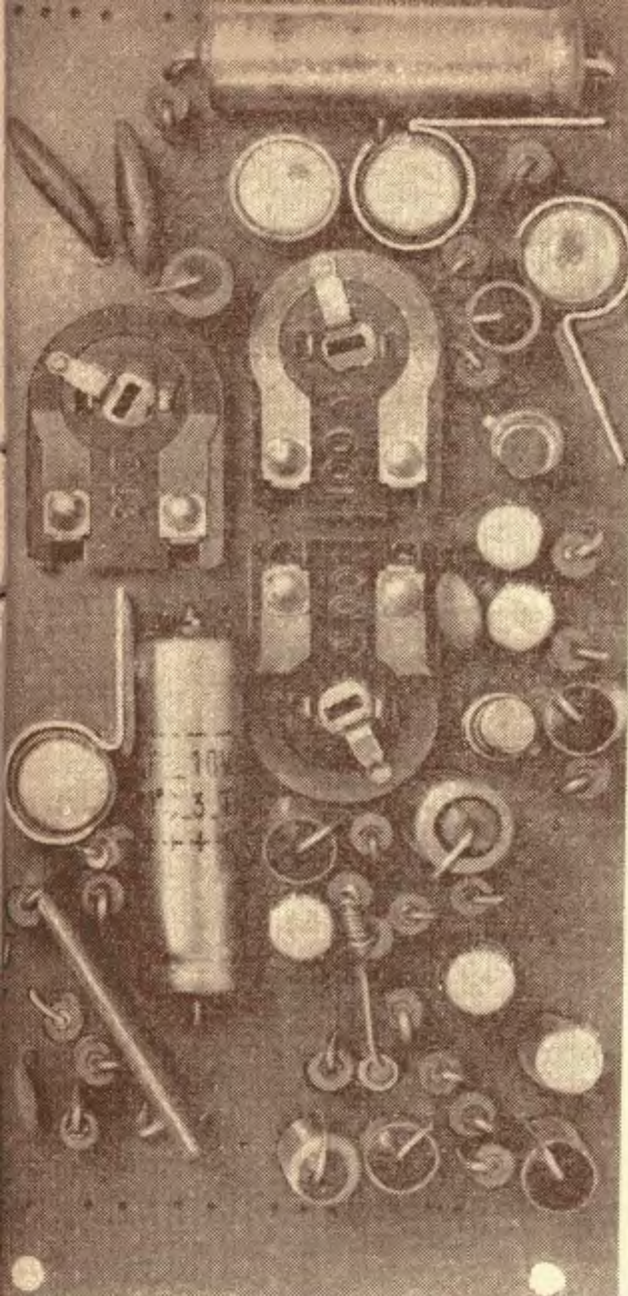


# NEW LOOK TAPE RECORDER

BEHIND the facia of the commercial tape recorder, a quiet revolution is going on. In commercial production models transistors are now largely superseding valves.

This article describes a fully transistorised tape recorder circuit illustrating some of what are now becoming the conventional commercial techniques. Typical of these are the "Ridler" type d.c. coupled self-compensating, pre-amplifier input circuit, and the self-oscillating erase head which uses the erase head as the inductance of the erase/bias generator thus obviating the necessity of a separate oscillator coil on the circuit board.

The circuit uses nine conventional, easily obtainable germanium transistors, together with two temperature compensating diodes. It is designed to operate from a nominal 9 volt h.t. rail and is capable of delivering some 800mW audio output into a standard 8 ohm load.

Volume and top-cut tone controls are included and there are facilities for using a type DM71 level indicator.

The output stage is of the modern transformerless complementary-symmetry class-B, push-pull type, which permits a very low standing quiescent current for current economy—this being particularly advantageous where a battery supply is used.

## COIL-LESS DESIGN

The circuitry is unusual in that the inductors normally found in tape recorders hitherto (e.g. audio transformers, chokes, oscillator coils, and compensating inductors) have all been eliminated to give a truly "coil-less" design.

Any standard medium impedance record playback head of about 100mH inductance can be used, but the erase head must be one of the new-generation high-efficiency, self-oscillating heads, such as the Miniflux LF/6-0, or Marriott R/EC/23.

The blueprint enclosed with this issue provides constructional details for the electronic module. It also includes details of the wiring needed to connect up the printed wiring board into a complete working system.

In this article constructional notes are given for an actual tape recorder using a BSR type TD2 mains powered deck. The TD2 deck is normally fitted with a BSR MN155 record replay head and a TG3 erase head, but in the equipment described here the TG3 erase head has been replaced with a Miniflux LF/6-0 self-oscillating erase head. A circuit is also given for a small mains power pack to provide the 9V d.c. supply necessary for the module as an alternative to battery operation.

PE BLUEPRINT

**constructing a transistor tape recorder using a printed circuit amplifier module**

**By R. HIRST**

## CIRCUIT DESCRIPTION

Fig. 1 on the blueprint gives the circuit diagram of the record replay amplifier and oscillator together with the appropriate connections to external components.

In the *record* position of the function switch S1 (as shown in the diagram) the input from the moving coil microphone is fed into the base of the first transistor TR1 and is subsequently further amplified in stages TR2, TR3.

The emitter of TR2 is fully decoupled by C5 and the three stage pre-amplifier has a virtually flat response, except for a slight bass boost arising from the shunting effect of C2 and R7 across R2.

From the volume control VR5 the signal is applied to TR4 which drives the complementary symmetry push-pull class B pair of transistors TR5 and TR6; these in turn emitter-follower drive the output pair TR7 and TR8. The output signal then passes via C11, R16, R17 and the switch S1E to the record/playback head X1.

## OSCILLATOR

The oscillator comprises a transformer coupled feedback circuit, where the erase head coils are used as the transformer. Transistor TR9 works in Class C and the circuit is tuned to 50kc/s approximately by the capacitor C14 across two windings of the erase head X2. S1F of the function switch is arranged so that the d.c. supply is applied to TR9 in the record position only. The filter R19, C15 is inserted to prevent undue clicks occurring when the oscillator is switched on or switched off. The preset potentiometer VR3 provides adjustment for a suitable erase level.

## RECORDING LEVEL INDICATOR

A DM71 indicator tube can be connected between pins 15, 16, 17 and 18, as shown dotted in Fig. 1. The grid of this tube is driven by the audio signal applied via R18 from the output of TR7, TR8. The positive h.t. supply to V1 is provided by the connection through pin 18 to the bias overwind on the erase head.

If the indicator tube is not required, pins 16 and 17 are shorted.

## PLAYBACK OPERATION

When the function switch is transferred to the *playback* position, the output from the head X1 passes via pin 2 into the input of the pre-amplifier first stage TR1. The replay head itself plays a substantial part in the equalisation that is necessary to offset the frequency versus voltage output characteristic. This frequency compensation in the pre-amplifier is effected mainly by the feedback through R4 which reduces the input impedance so that the changing head impedance does not materially effect the amplifier response. Because a low impedance (approximately 100mH) head is used the d.c. resistance becomes significant below 100c/s, and a degree of passive bass boost is therefore introduced by R7 and C2 across R2.

A variable tone control VR4 is placed across the emitter circuit of TR2 in the *playback* position, but is not operative in the *record* position. The response-corrected signal from the collector of TR2 is now fed via an emitter follower TR3 impedance changing stage to the volume control VR5, and thence into the power amplifier stage TR4-TR8.

## PRESET ADJUSTMENTS

At this point it might be well to examine the purpose of the preset potentiometers VR1 and VR2. VR1 is used in setting up the amplifier and is adjusted until the d.c. centre rail voltage at the emitter of TR7 is approximately half the supply rail voltage, i.e. in the case of a 9V supply between 4·5 and 5V.

VR2 works in conjunction with the thermal compensating diodes D1 and D2 to keep the bias currents in the output stages down when the amplifier is operating at high temperatures. In setting up the amplifier VR2 is adjusted until the quiescent current passing through TR7 and TR8 is of the order of 1·8mA. This setting of the quiescent condition will virtually eliminate any cross-over distortion in this class B output stage.

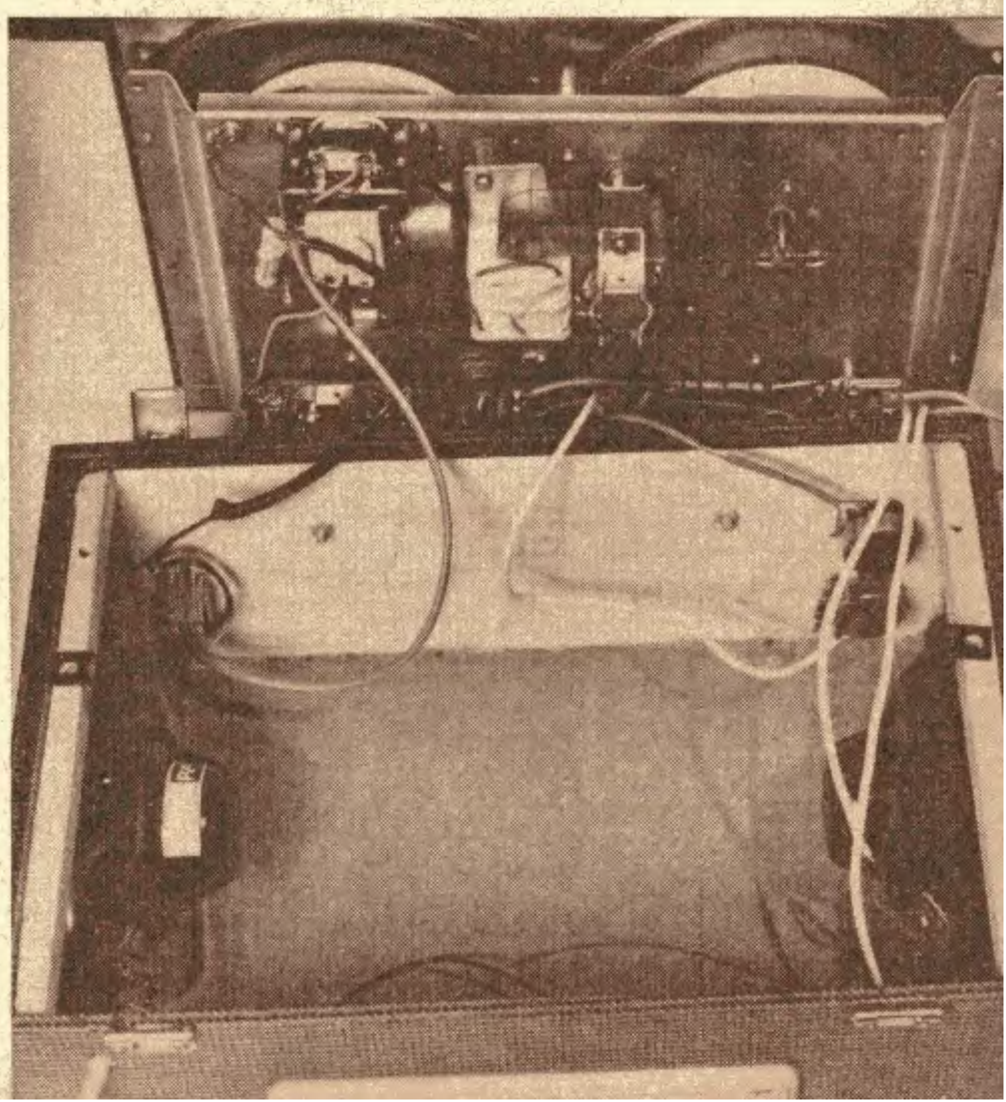
The circuit sensitivity is designed so that a maximum r.m.s. output of 800mW may be obtained from a fully modulated tape. This output is fed via C11 into a 8 ohm loudspeaker. Care should be taken that no load less than 8 ohms is connected across pins 9 and 10.

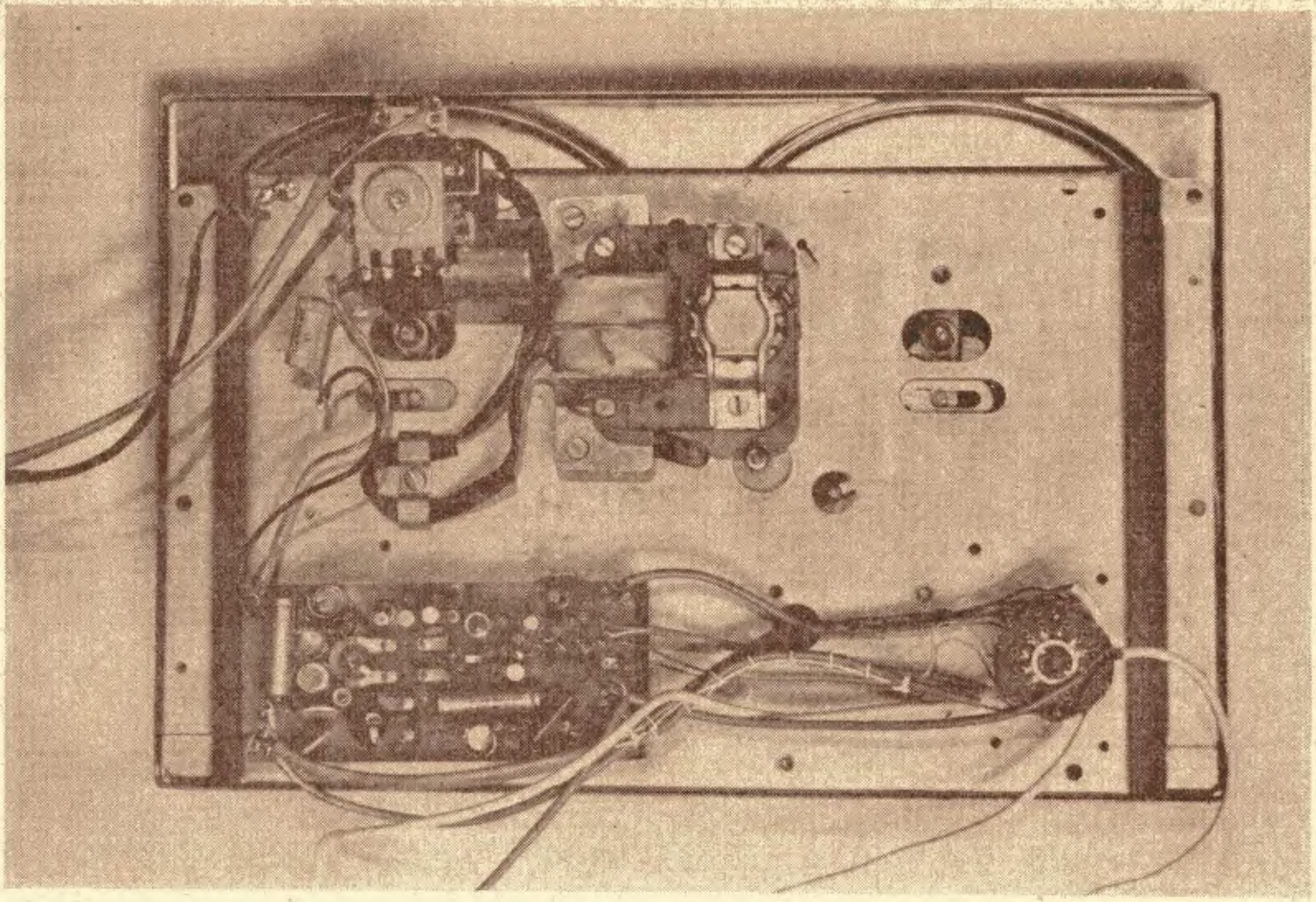
## CIRCUIT BOARD CONSTRUCTION

A full list of components for the amplifier module is given on the blueprint. This amplifier can be constructed on a Verokit or Electrokit board, or as a "printed wiring" module. A full size template for etching a printed board appears in Fig. 3. (Those who do not wish to carry out the etching procedure themselves will be interested to learn that a prepared circuit board type PC 8206, and completed amplifier unit type PC6, can be obtained from Newmarket Transistors Ltd., Newmarket, Suffolk.)

For constructors who propose to use the suggested layout incorporated in the print board described above, an amplifier component layout is given in Fig. 2. For ease of assembly this layout should be followed carefully, and only the specified type of components used. Other layouts may give rise to instability, and different style components may not fit physically in this present arrangement.

***View inside the tape recorder cabinet showing the two 15 ohm elliptical loudspeakers. These loudspeakers are connected in parallel.***





*View of the underside of the tape deck showing positioning of the switch, power pack and module*

## MAINS POWER PACK

The circuit diagram Fig. 1 shows the amplifier as supplied from a 9V battery. For mains operation a suitable power pack circuit is given in Fig. 4. This can be obtained as a completed unit (type PC101) from Newmarket Transistors Ltd.

The power pack uses a standard bridge rectifier fed from the 12V secondary of a mains transformer T1. Although the amplifier circuit of Fig. 1 indicates a 9V power supply, it is possible to operate on supply voltages up to 12V. Care should be taken however to see that the power pack output does not exceed this figure. The series dropping resistors R23 and R24 may need changing in value depending upon the output actually obtained on load.

## COMPLETE TAPE RECORDER

The photographs show a complete tape recorder system built with the amplifier module described above. The case was made of plywood and covered with self-adhesive plastic material. The overall dimensions are 13½in × 9¼in × 6¾in deep.

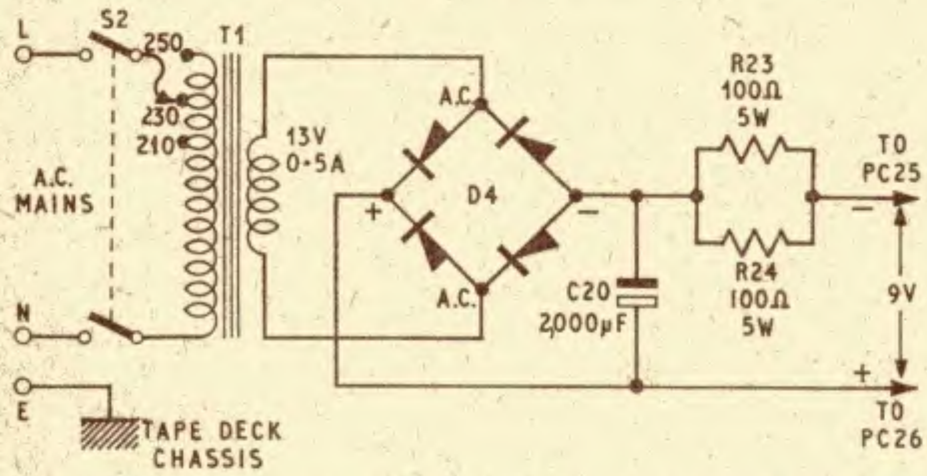



*Fig. 4. Circuit diagram of a suitable mains power pack for the tape recorder*

A pair of small 15 ohm elliptical loudspeakers are fitted inside the cabinet, one to either side panel. Since these units are connected in parallel, the correct load impedance of 8 ohms is offered to the amplifier.

The cabinet wiring is shown in Fig. 5. The arrangement of the amplifier module on the underside of the tape deck can be clearly seen in this diagram.

The printed wiring board is secured as follows: a small block of softwood 2⅛in × ⅝in × ½in is firmly glued to the tape deck itself to support the right hand side of the amplifier, and the amplifier is then fixed to this block with two ¼in No. 6 wood screws. The left hand end of the board is mounted on two metal posts ⅝in long by ¼in diameter, drilled to take the fixing screws required. Posts were not used to secure the right hand end of the amplifier as through fixing screws would foul the flywheel assembly on the top side of the deck.

Some of the fixing holes will have to be drilled in the tape deck and care must be taken to ensure that none of the drilling waste falls into the mechanism of the motor. A good way of ensuring this is to smear the drill with thick grease prior to drilling.

# COMPONENTS . . .

**Mains Power Pack**

| | |
|---|---|
| R23 | 100Ω 5W wirewound (see text) |
| R24 | 100Ω 5W wirewound (see text) |
| C20 | 2,000μF elect. 25V |
| D4 | Selenium bridge rectifier 18V r.m.s. 1A (Radiospares REC.24) |
| T1 | Filament transformer. Tapped primary; secondary 13V 0·5A (Radiospares "Standard" type) |
| S2 | Double pole on/off toggle switch |

The method of mounting the power supply components should be clear from Fig. 5. Care must be taken to ensure that the plastic clip retaining the smoothing capacitor does not foul the moving part of the spool carrier assembly.

## MODIFIED SWITCH

Normally only one Yaxley type switch wafer is supplied with the tape deck. For the particular system described here, an extra switch wafer will have to be acquired to meet the additional number of switching operations. (This can be obtained from the deck manufacturers.)

The two wafers should be spaced ¾in apart on the switch and care taken to ensure that the spacing pillars are not so big in diameter as to short out the metal switch contacts. Inspection of the stand-off pillars on the deck as supplied will show that they are tapered.

The switch wafers tend to be brittle, and they should be eased gently on to the shaft. Note particularly that should it ever be necessary to remove these wafers, extreme caution must be exercised as the centre of the wafer is liable to stick to the shaft and detach itself from the body, thus ruining the whole wafer.

## GROUPING OF LEADS

To prevent hum pick-up and instability in the amplifier, certain leads should be grouped together in a common sleeving as follows:

(a) Pins 1 and 2 to S1A.
(b) Pins 3 and 4 to S1B and S1C.
(c) Pin 5 to tone control VR4 (via R22 and S1C).
(d) Pins 6, 7 and 8 to volume control VR5.
(e) Pins 9 and 10 to S1D.
(f) Pin 11 to S1E.
(g) Pins 19, 20, 21, 22 to erase head X2 (cable "A").
(h) Pins 23 and 24 to S1F.
(i) Pins 25 and 26 to the power supply unit.
(j) The mains leads from the motor should be connected directly to the mains transformer input terminals.

*continued on page 851*

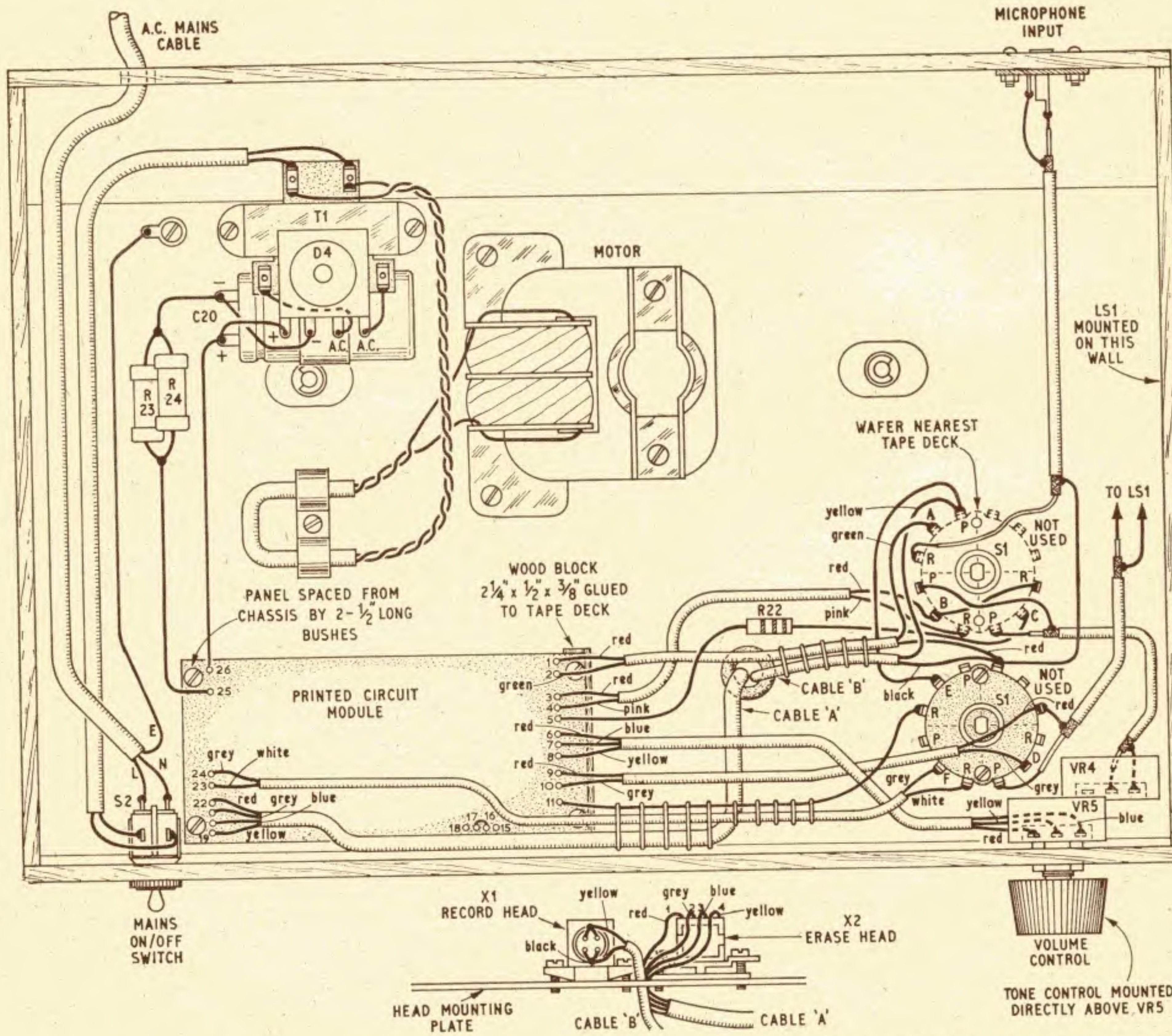
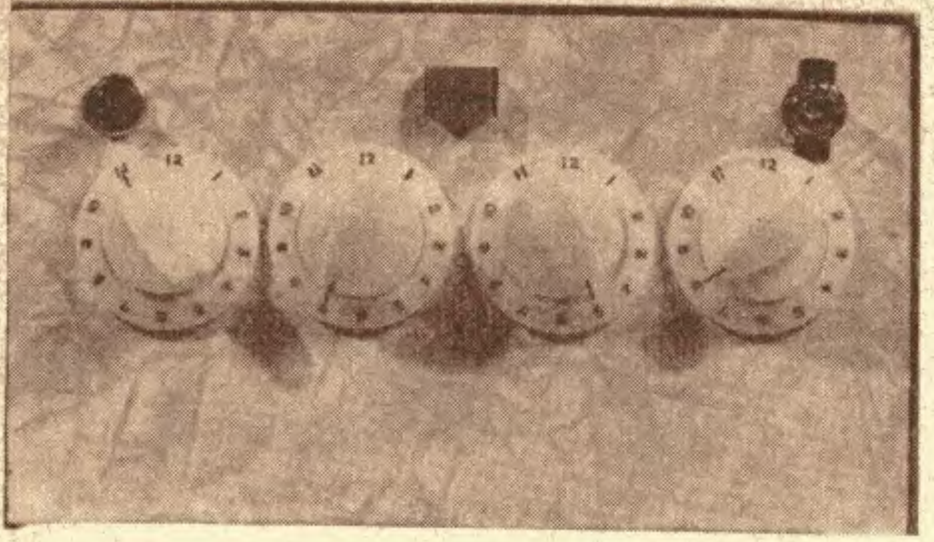



*Fig. 5. The complete wiring details of the tape recorder. The arrangement of the amplifier module on the underside of the deck can be seen more clearly than in the photograph on the preceding page*



# ELECTRO-COMBINATION LOCK

## By P. L. TILSON

THE MAIN disadvantages with an ordinary mechanical combination lock are firstly that the lock must be on the safe or strongbox itself, and is thus easily visible, and can be blown off; secondly, an expert can find the combination.

The electrical lock described in this article can be mounted any reasonable distance from the safe, has no tumblers, and so cannot be "stethoscoped". If the wrong combination is selected, even by only one number, an alarm bell rings, and continues to ring until cancelled by the owner of the safe or somebody else knowing the combination. This lock costs far less to make than it would cost to buy a commercial lock of the combination type.

The lock on the safe is, in fact, a solenoid operated bolt. These are readily available in two types; 250 volt a.c. operated, and 12 volt d.c. operated. For the circuit in question, the latter type was chosen. The a.c. type would have meant an additional relay, and therefore a higher cost.

### COMBINATION

The correct combination for the circuit shown in Fig. 1 is **11, 7, 5, 8**. When S1–4 are set to these positions and S5 pressed, current flows from the power supply through these set switches, through the bolt solenoid, the normally closed contacts of S6, and back to the power supply unit. Other combinations can be arranged by wiring the wafer switches in a different sequence, or renumbering the switch positions.

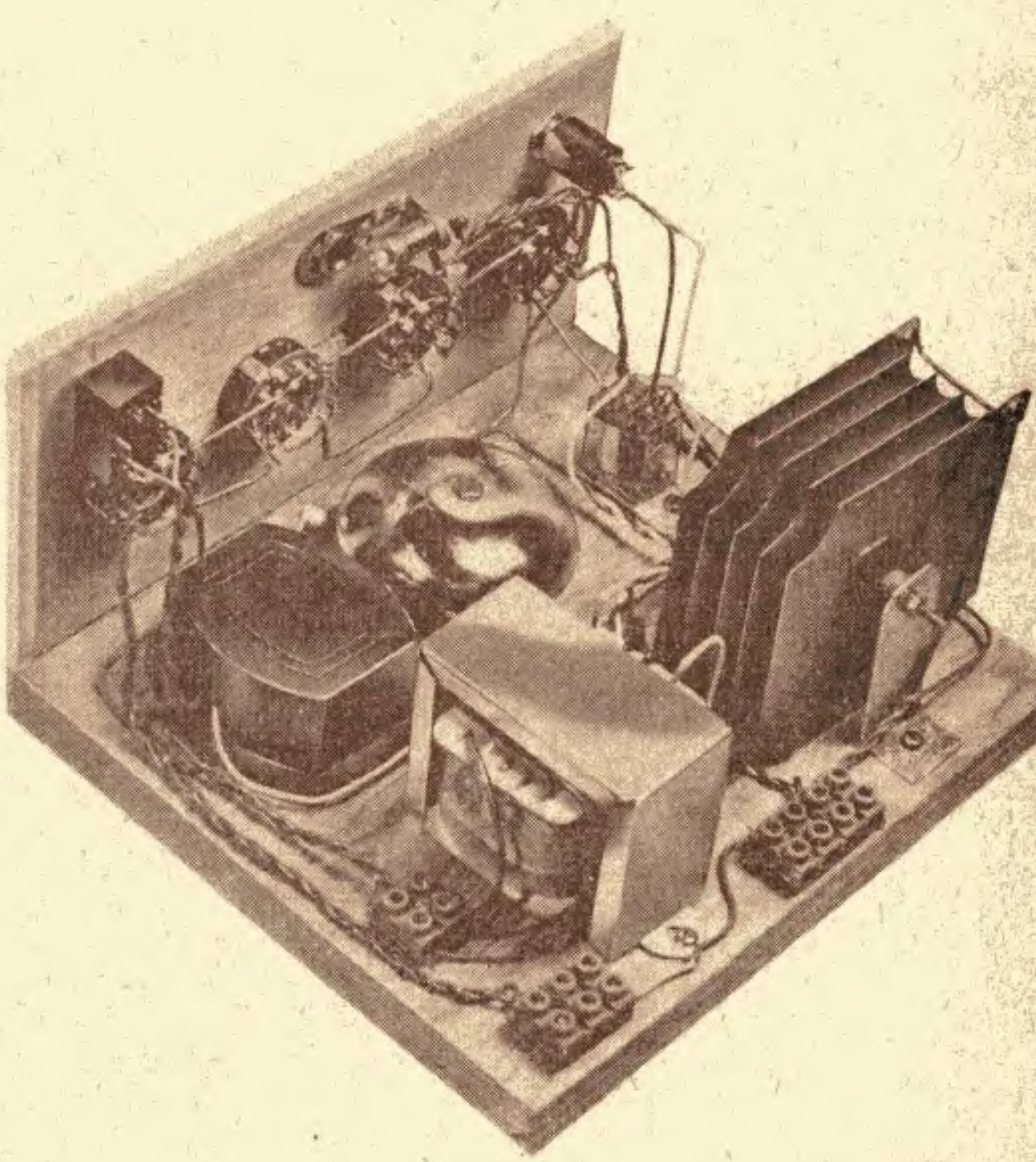
If the wrong combination is set the current flows through the wafer switches, but on finding the one which is incorrectly set, it follows a path through the relay coil, and returns to the power supply unit through S5 (closed) and S6. The relay is operated; contacts RLA1 and RLA2 close. Contacts RLA1 holds the relay on even if S5 is switched off. Contacts RLA2 supply current to the alarm bell, which will continue to ring until S6 is opened and disconnects the supply to the relay coil. To reset the circuit in readiness for a subsequent alarm, S6 should be closed again.

Any number of switches may be connected up as in Fig. 1, with a corresponding increase or decrease in the number of possible combinations. A simple formula can be used to calculate the number of combinations:

$$c = x^n - 1$$

where $c$ is the number of possible combinations, $x$ is the number of positions on the switches, and $n$ the number of switches. Thus with the circuit shown in Fig. 1, 20,735 different combinations are possible! With one more switch, the number is increased to 248,831! It should be noted that all the switch contacts *except* those of the actual combination, should be connected together and taken to one end of the relay coil. If this is not done, the alarm system cannot operate.

There is no reason why the unit should not be built for 6 volt operation if this is more convenient. In this case, a relay suitable for 6 volt operation should be used (type MH2 185 ohms). Likewise the transformer, solenoid, rectifier, bell, and pilot lamp should also be 6 volt types.



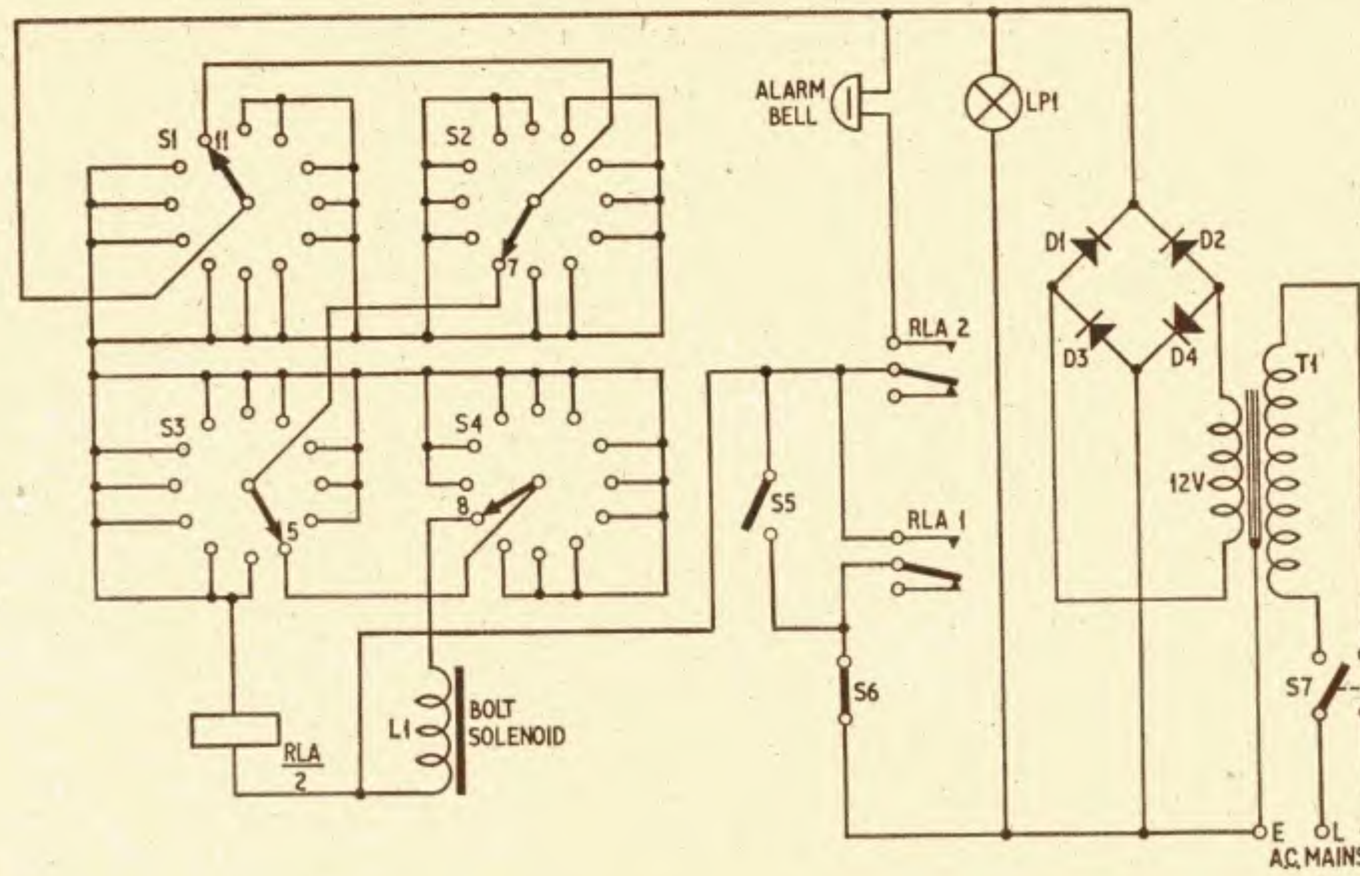



*Fig. 1. Circuit diagram of the combination switching system designed for a 12 volt d.c. power supply. The solenoid L1 and switch S6 are shown here but are installed in the safe remote from the main unit*

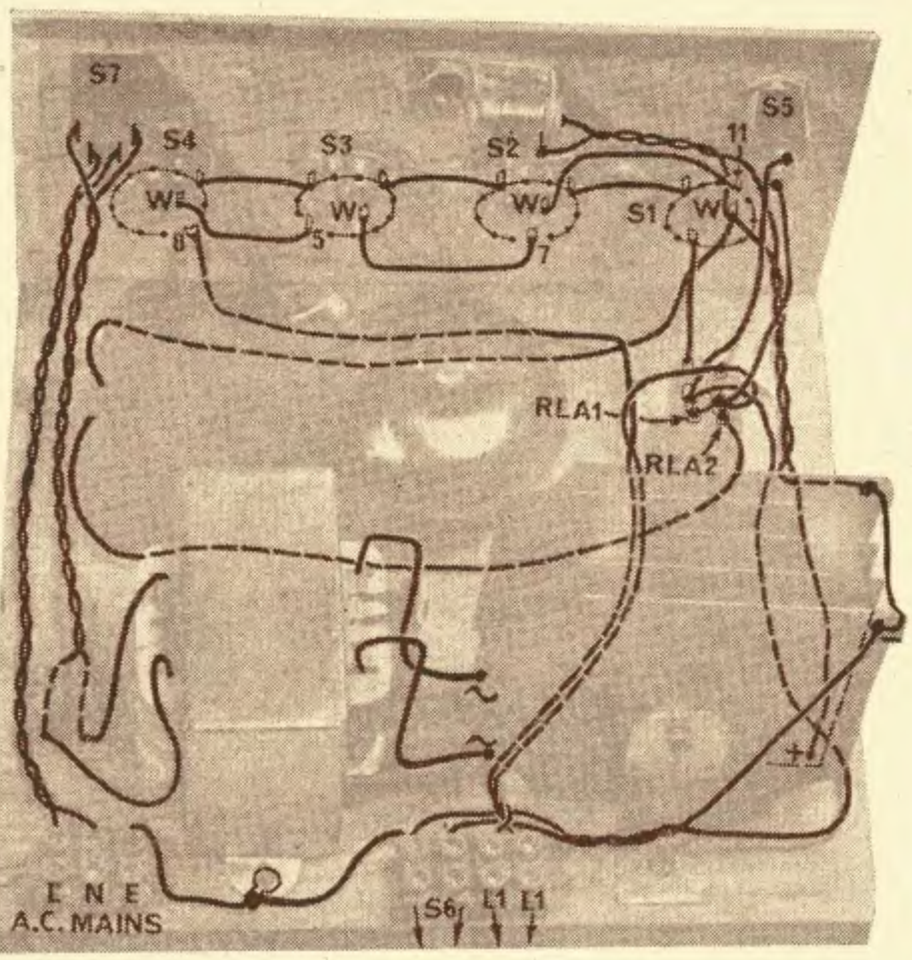



*Fig. 2. This photograph of the main switching and power unit has been treated to show the layout and wiring of components*

# COMPONENTS . . .

**Transformer**
T1 A.C. mains primary, 12V 3A secondary

**Solenoid**
L1 Solenoid operated bolt, 12 volt (Service Trading Co., 47/49 High Street, Kingston on Thames)

**Relay**
RLA 12 volts 700 ohms (Keyswitch Relays Ltd., type MH2)

**Rectifier**
12V 3A metal bridge rectifier

**Switches**

| | |
|---|---|
| S1, S2, S3, S4 | 1-pole 12-way single wafer types |
| S5 | Push on, release off single pole push button |
| S6 | On/off toggle switch |

**Lamp**
LP1 Indicator lamp with 12V bulb

**Miscellaneous**
P.V.C. insulated wire, four core cable, plywood, nuts and bolts

A practical wiring diagram of the control unit and the power supply unit is shown in Fig. 2. The panel indicator lamp may be omitted if desired.

Needless to say, all connections in the unit should be soldered, and a miniature electrical iron is preferable for this operation. Cored solder containing a *non-corrosive* flux (such as Ersin Multicore) should be used for this purpose. Four-core cable is used for connecting the solenoid and S6 to the control unit, as this happened to be handy, but remember, the flex used must be capable of carrying sufficient current to operate the solenoid. Ordinary 5 amp lighting flex is admirably suited to this purpose.

## THE SAFE BOLT

It is not proposed to give constructional details of the safe itself as this depends on the individual requirements of the constructor. The author's safe was a box 1 foot square and let six inches into the wall. The surface of the box was panelled to match the surrounding wood.

The solenoid is fixed to the door of the safe with a single clamp and screwed down firmly. The position of the end of the iron core of the solenoid is marked on the safe wall, and a hole of suitable diameter is drilled to take the core. As may be seen in Fig. 3, the end of the core is chamfered, as is the wall of the safe, to enable the door to be closed without withdrawing the bolt. Fig. 4 illustrates the crude, but effective method of returning the bolt. Any form of coil spring is suitable here, provided that it is not so strong that the solenoid cannot withdraw the bolt. The wires from the coil may be stapled to the door and walls of the safe, and led out of the back.

The only other part which is housed in the safe itself is the alarm bell "cancellation" switch S6. This prevents anybody from cancelling the alarm before attempting to open the safe.

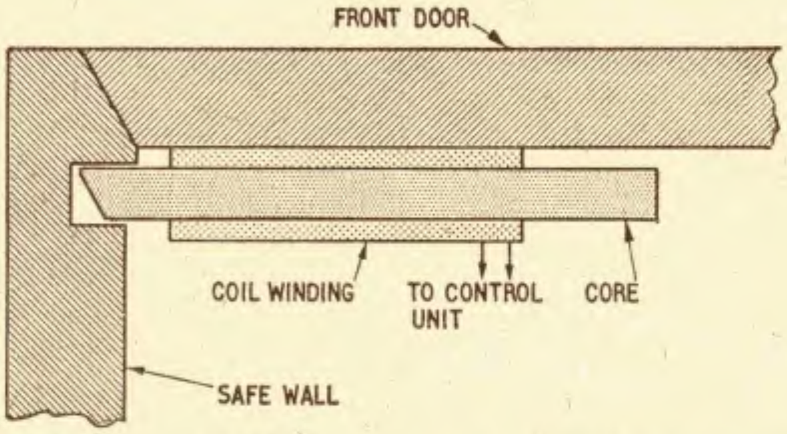



*Fig. 3. Sectional plan view of the solenoid bolt mounted inside the safe on the door. Note the chamfered bolt to facilitate easy closure*

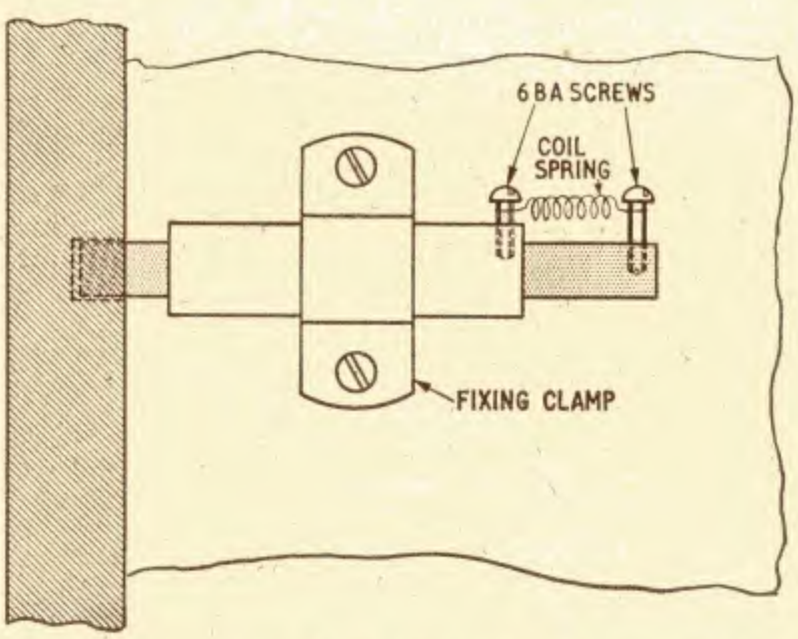



*Fig. 4. Interior view of the solenoid bolt mounted on the door with a clamp. The coil spring allows the bolt to remain in the "locked" position until operated by the combination circuit*

## TESTING

To test the unit, the safe door should at first be left open. Set the combination switches to the correct combination code, and press S5 intermittently. The bolt should move smoothly backwards and forwards. If it does move, but only slightly, try adjusting the tension of the return spring. If the bolt does not appear to move at all, check the wiring to the bolt, and make sure that S6 is closed. If all is well, set the switches to the "wrong" combination and press S5 again. The alarm bell should ring, and continue ringing even when S5 is released. If it stops ringing when S5 is released check the wiring around the RLA1 contacts of the relay, and of the combination switches themselves. ★

# NEW LOOK TAPE RECORDER

*continued from page 846*

## ERASE HEAD MOUNTING

After removing the existing erase head, a Miniflux erase head type LF60 should be firmly glued into position. Prior to fixing, a check should be made to see that the "black section" of the head barely shows above the horizontal length of the tape. If necessary adjustment should be made to lower or higher the head position by packing up or filing down the head mounting plate.

Before switching on it is imperative that all connections are rechecked against the circuit diagram Fig. 1 and the wiring diagram Fig 5, otherwise damage to transistors and components may be occasioned.

A microphone of the moving coil variety will be found to be most suitable for use with this recorder.

## SETTING UP PROCEDURE

After all wiring has been completed the three preset controls must be carefully adjusted in order to obtain optimum performance from the recorder.

Ideally, all the following instruments are required for this setting up operation: a.f. signal generator, multirange test meter, valve voltmeter, and oscilloscope. The latter two instruments may, however, be dispensed with and the multirange meter used instead as will be described below.

A 9V battery should be used to power the module during this setting up operation.

## AMPLIFIER

1. Connect a voltmeter between pin 1 (+ line) on the circuit board and the negative side of C11. Set VR1 for a reading of 4·5V.

2. If really low distortion is required, a final dynamic adjustment should be made as follows. Inject a 1kc/s sine wave signal into the input of the amplifier (pin 2) and examine the output across pins 9 and 10 with an oscilloscope. Raise the input level until the trace shows signs of clipping and finally adjust VR1 for even clipping on both sides.
   *If no oscilloscope is available*, vary the amplitude of the applied input signal and observe the reading on the voltmeter. If this varies more than a few tenths of a volt from 4·5V, make careful adjustments to VR1 until these voltage changes are reduced to a minimum.

3. Inspect the waveform at pin 10 while applying 1kc/s sine wave signal to pin 2. Reduce VR2 until slight crossover distortion begins to show across axis of the display.
   *Alternatively*, unsolder TR8 emitter lead from the positive line. Connect a d.c. milliammeter to TR8 emitter (−) and to pin 1 (+). Adjust VR2 for a reading of 1·8mA.

## OSCILLATOR

1. Set VR3 for maximum resistance in circuit.

2. Connect a valve voltmeter between pins 19 and 26. Slowly adjust VR3 for a reading of 50–60V peak to peak.
   *Alternatively*, connect a d.c. milliammeter between pin 23 (+) and the negative terminal of the battery. Slowly reduce the value of VR3 until the total current is 30mA. ★

# the 73 page by Jack Hum G5UM

## Speech or Morse?

On this page last time we had something to say on the subject of transmitting contests. What we did *not* refer to was the means of communication commonly used in such contests—and this omission was deliberate. For around the two basic modes of communication employed within the amateur bands a more or less permanent controversy persists.

These basic modes are *telegraphy* and *telephony*. Which one to use will be determined almost automatically in the light of the type of communication the amateur operator wishes to establish.

For example, the chance of making contact with a fellow-amateur in Australia on one of the long distance bands such as 14 or 21 Mc/s, with a high prevalence of interference and fading, is much greater on the key than through the microphone. Shout yourself hoarse and he won't understand you. Take to morse and he will.

Conversely, a chat with a man in the next street or suburb or county is more naturally done by telephony than morse.

In other words, the circumstances govern the mode.

## A Chore

Unfortunately, this basically commonsensical attitude is not shared by all members of the amateur fraternity—for let the fact be faced: learning morse *is* a chore, and one that comes to be resented by hundreds of amateur radio aspirants only too well aware that they cannot get that coveted transmitting licence without it.

The Post Office requirement is that both the Radio Amateur Examination and the 12 words-a-minute morse test are pre-requisites to the issue of a transmitting permit (except in the case of the tiny minority of technicians, who are prepared to confine themselves to frequencies of 430 Mc/s and upwards, in exchange for a G8-plus-three licence—and no morse).

There is little comfort to a (probably young) enthusiast who is keen to get a licence to learn that, in effect, "morse is going to be awfully good for you". Yet this happens to be almost exactly the truth, "To mug up the necessary morse to pass the test and then with a sigh forget it all", as someone once said to the writer, is deliberately to shut oneself off from a considerable area of amateur activity.

It is easy enough to imagine, because one's initial interest in " the 73 men " comes from overhearing them talking on the air, that all conversation is telephonic.

A knowledge of morse soon disposes of this assumption—for at the low frequency end of any of the h.f. communication bands an immense amount of communication " on the key " may be heard at almost any time of the day or night.

The fully rounded amateur transmitter who is asked: " Is there a morse key in the house?" will invariably reply " Yes!"

## How to Learn

Let us return, nevertheless, to the realisation that learning morse is a chore, and one to be mastered. How best to go about it?

Whatever books or gramophone discs may be purchased as aids to learning morse, there is no escaping the hard fact that the twenty-six characters of the alphabet and the ten numerals from zero to nine must be committed to heart, and thereafter recognised as *sounds*. Soon the sounds coalesce as words and within a few months the learner should be copying the simpler repetitive phrases that occur in most amateur transmissions.

He may not believe it when " the chore " is first visited upon him, yet constant practice at morse can bring him to the glorious state of being able to sit back and take copy at " 25 per " without writing a word. It is then that the telegraphy enthusiast may well make his point that morse can impart just as much information as speech—and just as quickly.

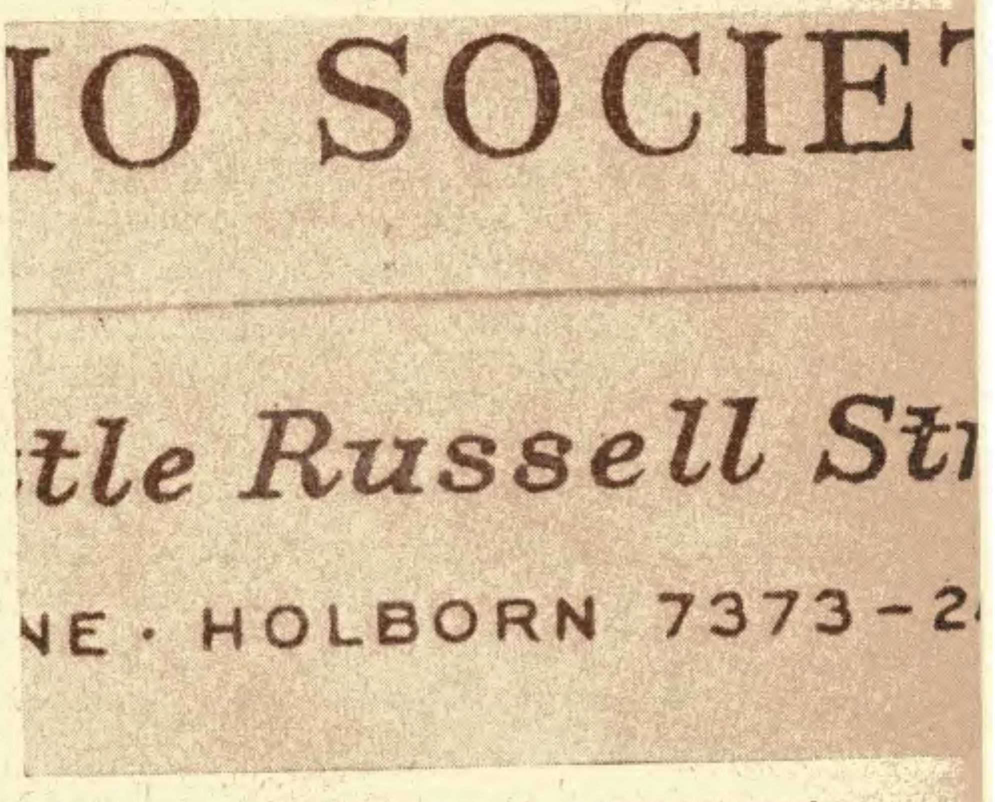
## Skill Counts

All of which brings us back to where we came in—*contests*. To do well in a radio transmitting contest (or *receiving* contest, for that matter) calls for the exercise of skill developed and matured over the years, and culminating in an ability to identify stations so submerged in a mess of interference that ordinary mortals hardly know they are there.

" He has crystal filter ears!" This is the kind of admiring description one sometimes hears bestowed.

Sending and receiving the morse code is itself a skill, part of the larger skill of knowing how to operate a radio station, and particularly of how to make it give good returns during a contest.

It is a melancholy thought that a large proportion of the bright, shiny, well-equipped receiving stations one sees illustrated in the radio magazines of the world are employed to only about one-third of their capacity, simply because their owners know no morse. The implication is plain.




***Newcomers to this feature may have asked themselves why it is called " The 73 Page". The digits " 73" have been the abbreviation for " best wishes " since the earliest days of electric telegraphy. Used to sign off almost every transmission in the amateur bands, they are much sought after for car index plates and house numbers. The Radio Society of Great Britain uses them in its telephone number, as shown in this enlargement of its letter-heading***

# ELECTRONIC BUILDING BLOCKS

## PART SEVEN

**by R. A. DARLEY**

FOLLOWING on last month's article on impedance matching devices, we will take a closer look at the Darlington pair and "bootstrap" high impedance amplifier, with special reference to their practical uses. Then we will discuss the theory of some well-known oscillator circuits.

### APPLICATIONS OF THE DARLINGTON PAIR

As well as being used in a.f. amplifier circuits, the Darlington pair has a number of other applications. Two such uses are illustrated in Figs. 7.1a and 7.1b.

As was discussed in part 2 of this series (see May issue), when a resistor and capacitor are wired in series and connected across a voltage supply, the potential at the junction of the two components varies in an exponential manner; a time constant is introduced, in which $T = CR$, where $T =$ time in seconds, $C =$ capacitance in farads, and $R =$ resistance in ohms.

By connecting this exponential voltage to the base of a transistor and connecting a relay in series with the emitter or collector, this exponential variation may be used to impart a time delay to the operation of the relay.

If a conventional transistor circuit is used in this application, it is found that the comparatively low input impedance of the transistor stage shunts one or other of the time-constant components and thus reduces the effective value of the component concerned.

By using a Darlington pair circuit as the transistor stage with a high input impedance, this difficulty is largely overcome.

In the circuit shown in Fig. 7.1a, at the moment that S1 is closed and the supply is connected to the circuit, only a very low emitter current is flowing and the relay is not operated; as time passes, the emitter current rises and, after a fixed time delay, the relay operates.

In the circuit of Fig. 7.1b the reverse action takes place; at the moment of switch on, maximum emitter current flows and the relay is operated. As time passes, the emitter current falls in value and, eventually, the relay drops out.

It is important to note that, in both of these circuits, the time delay imparted to the relay depends not only on the values of the time constant components, but also on the characteristics of the relay, the transistor, and the supply potential.

In Fig. 7.1b a switch (S1b) is shown connected in parallel with C and ganged to S1a. Once the circuit has been operated, a voltage is built up across this capacitor. If S1b is not in circuit when the supply voltage is cut off there is no effective discharge path for the capacitor. If the supply voltage is again reconnected it is found that, because the capacitor has retained its charge, the time constant effect is destroyed. The fitting of S1b overcomes this trouble by discharging the capacitor when the supply voltage is cut off.

In the case of the circuit of Fig. 7.1a, the capacitor discharges automatically through the low impedance forward biased emitter-base junctions of the transistors and no additional components are required.

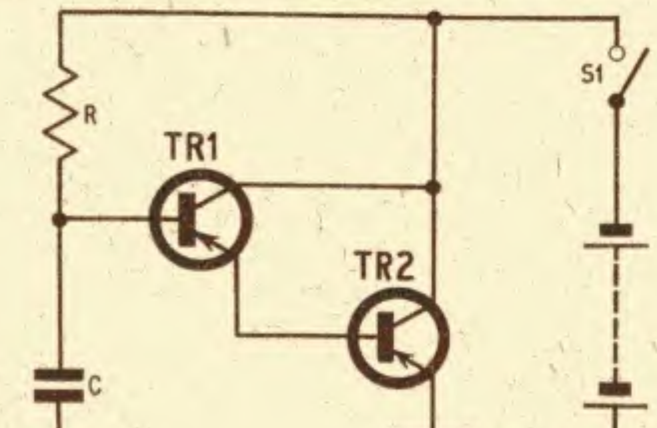



*Fig. 7.1a. Darlington pair used to operate a relay*

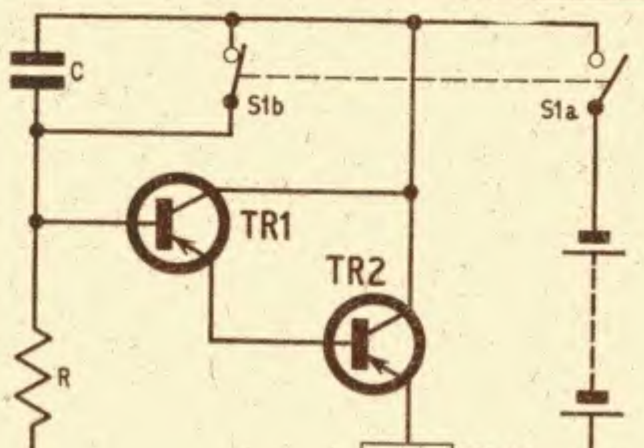



*Fig. 7.1b. Darlington pair used to operate a relay, then release it after a time delay*

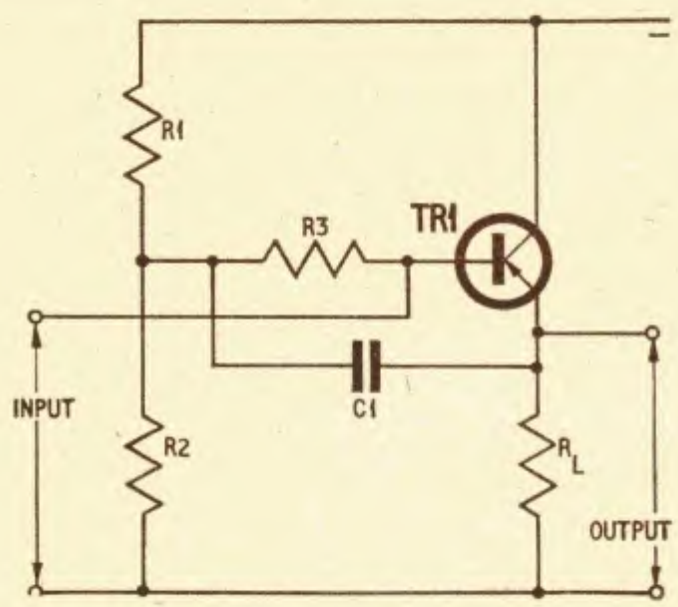



*Fig. 7.2a. Basic circuit of a "bootstrap" high impedance amplifier using an emitter follower*

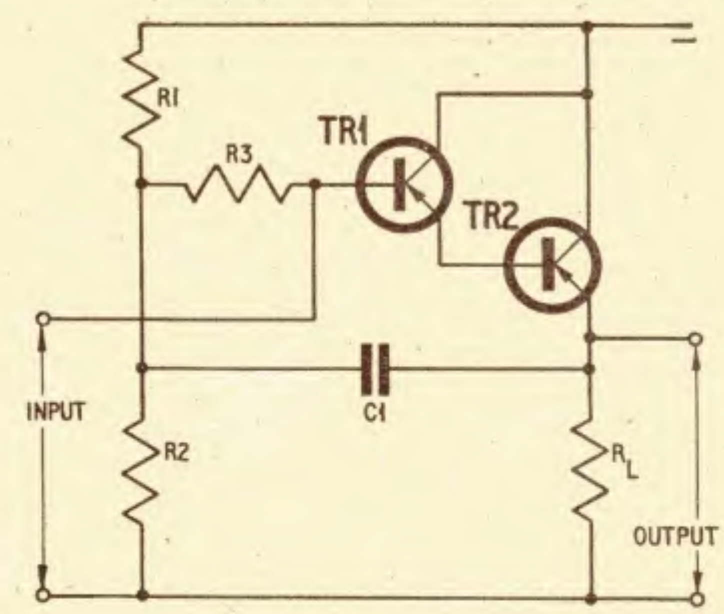



*Fig. 7.2b. "Bootstrap" circuit using a Darlington pair*

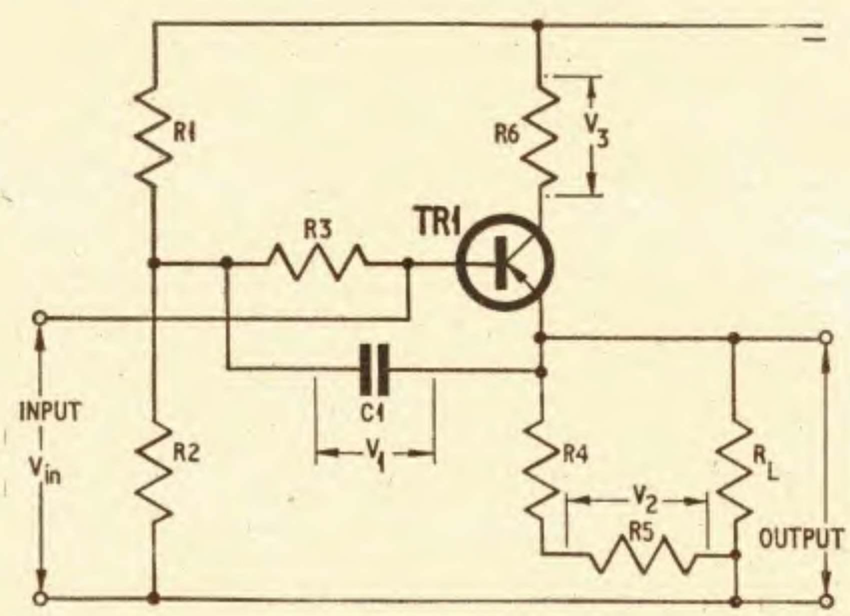



*Fig. 7.3 (right). Basic "bootstrap" circuit*

*Input impedance $Z_{in} > 1{,}000\ M\Omega$.*
*$V_{in} = V_1 = V_2 = V_3$*

## THE "BOOTSTRAP" HIGH IMPEDANCE AMPLIFIER

One of the snags with the Darlington pair emitter follower circuits is that the base bias resistors are effectively in parallel with the input to the transistor circuits.

It was also pointed out earlier in this series that, for good stability, the base bias should be provided via a voltage divider network, in which the current flowing through the lower resistor should be at least 10 times greater than that flowing in the transistor base. Quite clearly, the effect of such a base bias network on an emitter follower or Darlington pair circuit is to reduce the circuit's input impedance by a factor of at least 10.

As an alternative to the divider chain method of obtaining base bias, a high value resistor, of such a value as to limit the base current to the required value, can be connected between the base and negative supply line, as shown in Fig. 6.7 last month. This method has the advantage of considerably reducing the shunting effect on the input circuit, but has the disadvantage of giving poor circuit stability.

The circuit known as the "bootstrap" high impedance amplifier overcomes these disadvantages. Fig. 7.2a illustrates the circuit.

TR1 is connected as an emitter follower, with an emitter load $R_L$. Resistors R1 and R2 form a conventional voltage divider base bias network, but an additional resistor (R3) is connected between the junction of R1–R2 and the transistor base; this is an a.c. isolating resistor. For d.c. purposes, R3 has little effect on the biasing arrangements. A feedback capacitor (C1) is connected between the junctions of R1–R2–R3 and the emitter.

When an input signal is fed to the base of the transistor, an output signal will appear at the emitter, in phase with the input and of almost the same amplitude. If the impedance of C1 is low at the frequency of operation, the signal from the emitter will be fed back to the junction of the voltage divider chain. The a.c. voltages at both ends of R3 are therefore almost equal. If the voltage gain of the emitter follower circuit is exactly 1, the voltages (a.c.) at each end of R3 will be exactly equal. Therefore, no a.c. current is flowing through this resistor; the resistor presents an infinitely high impedance to a.c. It also follows that R1 and R2 can thus have no shunting effect on the input impedance of the circuit.

In practice, of course, the voltage gain is not quite equal to 1, so complete isolation of the base bias components from the input impedance does not take place; sufficient isolation is provided, however, for their effect to be almost ignored. With this circuit, the input impedance is the same as in the emitter follower, ($Z_{in} \simeq \beta\ R_L$) and is in parallel with the leakage resistance.

Using this circuit, quite high input impedances can be obtained with good stability. If a Darlington pair circuit is substituted for the emitter follower, as shown in Fig. 7.2b, impedances in the order of 4 megohms can be obtained using germanium transistors, and as high as 20 megohms using silicon transistors.

## ULTRA-HIGH IMPEDANCE AMPLIFIERS

In the circuit just described, the "bootstrap" principal was applied over one resistor only. Circuits are available in which the principal is employed over more than one part of a circuit, however, and as a matter of interest one such circuit will be roughly described.

When discussing the emitter follower circuit, it was mentioned that the input impedance of the circuit could be raised either by increasing the value of $R_L$ or the effective value of $\beta$, but if $R_L$ were raised to too high a value difficulties were encountered in meeting the mean emitter current requirements. By using the "bootstrap" principal these difficulties can be overcome.

Fig. 7.3 shows a simplified diagram of a circuit which meets this problem. TR1 is connected as an emitter follower, with emitter load $R_L$. Base bias is provided by the voltage divider network R1–R2 and isolating resistor R3. The input signal is applied to the base of TR1, and the output of the emitter is fed back to the junction of the potential divider via capacitor C1; resistor R3 is thus "bootstrapped" and, if the voltage ($V_1$) fed back is of the same phase and amplitude as $V_{in}$, it presents an infinite impedance to the input signal.

The d.c. emitter current of the transistor flows through resistors R4 and R5 in series; if a signal of the same phase and amplitude ($V_2$) is applied to the junction of R4–R5, no a.c. current will flow through R4. R4 is thus "bootstrapped" and presents an infinite impedance to a.c.; to d.c., R4 is the nominal d.c. value and no problems are presented in obtaining d.c. values of emitter current. The only path available for a.c. emitter current is through $R_L$, which is thus the effective emitter load, and may be any value that is required.

By connecting resistor R6 in series with the collector of the transistor and applying a suitable "bootstrap" voltage ($V_3$) across it, no a.c. voltage drop occurs between the emitter and collector of the transistor. It follows that the transistor leakage resistance is also effectively "bootstrapped" and presents an infinite impedance to a.c.

The input impedance of such a circuit is given as $Z_{in} = \beta \times R_L$. Load resistor $R_L$ can be made any value that is required without imposing any limits on the mean emitter current and causing distortion of the output.

The output impedance of the circuit is given as

$$Z_{out} = r_s/\beta$$

As this circuit is intended for use with inputs having very high values of source resistance the output impedance ($Z_{out}$) of the circuit will also be very high. It is necessary, if the circuit is eventually to feed a common emitter type of amplifier, to feed it at an impedance $Z_{out}$ into another "bootstrap" amplifier, and thence reduce the output impedance to the required value in a number of successive stages.

With such an arrangement it is possible, using silicon transistors, to obtain input impedances in excess of 1,000 megohms and output impedances of less than 100 ohms.

## OSCILLATOR CIRCUITS

Most oscillator circuits can be fitted into one or other of three categories, depending on the type of waveform developed. These categories are (a) sine wave generators, (b) pulse generators, and (c) saw-tooth generators. Each of these three categories can be broken down into a number of sub-divisions, depending on the mode and frequency of operation, and each of these sub-divisions can be further broken down into particular circuits. In the limited space that is available for this series it is not possible to describe all of the circuits.

## GENERAL PRINCIPLES OF OSCILLATOR OPERATION

Referring to Fig. 7.4, it can be seen that transistor TR1 is connected as a common emitter amplifier with the primary winding of transformer T1 connected as its collector load. The secondary of T1 is connected in series with the transistor base, but in such a way that any signal fed to the base via the transformer is 180 degrees out of phase with the signal at the collector.

When a transistor is connected in the common emitter mode, the signal appearing at the collector is 180 degrees out of phase with that at the base. In the circuit of Fig. 7.4, however, an additional 180 degree phase shift has been imparted to the signal by the transformer, so that the signal appearing at the secondary of T1 is in phase with the base.

If it is assumed that the gain of the circuit between the transistor base and the transformer secondary is greater than 1, the action of the circuit will be as follows.

When S1 is closed and power is supplied to the circuit, a base current will flow via the base bias network R1 and R2, which will cause a collector current to flow also. Although no signal is directly connected to the base, a small a.c. signal will appear at the collector, due to random electron movement (noise) in the transistor; this signal will be transmitted back to the base via T1. This base signal is then amplified by the transistor and appears at a much greater amplitude at the collector, where it is again fed back to the base and amplified even more. This action is almost instantaneous and is cumulative, the signal eventually becoming so large that the transistor is driven into saturation and can no longer amplify further.

The transformer is an a.c. device, and will only transmit changes in potential; thus, as the transistor runs into saturation and amplification ceases, signals also cease to appear at the transformer secondary and, therefore, at the base of TR1. With no base signal applied, the transistor drops out of saturation and reverts to its original condition, whence the complete cycle of events again repeats itself.

Such a circuit acts as a self-energising switch, rapidly switching itself on and off, the output waveform being a series of pulses. The frequency of operation and rise and decay times of such a circuit are determined by the characteristics of the components used, i.e. by the transit time and junction capacitance of the transistor, inductance and stray capacitance of the transformer windings, and so on. A simple circuit of this type can, for practical purposes, be considered as "uncontrolled", in that no special circuitry is employed to control the frequency of operation or the waveform.

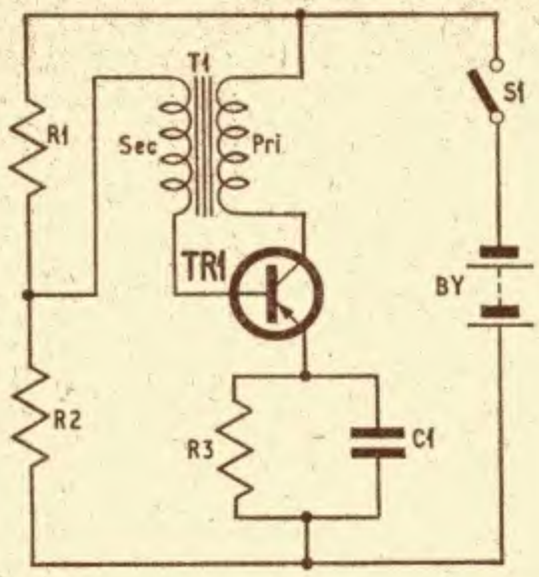



Fig. 7.4. Uncontrolled self-energising pulse oscillator

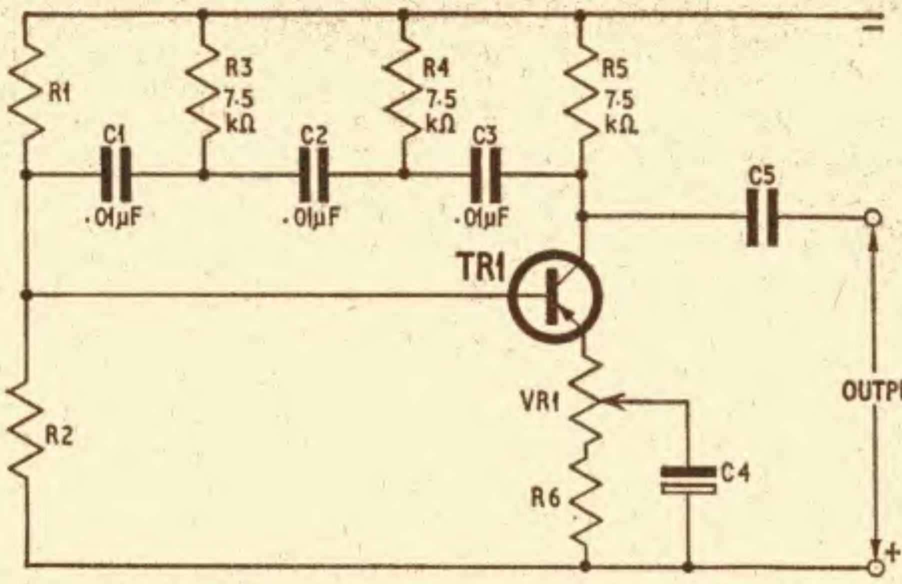



Fig. 7.5. Phase shift oscillator tuned to 1,000c/s

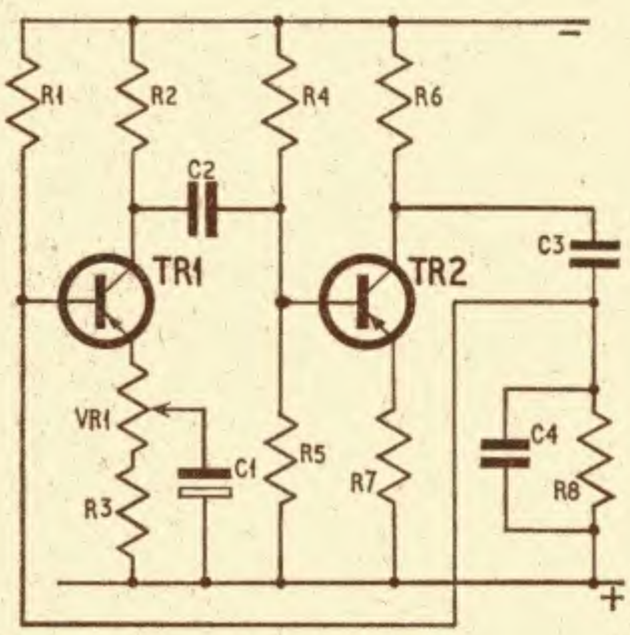



Fig. 7.6a. Simple Wien bridge audio oscillator

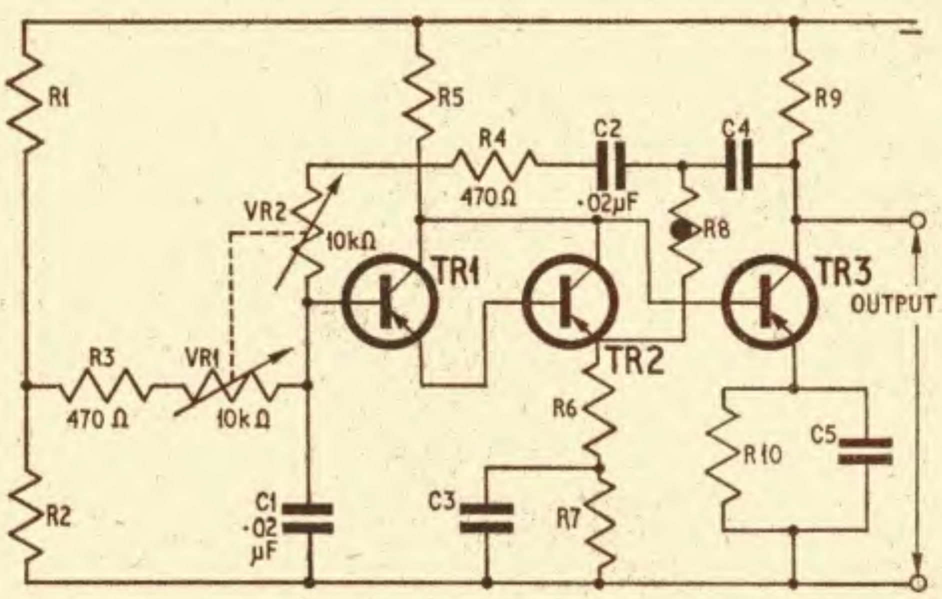



Fig. 7.6b. More advanced type of Wien bridge oscillator; frequency is variable between 1,000 and 10,000c/s

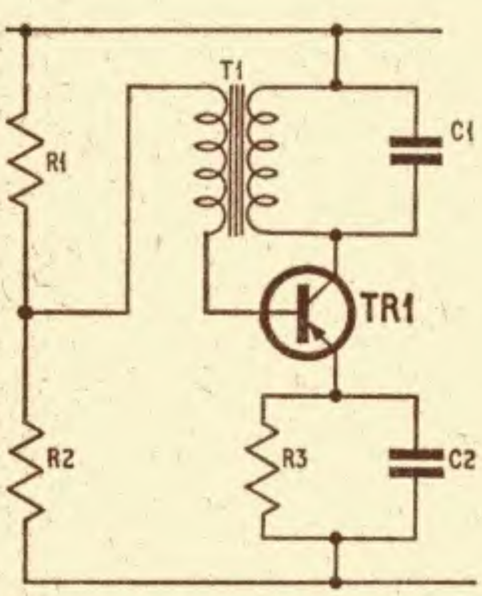



Fig. 7.7. Simple r.f. oscillator with a tuned collector circuit and inductive feedback to the base

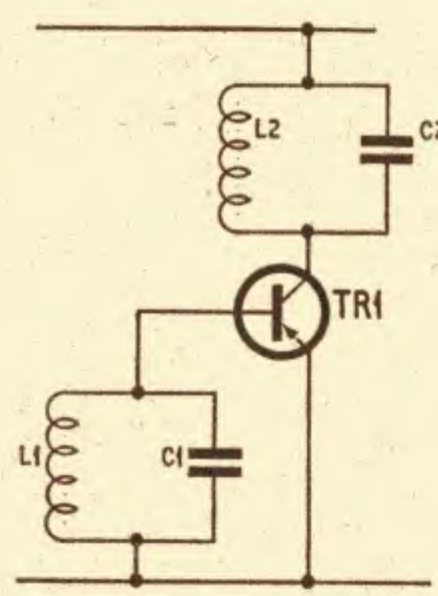



Fig. 7.8a. Basic tuned collector, tuned base oscillator

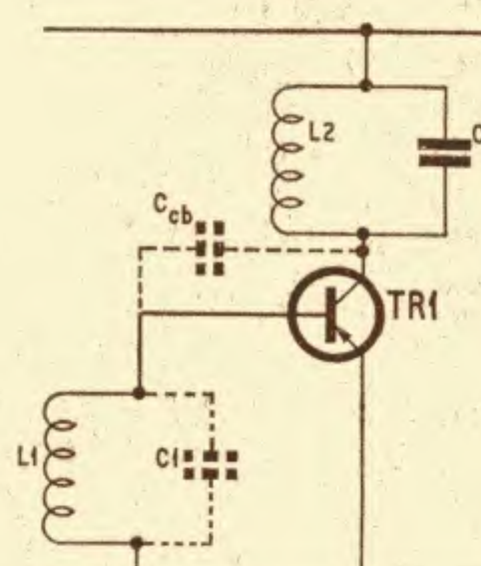



Fig. 7.8b. Extension of the circuit shown in Fig. 7.8a using the Miller effect capacitance for tuning L1

## SINE WAVE OSCILLATORS

If a tuned circuit or filter network is incorporated in either the feedback network or the transistor loading circuits, the rise and decay times and the frequency and waveform, will be controlled, a sine waveform being obtained.

Generally speaking, low frequency oscillators can be recognised by the use of RC networks, while r.f. oscillators can be recognised by the preferred use of LC networks. Inductances are avoided in low frequency work because they tend to be rather large. Crystal oscillators are generally operated at high frequencies.

## PHASE SHIFT OSCILLATOR

Fig. 7.5 illustrates the circuit known as the "phase shift oscillator". Transistor TR1 is connected in a conventional common emitter mode with resistors R1 and R2 providing the base bias network. R6 and VR1 make up the emitter load with C4 as the decoupling capacitor. VR1 enables the circuit gain to be adjusted by means of negative feedback due to the undecoupled part of the R6–VR1 chain.

The CR networks, C1–R3, C2–R4, and C3–R5, act as phase shifting devices or filters in the feedback loop between the collector and base, a 180 degree phase shift being obtained.

If an a.c. signal is passed through a pure capacitance, a phase shift of 90 degrees is imparted to the signal; if a resistance is connected in series or in parallel with the capacitance, the resulting phase shift will be less than 90 degrees, the precise amount of phase shift depending on the values of $C$ and $R$ and the frequency.

If three such phase shift networks are connected in cascade, a total phase shift of 180 degrees can be obtained if the component values and frequency of operation are suitably chosen. Note that, with any given set of $CR$ values, the overall phase shift will be exactly 180 degrees at only one frequency; thus, the network not only gives the 180 degrees phase shift required for operation, but it also controls the frequency and the waveform.

It is common practice to make all the resistors and all the capacitors of such a network of equal value. In such a case the frequency at which the phase shift is 180 degrees is given by the formula:

$$f = \frac{1}{2\pi CR\sqrt{6}} = \frac{1}{15{\cdot}4 \times CR}$$

The attenuation factor of the circuit at the frequency at which the phase shift is 180 degrees is 29; thus, in an idealised circuit, a transistor gain of only 29 is required and the circuit will oscillate at a frequency given by the formula above. In practice, it is not quite as simple as this and the following points should be taken into account:

(a) The range of values that can be selected for the phase shift resistors is limited; the selected values are a compromise between a value which would appreciably load the transistor input circuit (which has a low impedance) and a value that would be appreciably loaded by the transistor output circuit (high impedance). Values in the order of 2·7 kilohms to 27 kilohms are generally recommended.

(b) The frequency of operation of the circuit is modified from that given in the formula by the input and output impedances of the circuit and by additional phase shifts in the circuit. The frequency of operation is usually higher than that calculated. Remember that to increase the frequency of operation the $CR$ values of the phase shift network are decreased. In the circuit shown, where 7·5 kilohm resistors are used, the calculated frequency of operation is about 850 c/s, but in practice the circuit will oscillate at about 1,000 c/s.

(c) Although the theoretical attenuation of the phase shift network is only 29 at the frequency of operation, it will be found in practice that additional losses occur due to the transistors input and output impedances; generally speaking, the transistor gain is required to be at least 60 in order to overcome these losses. This gain can be obtained either by using a single high gain transistor or by using two low gain transistors connected as a super alpha pair in place of TR1.

Practical circuits of this kind have three main disadvantages: (a) the frequency of operation is subject to considerable change (up to 10 per cent) with variation of the gain control (VR1), which should be set to give minimum distortion of the signal; (b) the circuit is not generally suitable for use as a variable frequency oscillator, as a three-gang tuning control is required; (c) output amplitude and frequency are both subject to change with different loads attached to the output circuit, and a buffer stage is thus generally required between the oscillator and any load.

## WIEN BRIDGE OSCILLATOR

A rather different approach to the filter network is employed in the circuit of Fig. 7.6a, which is a basic version of the circuit known as the Wien bridge oscillator. In this case the filter network comprises four components R6 and C3, and R8 and C4. This circuit is very similar to one side of the Wien Bridge described in the July issue.

If a signal is applied across the complete network, it will be found that a definite phase shift occurs across the lower arm at all frequencies except one; at this frequency the phase shift is zero and the actual frequency at which this condition occurs is given by:

$$f = \frac{1}{2\pi\sqrt{(R_6 C_3 R_8 C_4)}}$$

It is common practice to make $R = R_6 = R_8$, and $C = C_3 = C_4$, in which case the above formula simplifies to:

$$f = \frac{1}{2\pi CR}$$

At the frequency of zero phase shift, the attenuation of the network is 3.

Returning to the circuit of Fig. 7.6a, transistors TR1 and TR2 are each connected as common emitter amplifiers. There is a phase shift of 180 degrees between the base and collector of each transistor, giving a total phase shift between TR1 base and TR2 collector of 360 degrees. The output of TR2 collector is effectively applied across the Wien network, and the signal at the junctions of the upper and lower arms is fed back to TR1 base. There is a total phase shift of 360 degrees at one frequency only, and, providing that the gain is correct, the circuit will oscillate at this frequency.

To give a sine wave output which is pure, the transistors are required to provide a gain of 3, to compensate for losses in the Wien network. If the transistor circuits were simply designed to give this degree of gain, they would exercise some degree of control over the frequency (through phase shift effects) and waveform (through non-linearity of frequency response). These snags are overcome by designing each transistor circuit to give a very high gain, which is then reduced to the required low value by the application of heavy negative feedback, i.e. the emitter resistors are left totally or partially un-decoupled.

The simple circuit shown in Fig. 7.6a may be used in a number of applications, but for general use it has three drawbacks:

(i) the input impedance of TR1 shunts the lower half of the Wien network, thereby limiting its value;

(ii) resistor R8 also acts as the lower half of the TR1 base bias network, and the circuit is thus not suitable for use as a variable frequency oscillator;

(iii) the gain of the circuit is not fully stabilised against changes of temperature and frequency.

A better circuit is shown in Fig. 7.6b. The single low input impedance transistor is replaced by two transistors, TR1 and TR2, connected as a super alpha pair, and having a high input impedance. A variable resistor VR2 is connected in the upper arm of the Wien network and VR1 in the lower arm as shown. Variations in the setting of VR2 have virtually no effect on the d.c. bias conditions of the circuit, but VR2 does enable the effective values of the Wien arm to be varied. VR1 and VR2 are ganged together. The circuit will oscillate at frequencies between approximately 1,000 and 10,000 cycles per second.

An additional feedback circuit is inserted between the output of TR3 and the emitter of TR2. The thermistor R8 is used as the feedback link; if the output of TR3 increases for any reason, the current taken by R8 will also increase, and in so doing will cause its resistance to fall, which in turn will result in a larger portion of the output of TR3 being applied to the emitter of TR2, thereby reducing the circuit gain. Effective amplitude stabilisation is thus obtained.

The three-section phase shift and the Wien network l.f. oscillators described are some of the most widely used types in general use; many other types or variations do exist. For example, the control network may be a "twin-T" or "parallel-T" type; a phase shift network using 4, 5, or 6 sections in place of the more usual 3 may be used.

### R.F. OSCILLATORS

In the case of RC oscillators it is generally essential that the overall circuit gain be 1, any greater value may give distortion. In the case of r.f. oscillators, however, this requirement is not as important, since the LC tuned circuits that are used give a "flywheel" effect to the circuit waveform.

The requirements of these oscillators are simple: the overall gain must be greater than 1; the output must be fed back to the input in phase; and the circuit must be frequency selective.

Figs. 7.7 and 7.8 illustrate two of the many circuits that may be used as r.f. oscillators, very little explanation being required in most cases. Fig. 7.7 shows a circuit with a transformer used between collector and base to give 180 degree phase change, the transformer primary being tuned by C1 to make the circuit frequency selective.

In some cases, there is a tuned circuit in the collector and another tuned circuit connected to the base, but with separate coils used instead of a transformer. In such cases, the circuit relies on the Miller feedback effect to cause oscillation. Between the base and collector junctions of a transistor there is some small capacitance; this capacitance provides a feedback path between collector and base.

Thus, a transistor circuit with a tuned collector and a tuned base, as shown in Fig. 7.8a, can be re-drawn as in Fig. 7.8b, where $C_{cb}$ is the effective Miller capacitance. In this circuit, C1 and L1 do not form a major tuned circuit; hence C1 is shown dotted. It is $C_{cb}$ and L1 which form the tuned circuit, of the series type.

Across a series LC circuit there is a phase shift of 180 degrees in voltage. In this circuit, at the frequency of oscillation, the series circuit is detuned so that the reactance of L1 is smaller than that of $C_{cb}$, so that the voltage across L1 is smaller than, and in opposite phase to, that across the series combination, i.e. the series circuit acts as an inductive reactance. C1 enables this inductive reactance to be tuned to the required frequency. Due to the resistive losses in the LC circuit, the phase shift is slightly less than 180 degrees; the collector tuned circuit (L2 and C2) is therefore slightly detuned to compensate for this. It is interesting to note that, at the frequency of oscillation, neither the apparent collector tuned circuit, the series tuned circuit, nor the apparent base tuned circuit are actually tuned to the frequency of oscillation.

**Next month: Basic circuits for cathode ray oscilloscopes**

# REV COUNTER AND DWELL METER

## BY 'DREW'

ONE OF this month's blueprints is devoted to constructing a car engine revolution counter and dwell meter. This unit is an invaluable aid in any garage or, if desired, it can be fitted permanently inside the car. It is very simple to construct and will provide the motorist with an extremely accurate device to help him assess his engine performance.

The size of the box used is ideally suited for garage work as seen in the photographs. If it is intended to fit the unit into the car permanently, the box can be made considerably smaller by rearranging the components in it.

Transistors and diodes are used throughout, the power being taken from a 12 volt car battery, with negligible current consumption.

### PULSE RATE METER

The circuit is a simple transistor monostable pulse generator (see Fig. 1 on the blueprint) which is switched on by the ignition voltage pulses derived from the primary winding of the ignition coil. The average value of the resulting square wave is measured by a moving coil meter, the deflection increasing in direct proportion to the pulse rate.

TR2 is heavily switched on by the voltage from R3. The collector to emitter voltage will then be about 100mV, producing a negligible reading on the meter, which is easily backed off by the meter's mechanical "set zero" control. C1 is fully charged through R2 and the base circuit of TR2. If a pulse is applied to R1 so that TR1 conducts, the collector to emitter voltage of TR1 will fall and switch TR2 off via the reversed biased diode D1. The collector to emitter voltage of TR2 is now stabilised at the Zener voltage of D3, i.e. about 6·2 volts.

The current through R3 begins to charge C1 in the opposite direction and after a time, determined by R3 and C1, switches TR2 back on again.

As soon as the collector voltage of TR2 drops, the base bias on TR1 drops through R5, thus switching TR1 off very quickly. As TR1 is switched off the charging current through C1 switches TR2 on, the whole process being repeated. From this it can be seen that pulses of constant duration and amplitude are produced at the collector of TR2. The frequency of the input pulses determine the spacing of the pulses at TR2.

The average current through the load is expressed as

$$I_{av} = \frac{I\,t_1}{t_2}$$

where $t_1$ is the length of the fixed pulse and $I$ is constant as previously described. Therefore

$$I_{av} = \frac{C}{t_2}$$

where $C$ is the meter current law.
Thus, as $f = 1/t_2$
where $t_2$ is the period of the input pulse, then

$$I_{av} = Cf$$

or the meter current law times frequency. The scale is thus linear.

As the current $I$ may be set to any value by VR1, the scale may be calibrated to any number of revolutions per minute.

### CONSTRUCTION

The construction and wiring of the unit should not prove difficult provided the blueprint is followed carefully. Before mounting the 12-way component tag board in the cabinet all wiring in Figs. 2a and 2b, including lead-off wires, should be carried out. It is best to solder all interconnecting wires underneath the tag board first (see Fig. 2b on the blueprint).

Next mount the components (as shown in Fig. 2a) on the top of the tag board. When soldering the transistors and diodes in position, a heat shunt should be used to prevent damage to these components due to overheating. Once the tag board wiring has been completed and checked for any errors, it can be placed aside until the aluminium box has been marked out and drilled.


*Complete revolution counter and dwell meter*

The box shown on the blueprint and in the photographs can be made up by chassis suppliers. The prototype was supplied by H. L. Smith & Co., 287 Edgware Road, London, W.2.

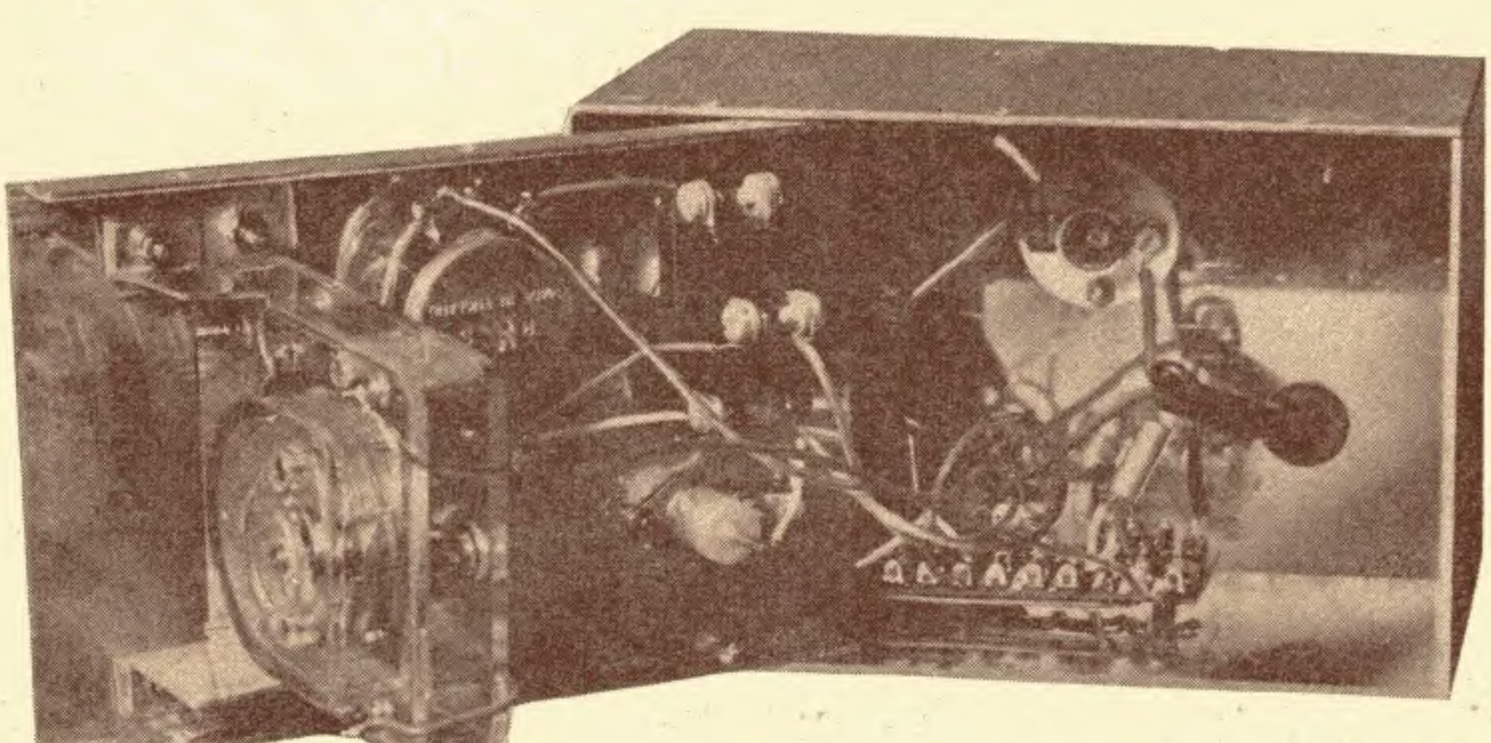
When all the drilling has been completed the components shown in Figs. 3a and 3b should be mounted in position.

Bracket "A" for the meter, shown in Fig. 4 on the blueprint, should be supplied with the meter, but two extra brackets "B" are required, also shown in Fig. 4. The bracket supplied with the meter is removed and reversed to allow the meter to be adjusted at an angle to the front panel of the case. Brackets "B" are then fitted between the "feet" of the meter bracket and the front panel. The front panel components are then wired.

Note that SK1 and LP1 are mounted on the back of the box, although SK1 can be mounted on the front panel if preferred. The lampholder is mounted on two ¼in spacers on the inside back wall, so that it will provide effective illumination, through the perspex case of the meter. For permanent installations the green wire is connected to the dashboard lamp to provide a switched source of supply for the meter lamp.

Connect these and the components on the front panel to the tag board as shown in Figs. 2a, 3a, and 3b. It will be seen from Fig. 3b that the tag board is mounted on the floor of the case, with ¼in spacers to raise it sufficiently to avoid any possible short circuits.

The front panel is fixed to the box with six P.K. self-tapping screws.



*Interior view of the unit. Note the small pieces of metal under the feet of the meter bracket*

## CALIBRATION

One method of calibration is to connect the 50c/s mains frequency, suitably reduced to 12 volts via a transformer, to the "rev" input (see Fig. 5). This 50c/s mains frequency corresponds to 1,500 r.p.m. of a four cylinder, four stroke engine. The meter deflection obtained can be marked on the scale; the rest of the scale can be marked from this by interpolating 0 to 1,500 and upwards.

An alternative method is to calibrate against a known accurate revolution counter already installed in a car. The prototype was set up in this way and was found to correspond with the revolution counters on two different cars.

The positive and negative supply lines (red lead positive and black lead negative) are connected to the car battery and a coaxial lead is taken from SK1 to the "contact breaker" coil terminal (see Fig. 6). Cars with positive or negative earth systems are suitable as the ignition pulse is in the form of a "ring"; the circuit triggers on the appropriate part. Check that the negative of the unit is connected to the negative of the battery.

The meter was first calibrated against a revolution counter fitted in a Zephyr 6 and was set at 2,000 r.p.m. by adjusting VR1 against the same reading on the car rev counter. The scale already on the meter was ideally suited; the mark on the meter indicating 0·2mA corresponded to 2,000 r.p.m.; 0·4mA to 4,000 r.p.m.; 0·6mA to 6,000 r.p.m. The engine speed was not taken higher than this because, being stationary, there was no load on it. It follows that higher readings should correspond equally well, so the initial calibration was all that was necessary.

Current consumption of the unit when the "rev" input is used is 10mA.

If the circuit cannot be made to trigger reliably, then R1 may be reduced slightly, but only if the wiring is correct.

The "rev" input is ideal for checking the engine performance, clutch slip, finding the best speed for gear changing, and measuring the revolutions per minute at maximum torque.

## USING THE DWELL METER

All that is required to bring the dwell meter into operation is to unplug the coaxial lead from SK1, insert into SK2 and switch S1 to the "dwell" position. The dwell meter measures the on-off ratio of the points. The points of a four cylinder engine should be open for approximately 30 degrees and closed for 60 degrees, but you should check this from the manufacturer's data.

When the points are open there is 12V across them and zero volts when they are closed. Thus, neglecting the back e.m.f. of the coil the waveform should be as shown in Fig. 7. From this it can be seen that no matter what the engine revs are the ratio remains unchanged.

If the meter is set to read full-scale deflection by adjusting VR2 when the points are open, then it should read about two-fifths scale when the points are closed.

If the meter reads higher than specified, the gap should be reduced and vice versa. The results obtained on the Zephyr 6 and Morris 1100 showed two-fifths deflection when the contact breaker points were open.

★

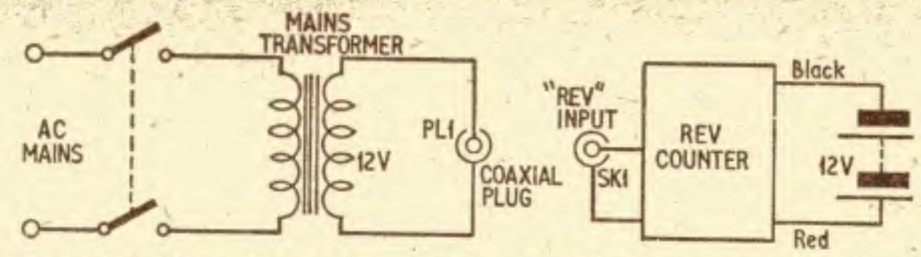



*Fig. 5. Calibration set-up using the 50c/s mains frequency*

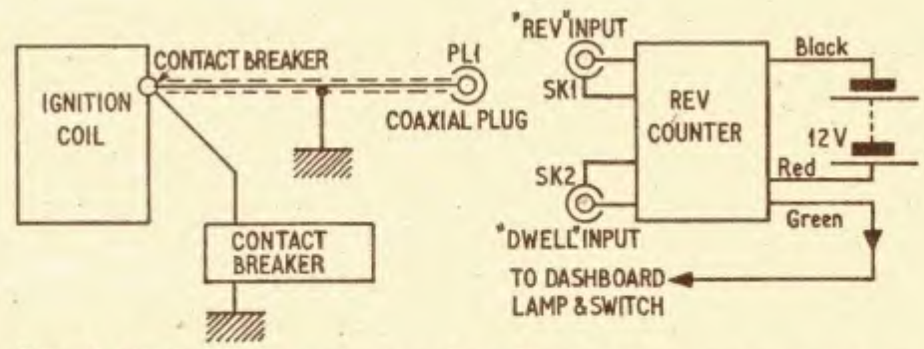



*Fig. 6. Calibration set-up using direct comparison with an existing built-in car rev counter; also the set-up for normal measuring*

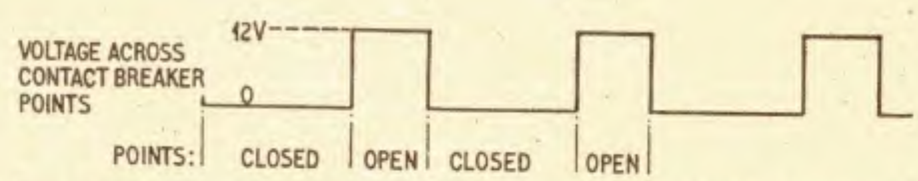
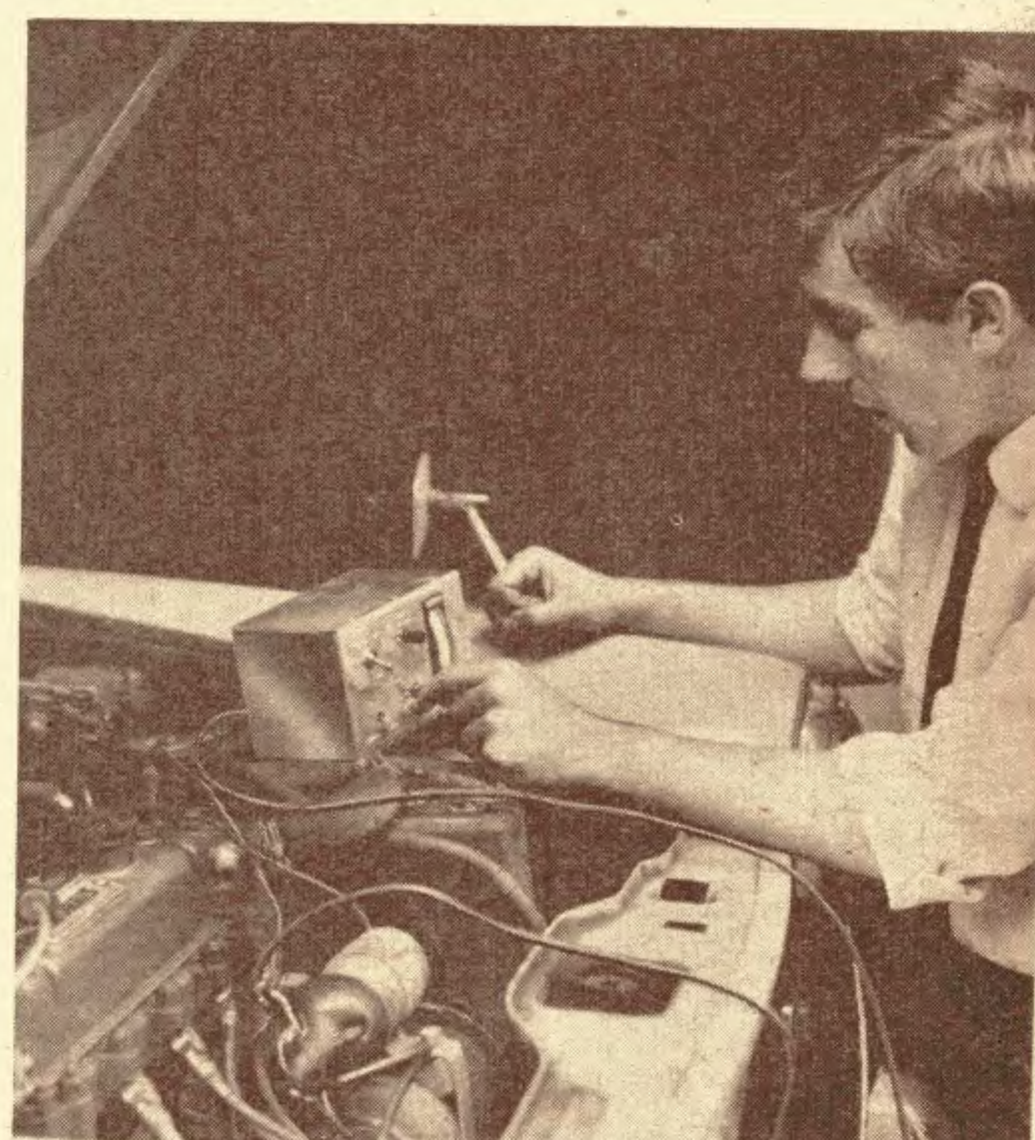



*Fig. 7. Illustration of the ratio of contacts being open and closed*

*Photograph of the unit being used to measure revs per minute on a Morris 1100. Note the connection on the CB terminal of the ignition coil. The earth connection is made through the battery positive line*



# ELECTRONORAMA

## HIGHLIGHTS FROM THE CONTEMPORARY SCENE

# LONDON...

# TELEX COMPUTER LINK

# ...COWES

FOR THE first time in over a century of yacht racing a magnetic tape computer calculated results of all handicap events during the Cowes Regatta.

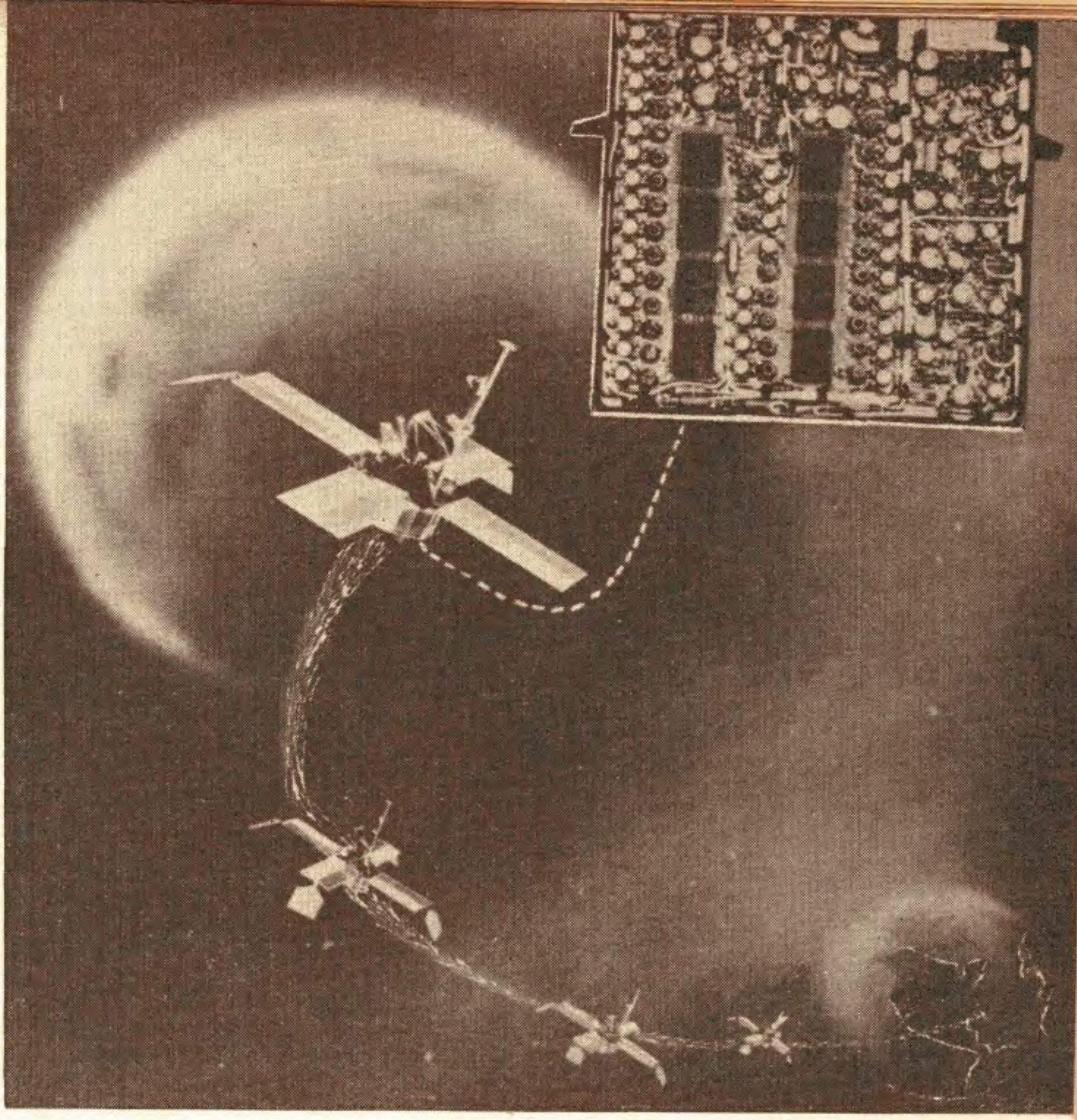
Results of the Combined Clubs Regatta races were calculated remotely by a Series 200 computer at the Honeywell Datacentre, London. Linked to the regatta centre by G.P.O. telex service, the computer was fed with the times and sail numbers of the yachts as they passed the finishing buoy. Taking into account the basic speed factor, or handicap, allotted to each yacht, the computer transmitted corrected times back to the teleprinter. The punched-paper tape from the teleprinter was fed to a Flexowriter supplied by Friden; this can be seen on the the right.

## Mars Data Storage

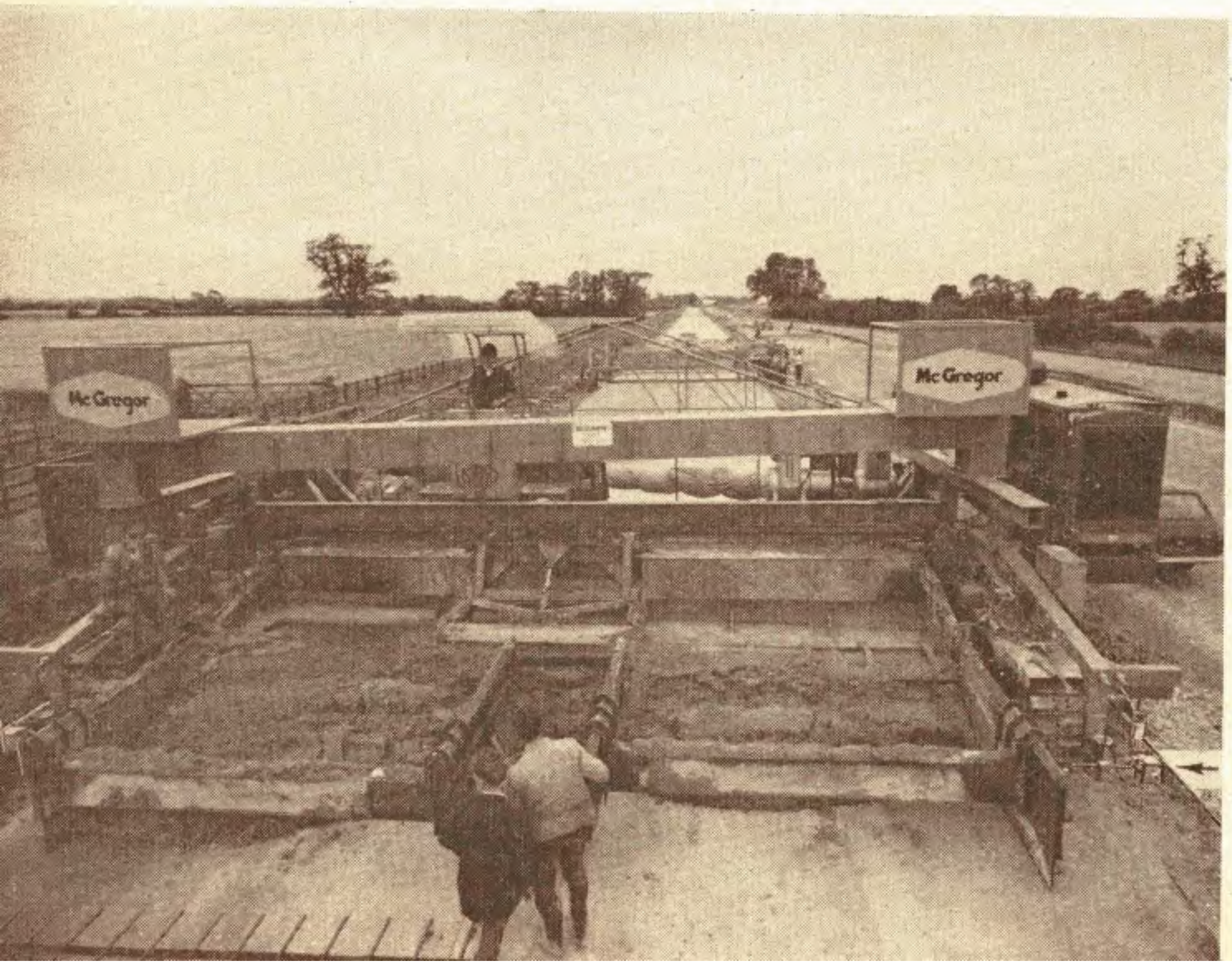
A TINY memory developed by Sperry Rand Corporation's Univac Division was the "clearing house" for the photos of Mars taken by cameras aboard the Mariner IV spacecraft. The device is called a data buffer memory system, a completely solid state memory package six inches square and one inch thick. It is reproduced here in the top right hand corner of the photograph.

The device is actually two memories sandwiched together, each containing 1,320 data "bits" of storage. During the spacecraft's close approach to Mars the memory received and stored the television pictures and made them available for transmission to earth.

The weight of the memory is only 21 ounces and its power consumption is less than half a watt. The memory was designed to withstand the severe heat of the sun in the vicinity of earth and the extreme cold of deep space in the vicinity of Mars. Every individual soldered joint was examined through a microscope for soldering defects.



## Electronic Controlled Road Maker




READERS who have been anywhere near the Cromwell By-Pass, just north of Newark, Nottinghamshire, may have noticed this gigantic road making machine in operation.

Known as the "slip-form paver", this machine will extrude concrete as a finished road slab, without the use of any side supports. It is self propelled, runs on caterpillar tracks, and lays the concrete road at a rate of up to seven feet per minute.

The entire machine is controlled and guided automatically by electronic sensors fitted on the sides, so that it follows an even path between two guide cables running down either side of the track.

Ministry of Transport engineers, the Road Research Laboratory, and the Contractors have pooled their resources to perfect this system.

# BEGINNERS start here... 12

## An Instructional Series for the Newcomer to Electronics


*The essential tools and materials for soldering. A lightweight instrument iron type similar to that to that illustrated is ideal for work with transistors and other small components. Soldering irons of this type can be obtained in various wattage ratings, i.e., 12, 15, 20 and 25 watts. A good average rating for general transistor work is 15 watts. A "cored" solder such as that illustrated should always be used. This contains flux, and for normal jointing purposes no additional flux need be applied. Solder is obtainable in small handy packs, as illustrated, or in a handy dispenser.*

*Wire cutters and long nosed pliers are indispensable. A pair of tweezers, a pocket knife and a pair of "Bib" wire cutters and strippers are most useful additional items.*

### SOLDERING TECHNIQUE

We come now to an important facet of "toolcraft" as it applies to electronic construction, namely, *soldering*.

The art of joining two or more metals together by the soldering process requires a little practice, and if you have not had the chance to carry out any work of this nature before, a few moments spent in trying one or two joints using a few lengths of wire and a valveholder or tag strip will be amply rewarded when you come to serious assembly work. Further practice will be obtained if you build the multivibrator a.c. generator which will be described next month. This design has been specially laid out to enable beginners to obtain assembly and soldering practice. In the meantime if you can fix yourself up with a soldering iron, some cored solder and odd pieces of tinned copper wire, you can then try out the points of soldering technique as we discuss them.

The technique of soldering can actually be divided into two main classes. One is the *heavy duty* method used by sheet metal workers, tinsmiths and so on. In this method the two metals to be joined are thoroughly cleaned and the flux is applied in a paste form before applying the solder. The solder is melted by a naked flame or by a heavy copper-ended iron, which has been immersed in a naked flame until a green glow is emitted from the fire or gas ring. The green glow is indication that the iron is sufficiently hot to melt the solder. This type of soldering method is called sweating and was the only method before the introduction of flux-cored solder and electric irons. Electronic equipment constructors are not concerned very frequently with this method, although work on metal cabinets, chassis, and racks sometimes involves the use of such techniques.

### INSTRUMENT SOLDERING

By far the most common soldering method used in electronics might be called *instrument soldering*. It is a lightweight, delicate operation, carried out with a small slender soldering iron. A 25 watt iron is commonly employed in valve circuitry. For printed circuit work, a 15 watt iron is ideal. Such a tool is small enough to be used like a pencil.

Instrument soldering can be a highly skilled affair, especially in such operations as soldering the hairsprings on to the coil and supports of a moving coil meter movement.

## THE NEED FOR FLUX

What takes place when the molten solder is applied to the metals to be joined can be seen in the cross sectional drawing Fig. 12.1.

The action of the *flux* is particularly important, because it dissolves off oxide coatings and some of the dirt which might be on the metal surfaces. The flux also increases the flow of the solder, as discussed later on.

When the molten solder flows into contact with the cleaned surfaces, the tin in the solder alloy forms a further alloy with the surface layers of the metals. In particular, this causes a strong bonding so that when the solder solidifies, the joint becomes one solid mass, strong mechanically and a good electrical conductor. *But, if precautions are not taken to ensure optimum conditions for the bonding to take place, troubles can occur.*

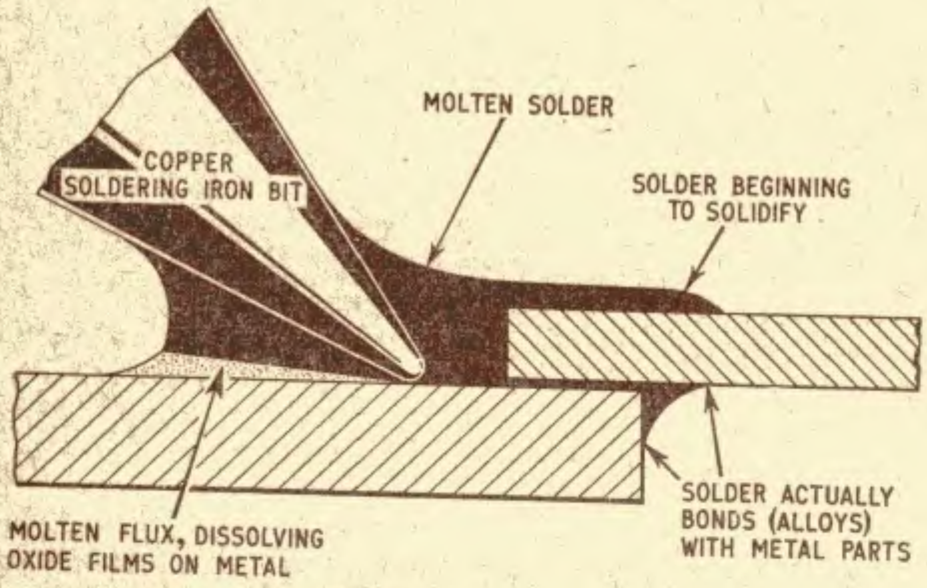



**Fig. 12.1. This diagram shows the action of the flux when making a soldered joint. It is essential that the two surfaces be perfectly clean and free from grease before they are brought together to make a joint. Good electrical and mechanical contact is vital before the solder is applied**

## DRY JOINTS

There are one or two faults that can arise when making small electrical joints by soldering. The most common is the notorious *dry joint* which beginners often make!

A dry joint may look all right, but offers a high electrical resistance, with resulting noise and intermittent troubles in the circuit. This type of faulty joint arises because there is a layer of oxide left between the metal and the solder, where the solder never "wetted" the surfaces properly.

Like most practical skills, it takes some experience to get the feel of soldering, so that you know by touch whether a joint is sound or not.

The correct iron temperature is important, together with the right type and amount of flux. It goes without saying that the surfaces to be jointed must be bright and clean. Dirt would tend to cause dry joints.

Flux has already been mentioned. Solder on its own, although melted, tends to be a bit pasty and fails to flow and wet the surfaces. The flux is a material which makes the solder much more fluid. For virtually all electronic and instrument jobs, a "cored" type of solder should be used.

A well known fluxed solder of this type has the brand name "Multicore", and is composed of 60 per cent lead to 40 per cent tin. A special resin flux material is contained in cores inside the "wire" of solder material.

This solder can be obtained in several sizes, these corresponding to the standard wire gauges of 14, 16, 18 and 22 s.w.g. For most electronic work 18 s.w.g. solder will be suitable. This can be purchased in small quantities: a handy dispenser holding 12 ft of solder costs 2s 6d, while a carton of 30 ft costs 5s.

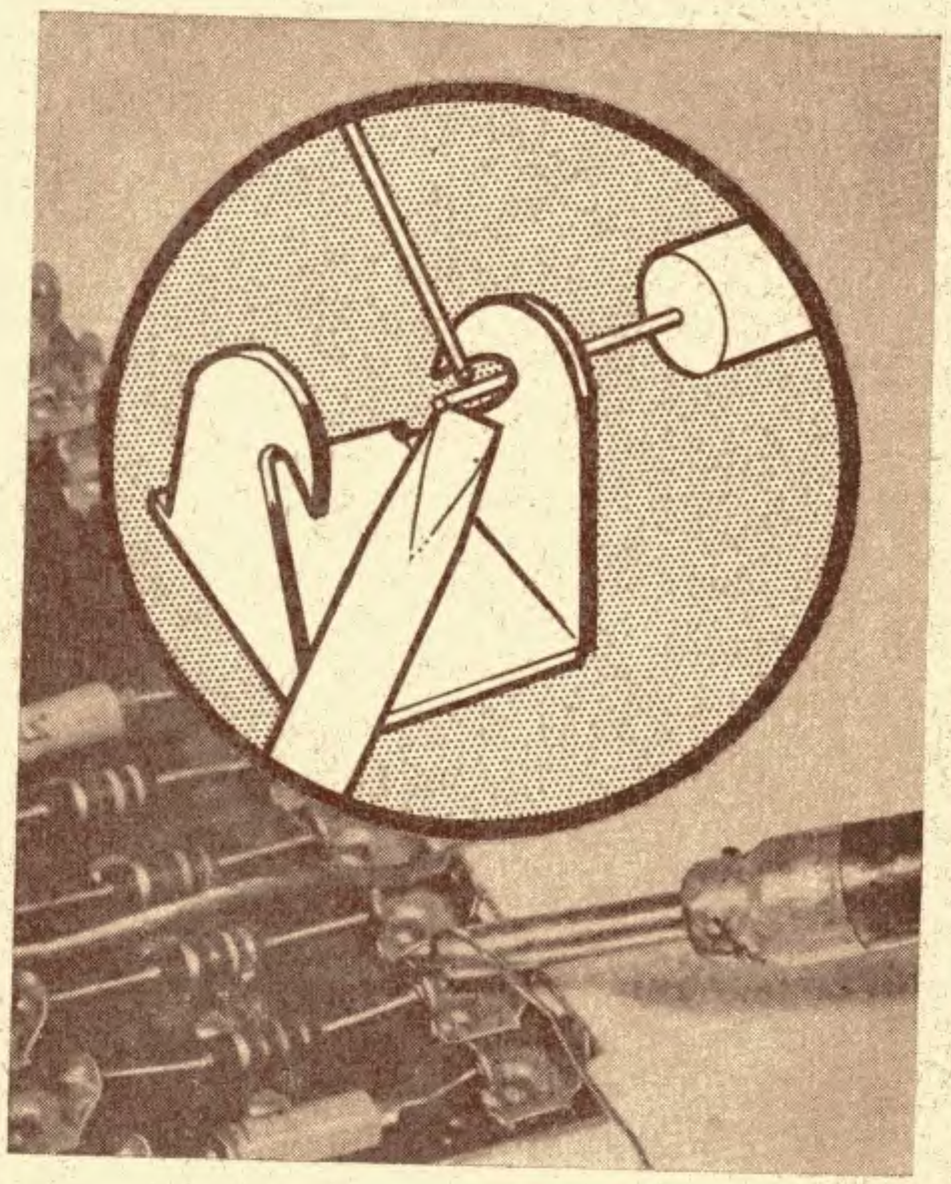
## KEEP THE IRON IN PLACE

Here lies one of the secrets of good soldering: if some solder is melted on to the iron, the flux quickly vaporises and is lost and by the time the iron has been transferred to the work, the solder no longer runs and a poor joint results.

The solder should be run straight onto the joint *with the iron in place*, thereby maintaining a supply of flux on the job. So important is this fluxing, that even when stripping or unsoldering it is necessary to run on fresh (fluxed) solder to make the original joint run.

If there is any doubt that the solder may not run, then separate "wetting" of the parts should be carried out. This is called "tinning" the surfaces, and of course the soldering iron bit itself should be cleaned and tinned when making ready for use.

**The illustration below shows how the two parts comprising the joint (in this case, the wire lead of a resistor and a tag of a component group board), the solder, and the iron are all brought together for the soldering operation**



A VERSATILE electronic counting and timing device is indispensable in the modern physics laboratory. It will be noted that in the fields of nuclear physics and nucleonics, the term "scaler" is generally given to apparatus of the type we are considering, this is in order to avoid any possible confusion with atomic radiation detectors such as Geiger Muller tubes which have long been referred to as "counters".

## PULSE OR SINE WAVE INPUT

To be truly versatile, the scaler must work from either pulse or sine wave input. The "hard" valve input circuit employed in this design will shape and limit pulses from a Geiger Muller tube and also produce a satisfactory waveform for driving the first Dekatron tube from a sine wave input of about 3 volts.

The maximum practical counting rate for a Geiger Muller tube is about 500 counts per second and cold cathode trigger tubes will handle this frequency quite easily. For the present design however, a higher rate of count was required for timing purposes and for measuring the frequencies of audio sources. A Dekatron will work up to 5,000 counts per second and hard valve circuits will operate far faster than this. A hard valve input circuit to the first Dekatron was therefore used, the latter stages being coupled by cold cathode tubes.

## AUDIO OUTPUT

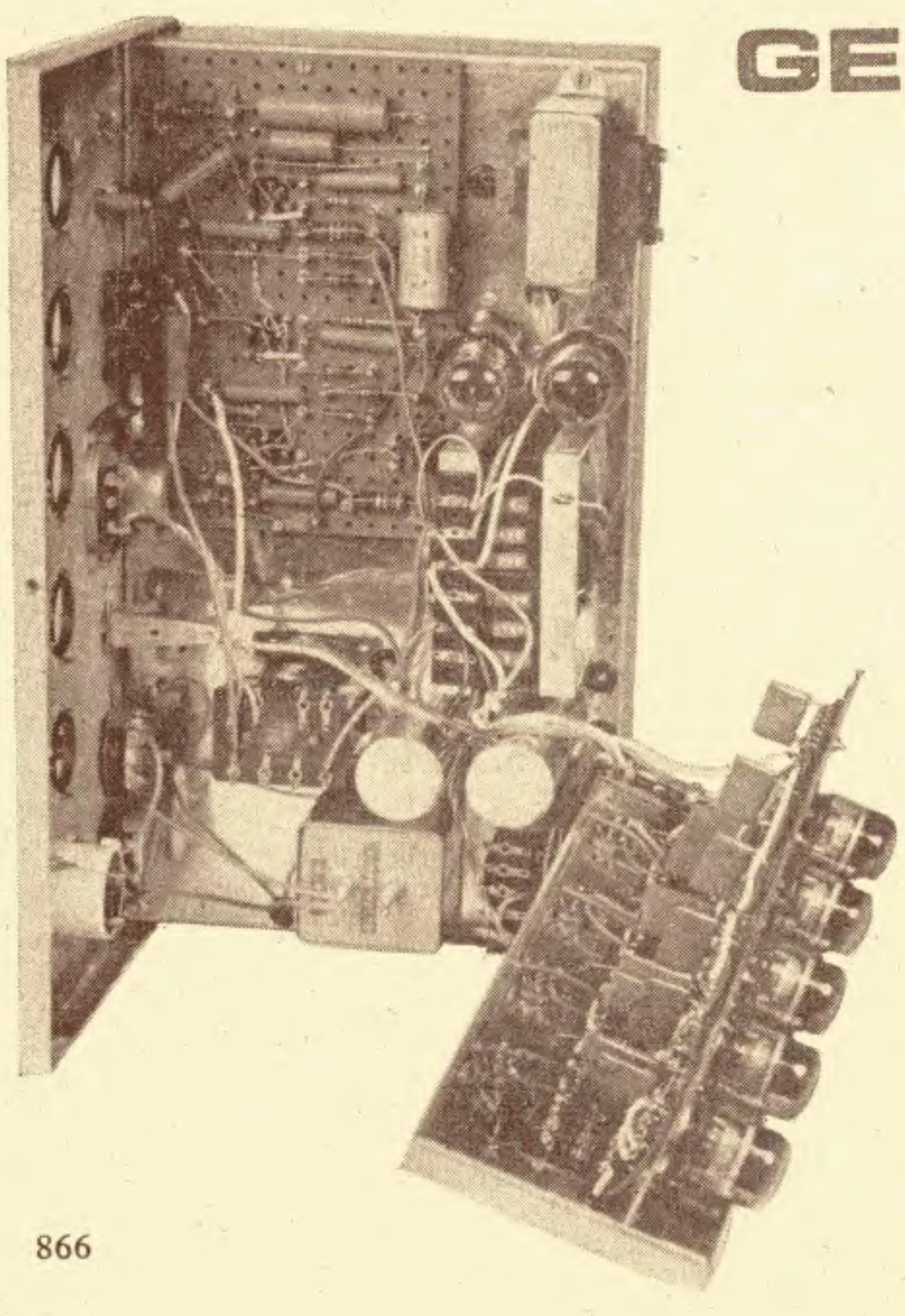
The ticking of a Geiger Muller counter is so well known to every reader or viewer of science fiction that it seemed mandatory for this audio facility to be included. Besides giving a striking demonstration of the random nature of radiation pulses, this audio output is invaluable in providing a sound source from an audio oscillator whose cycles can be simultaneously counted and hence the frequency accurately calculated.

A useful internal 100c/s timing or testing signal has been incorporated. More accurate timing of moving bodies using an external 500c/s electrically maintained tuning fork and mechanical or photo-cell switching is also catered for. Sockets for this input, or that from an audio oscillator are provided.

The general consideration of simplicity of construction from readily available, yet reliable, components was kept in mind throughout. The actual cost of the scaler will depend upon the sources of supply and, in the case of educational establishments, upon the generosity of component manufacturers. Assuming new components are used throughout, the total cost is likely to be in the region of £40. This is considerably less than half the cost of a ready made commercial instrument capable of providing the same facilities and performance.

## ELECTRONIC DETAILS

The scaler circuit may be considered as a number of distinct sub units, and the equipment has in fact been built as such. This arrangement facilitates theoretical understanding of the circuit principles; also simplifies the construction of the scaler and the testing of its performance. The block diagram Fig. 1 shows the relationship of these sub units, each of which will now be described in detail.



# GENERAL PURPOSE SCALER

By R. W. SAWYER, B.Sc.

### SPECIFICATION

| | |
|---|---|
| Display | Five Dekatrons |
| Input | Sine wave, pulse or G.M. tube |
| Counting Rate | Over 3,000 cycles per second |
| Total Count | 100,000 |
| Audible Count | Miniature loudspeaker included |
| E.H.T. Supply | Metered variable e.h.t. supply for G.M. tube |
| Timing Facility | Internal source of 100c/s pulses |
| Mechanical | Unit construction |

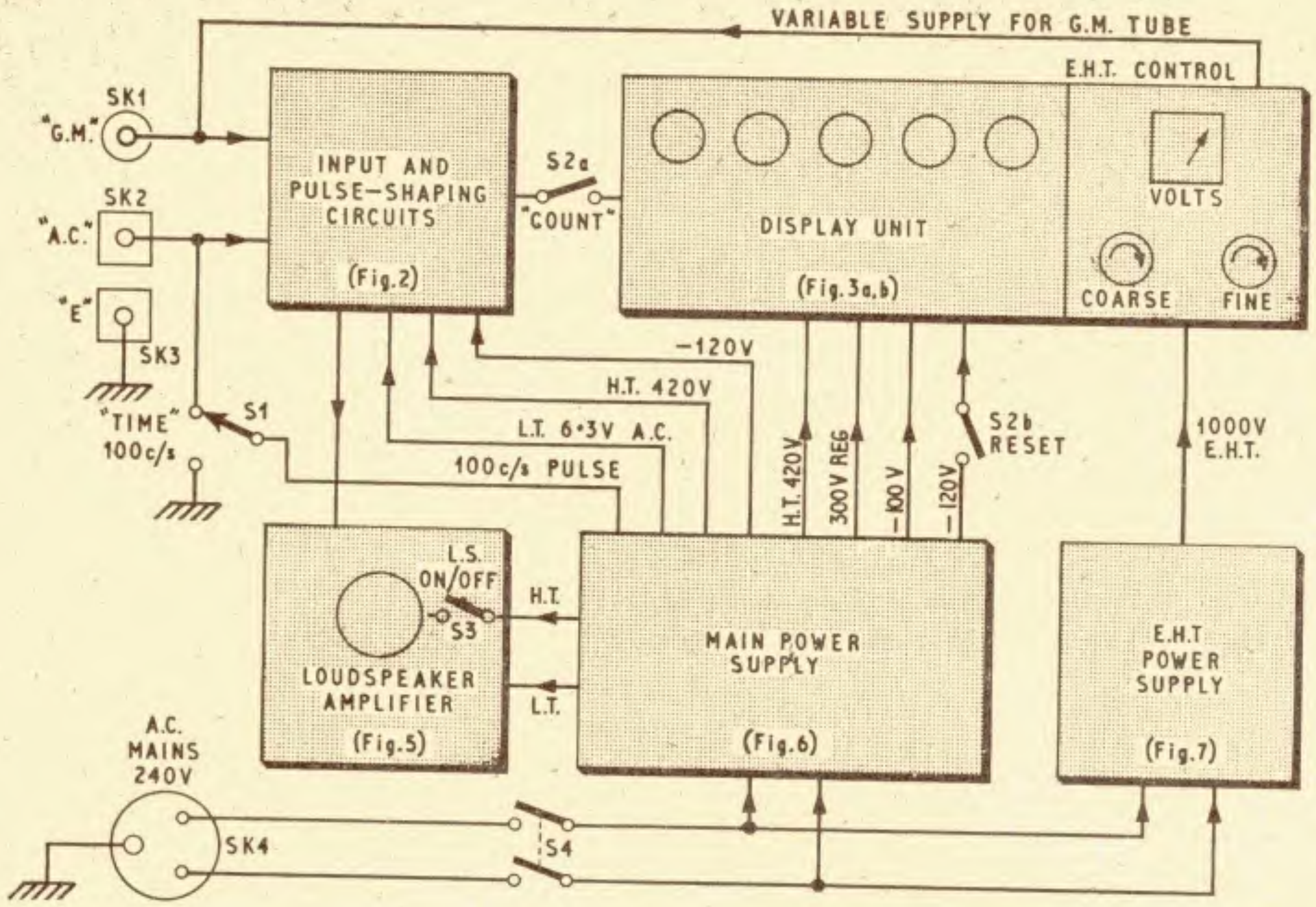



*Fig. 1. Block diagram showing inter-relation of sub-units and operating controls*

## INPUT AND PULSE SHAPING CIRCUIT

The circuit diagram for the input and pulse shaping stages is given in Fig. 2.

Two pentodes, type EF91, convert the input signal into a negative-going pulse of about $-145$ volts amplitude. The first valve V1 functions as a conventional amplifier having a gain of about 25 times. It also serves to reverse the phase of the negative pulse from a Geiger Muller tube fed into SK1.

The second valve V2 is a pulse shaper. The grid is biased beyond cut-off by a negative voltage derived from the $-120$V line, while a connection to earth through a diode D1 prevents the grid being driven positive. The grid swing is thus sharply limited and the output amplitude is kept constant. A sine wave applied to the grid of V2, having been already amplified by the first valve, will result in the production of a well shaped square wave at the anode of this second valve. This output is fed to the display unit via the *count* switch S2.

Timing pulses are applied to V1 grid via the switch S1. These 100c/s pulses are derived from the main power supply unit.

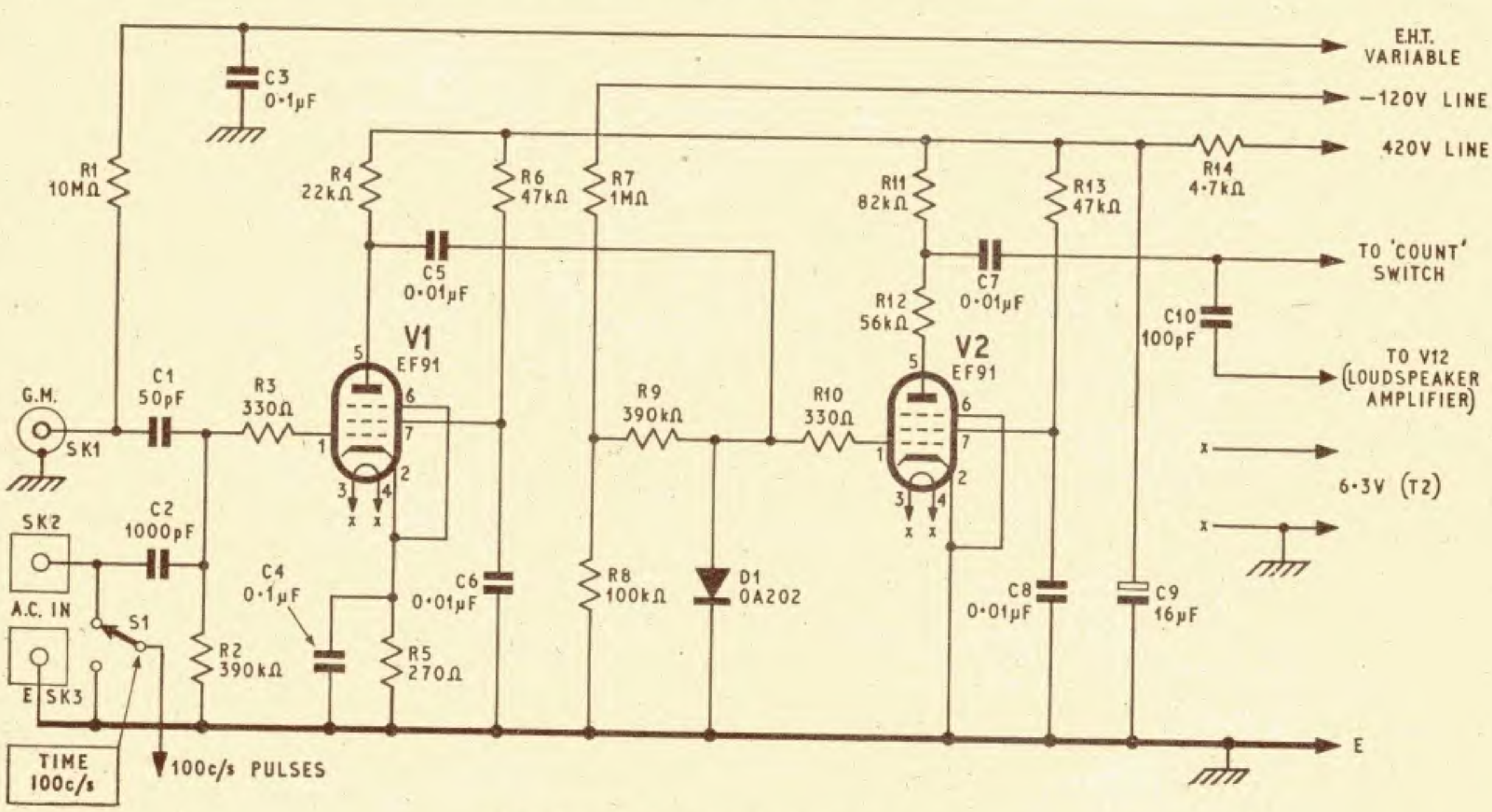
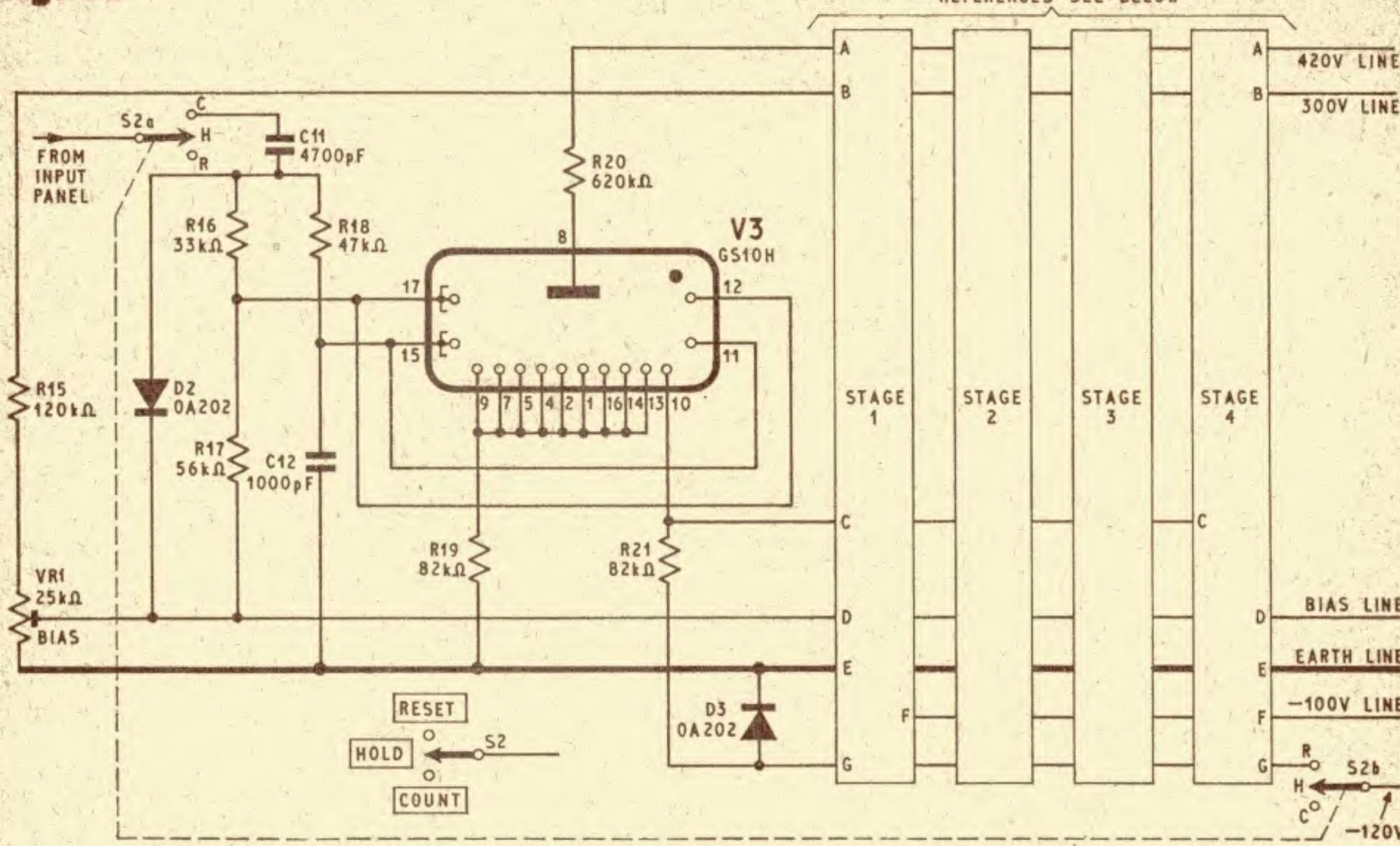



*Fig. 2. Input and pulse shaping circuits*

**Fig. 3a**




| ITEM | STAGE 1 | STAGE 2 | STAGE 3 | STAGE 4 |
|---|---|---|---|---|
| VA | V4 | V6 | V8 | V10 |
| VB | V5 | V7 | V9 | V11 |
| RA | R22 | R33 | R44 | R55 |
| RB | R23 | R34 | R45 | R56 |
| RC | R24 | R35 | R46 | R57 |
| RD | R25 | R36 | R47 | R58 |
| RE | R26 | R37 | R48 | R59 |
| RF | R27 | R38 | R49 | R60 |
| RG | R28 | R39 | R50 | R61 |
| RH | R29 | R40 | R51 | R62 |
| RI | R30 | R41 | R52 | R63 |
| RJ | R31 | R42 | R53 | R64 |
| RK | R32 | R43 | R54 | R65 |
| CA | C13 | C16 | C19 | C22 |
| CB | C14 | C17 | C20 | C23 |
| CC | C15 | C18 | C21 | C24 |

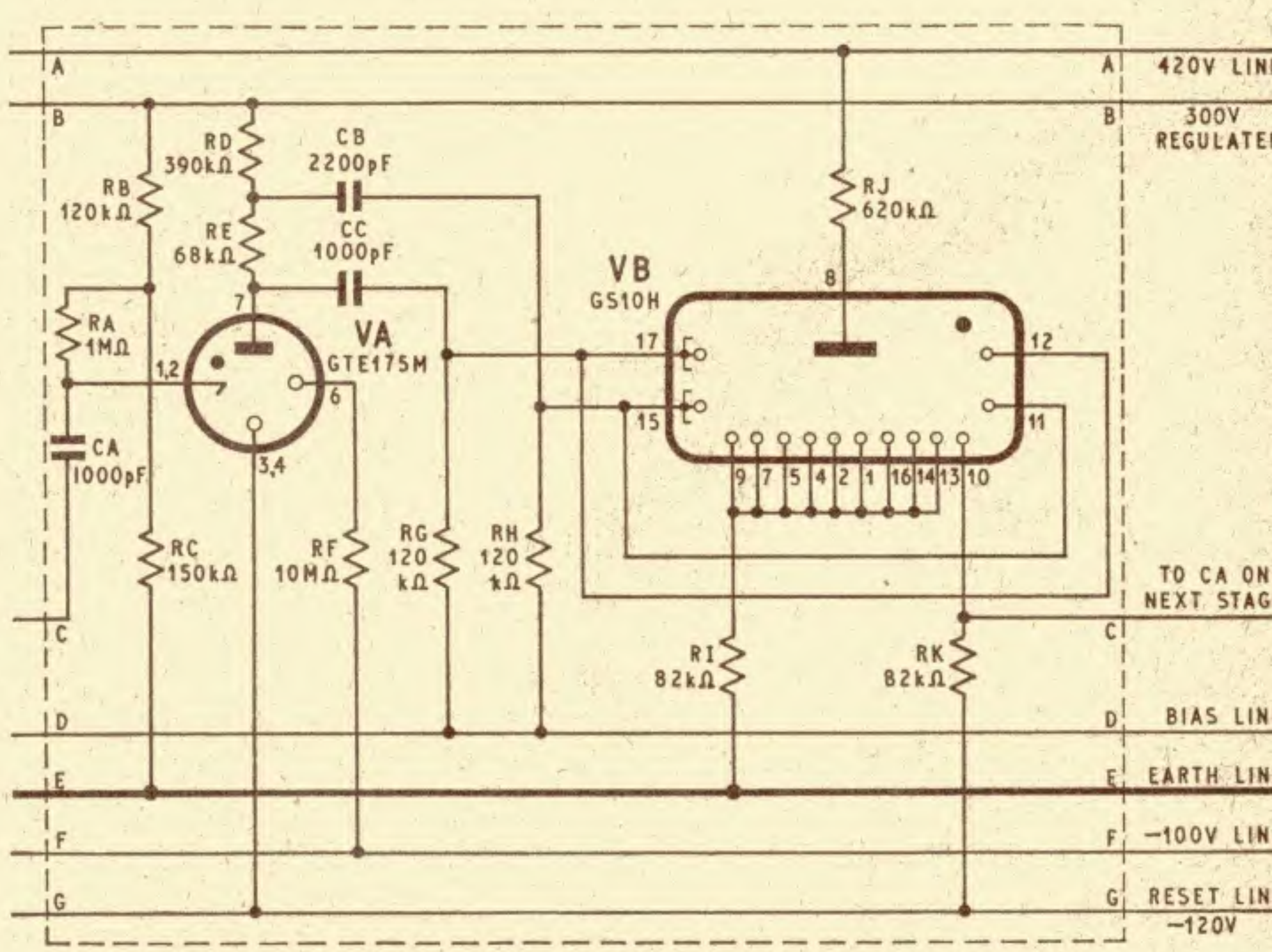



**Fig. 3b**

*Fig. 3. Display unit circuit diagram. The input circuit and first dekatron stage is given in Fig. 3a. The four subsequent stages are identical; each incorporates a trigger tube and a Dekatron and the circuit is given in Fig. 3b*

## DEKATRON DISPLAY UNIT

The first Dekatron stage of the display unit is shown in full detail in Fig. 3a. The four subsequent Dekatron stages are shown in block form only in this diagram, but all inter-stage connections are indicated, as well as the output connections of the display unit.

These four subsequent stages are identical in all respects, and the common circuit arrangement appears in Fig. 3b. For clarity, each component in Fig. 3b has been "numbered" in an alphabetical sequence and the accompanying table sets out the actual reference number for each component stage by stage. These latter numbers are of course used to identify individual components in the physical layout and wiring diagrams, and also in the component list.

## OPERATION OF THE COUNTING TUBES

Five Ericsson GS10H Dekatron tubes are used in the display unit. The Dekatrons are in effect neon tubes with a circular anode surrounded by 30 rod-shaped cathodes, as depicted in Fig. 4. The counting cathodes are identified as K0 and K1 to K9. The last mentioned nine cathodes are connected together externally in the present application. The cathodes between each of these counting cathodes are known as guides. These are connected together in two sets of ten, known as first guides and second guides respectively, in a clockwise direction.

When a potential exceeding 400 volts is applied to the tube through a suitable limiting resistor, a discharge takes place to one of the earthed cathodes which becomes surrounded by the characteristic negative glow. Only one glow occurs because the potential across the tube then drops to about 190 volts which is insufficient to break down another anode-cathode gap. The guides are meanwhile maintained at about 35 volts positive. This bias voltage is obtained from a potential divider across the 300 volt line and earth, and is preset by the bias potentiometer VR1 (see Fig. 3b).

The glow may be transferred to one cathode to the next by the application of two successive negative pulses applied in turn to the intervening guides. For example, if the glow is on cathode 6 and the first guides are pulsed negatively the glow will move to the nearest of the first guides, that is to say, one step in a clockwise direction. If as this pulse dies away a negative pulse is applied to the second guides, the glow will move to the adjacent second guide. As this pulse fades and the guide returns to its normal 35 volts positive, the glow shifts to the now adjacent cathode 7.

Thus the glow may be moved from cathode to cathode round the tube. K0 (pin 10) has a separate lead with a cathode resistor (R21) across which a voltage will be developed when the glow returns to this cathode after the count of ten. A positive pulse taken from this cathode lead is used to initiate the triggering pulses for the next stage.

## RESETTING THE SCALER

To reset the scaler, the voltage on the common K0 return is momentarily lowered to about −120 volts by means of S2b. Under normal counting conditions this common return is grounded in a positive direction through a diode D3 which allows the normal working current to pass.

The two successive negative pulses required to drive the first Dekatron V3 are produced by feeding the pulse from the input circuit (see Fig. 2) via S2a to a network known as the integrated pulse drive. This circuit passes a pulse immediately on to the first guides, but the pulse to the second guides is delayed while the 0·001 $\mu$F capacitor C12 charges through the 47 kilohm resistor R18. The pulse dies away as the capacitor discharges.

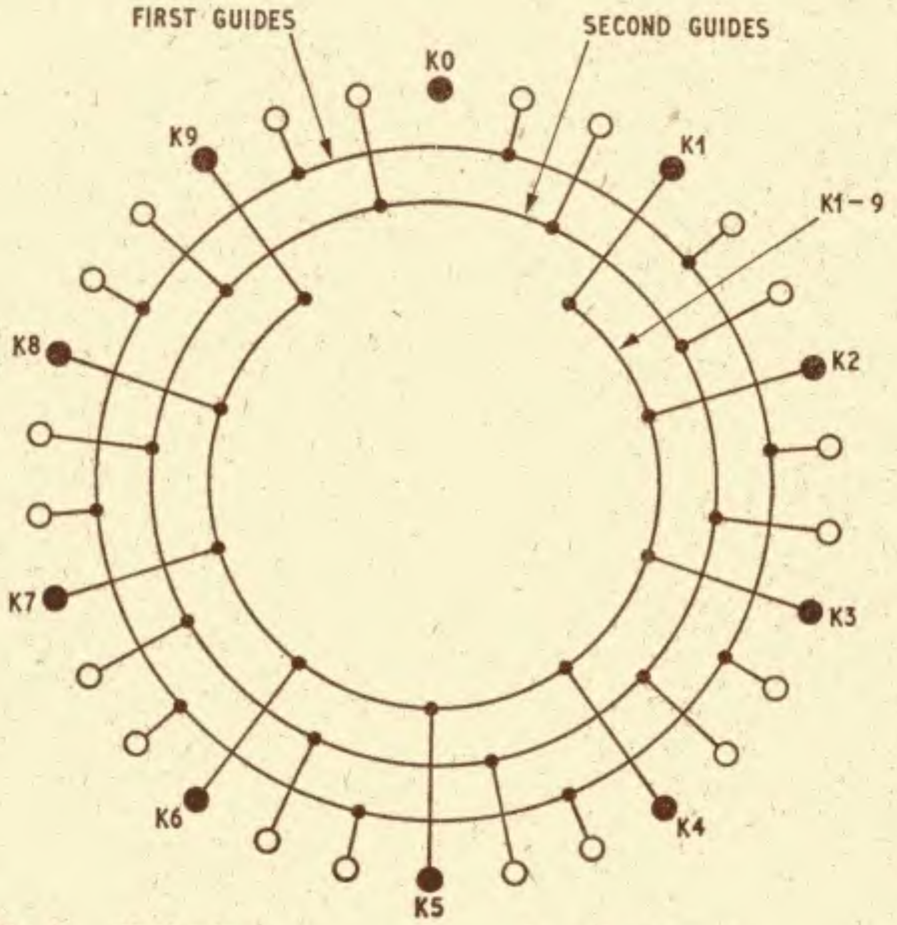
## COLD CATHODE TUBES

The coupling to the remaining Dekatrons is by means of GTE175M trigger tubes. These are gas-filled tetrodes having an anode, auxiliary cathode, trigger, and cathode. By supplying suitable voltages, two red glows can be maintained in the tube, one between the anode and auxiliary cathode and the other between the trigger and cathode. It is useful to verify the presence of these glows visually if trouble is experienced in getting the tubes to function correctly. A positive pulse applied to the trigger will cause the discharge to spread suddenly across the anode to cathode gap with an increase of anode current. Pulses are taken from the resistors in the anode circuit through a suitable network to drive the following Dekatron.

Referring to Fig. 3b, it will be seen that the output pulse from the first Dekatron V3 is applied via CA to the trigger of VA. As the trigger tube conducts, negative pulses appear at the anode and these are fed to the first and second guides of the next Dekatron VB via CB and CC.

This process is repeated through to the fifth and final stage.

To summarise: each Dekatron counts the pulses it receives, and at the tenth passes on a triggering pulse to the following stage. It then recommences to count.




| | | | |
|---|---|---|---|
| Pin 1 | Cathode 6 | 9 | Cathode 1 |
| 2 | Cathode 5 | 10 | Cathode 0 |
| 3 | Do not connect | 11 | Routing Guide 2 |
| 4 | Cathode 4 | 12 | Routing Guide 1 |
| 5 | Cathode 3 | 13 | Cathode 9 |
| 6 | Do not connect | 14 | Cathode 8 |
| 7 | Cathode 2 | 15 | Commoned Guide 2 |
| 8 | Anode | 16 | Cathode 7 |
| | | 17 | Commoned Guide 1 |

*Fig. 4. Electrode arrangement of Dekatron tube*

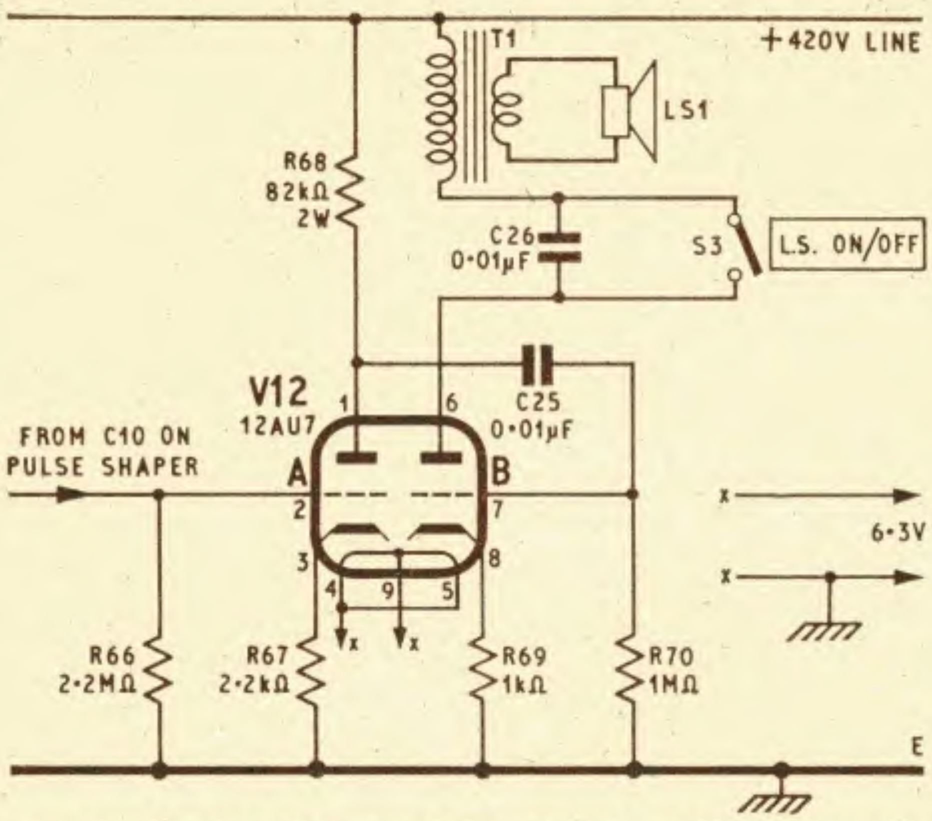



*Fig. 5. Loudspeaker amplifier circuit. This is actually built on the same panel as the input and pulse shaping circuit*

The stored count is indicated by the glow visible at the top end of the Dekatron tube which registers against a numbered escutcheon. The first tube thus indicates digits, the second tens, and so on; the fifth tube indicates tens of thousands ($10^4$).

## AUDIO OUTPUT CIRCUIT

An audible "count" is obtained by means of a conventional two stage audio amplifier and a small loudspeaker. The circuit is shown in Fig. 5. A 12AU7 double triode is used. The first triode section is resistance capacity coupled to the second triode which drives the loudspeaker via the output transformer T1.

Signals are applied from V2 via C10. A high impedance input is used so that the main circuit is not unduly loaded. This high impedance input increases the capacitative pick-up on the grid of V12A from pulsed currents in the apparatus, but a switch S3 in the anode circuit of V12B effectively controls the loudspeaker. A small capacitor C26 is wired across this switch to absorb the forward e.m.f. produced by the transformer primary when the circuit is broken. Without this capacitor a spurious pulse would be formed in the counting circuits when the switch is opened.

## MAIN POWER SUPPLY

The main power supply unit (Fig. 6) follows conventional practice and needs no detailed description. But one or two points are of interest.

The generally specified h.t. for Dekatrons is 475 volts. A small mains transformer suitable for this supply is not readily available. There are, however, plenty of 350-0-350 volt transformers which are light in weight and cheap, and these will provide a smoothed h.t. of some 420 volts. This voltage is quite satisfactory, although it may result in a slight delay in the initial striking of the Dekatrons when the instrument is first switched on. This delay is usually less than the warm-up period of the valves in the input circuit and so does not affect the working. The phenomenon, which shows the need for ionisation before discharge can take place, can be demonstrated by switching on in darkness. Once ionised with the assistance of light or random radiation, the Dekatrons continue to function normally.

The power unit employs two silicon rectifiers D4, D5 in a full wave circuit. Silicon rectifiers, unlike valves, usually become conductive when they fail, fuses are therefore placed in each rectifier lead to guard against this contingency.

In addition to the smoothed output of 420V, a regulated supply of 300V is obtained from a pair of neon tubes V13, V14.

Negative supplies of 100V and 120V are derived from a half wave rectifier D6 which is fed from one half of the centre tapped secondary of T2.

## INTERNAL TIMING PULSE

Since the unsmoothed h.t. supply contains a 100c/s ripple, this provides a convenient pulse signal for timing or test purposes. This 100c/s pulse is tapped off through a capacitor divider system (C28, C29) and applied to the input of the scaler (as required) via S1

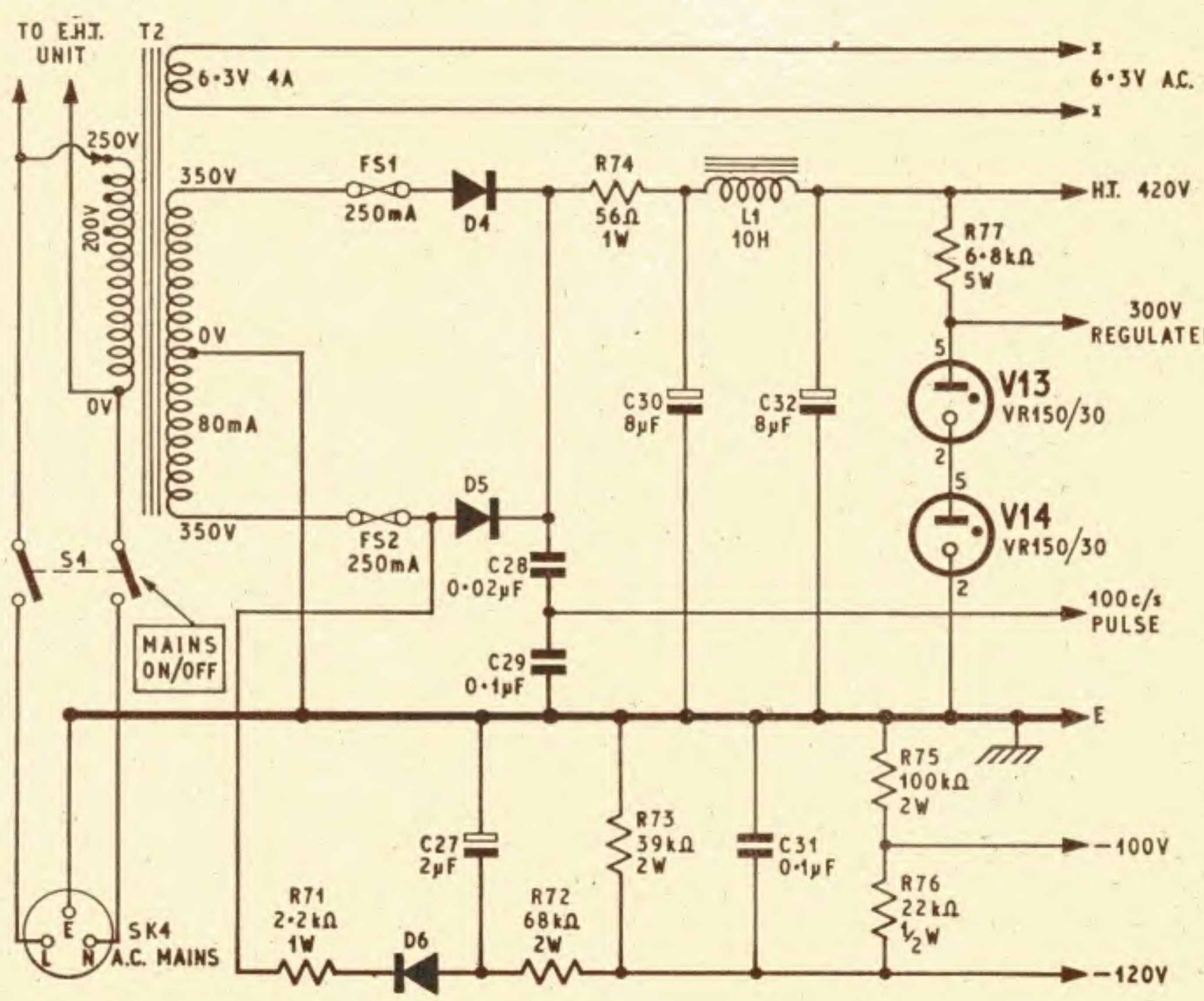



*Fig. 6. Main power supply circuit*

# COMPONENTS . . .

**Resistors**

| | | | |
|---|---|---|---|
| R1 | 10MΩ 5% H.S. | R46 | 150kΩ 5% H.S. |
| R2 | 390kΩ 10% | R47 | 390kΩ 5% H.S. |
| R3 | 330Ω 10% | R48 | 68kΩ 5% H.S. |
| R4 | 22kΩ 10% 2W | R49 | 10MΩ 5% H.S. |
| R5 | 270Ω 10% | R50 | 120kΩ 5% H.S. |
| R6 | 47kΩ 10% | R51 | 120kΩ 5% H.S. |
| R7 | 1MΩ 10% | R52 | 82kΩ 5% H.S. |
| R8 | 100kΩ 10% | R53 | 620kΩ 5% H.S. |
| R9 | 390kΩ 10% | R54 | 82kΩ 5% H.S. |
| R10 | 330Ω 10% | R55 | 1MΩ 5% H.S. |
| R11 | 82kΩ 10% | R56 | 120kΩ 5% H.S. |
| R12 | 56kΩ 10% | R57 | 150kΩ 5% H.S. |
| R13 | 47kΩ 10% | R58 | 390kΩ 5% H.S. |
| R14 | 4·7kΩ 10% 2W | R59 | 68kΩ 5% H.S. |
| R15 | 120kΩ 5% H.S. | R60 | 10MΩ 5% H.S. |
| R16 | 33kΩ 5% H.S. | R61 | 120kΩ 5% H.S. |
| R17 | 56kΩ 5% H.S. | R62 | 120kΩ 5% H.S. |
| R18 | 47kΩ 5% H.S. | R63 | 82kΩ 5% H.S. |
| R19 | 82kΩ 5% H.S. | R64 | 620kΩ 5% H.S. |
| R20 | 620kΩ 5% H.S. | R65 | 82kΩ 5% H.S. |
| R21 | 82kΩ 5% H.S. | R66 | 2·2MΩ 10% |
| R22 | 1MΩ 5% H.S. | R67 | 2·2kΩ 10% |
| R23 | 120kΩ 5% H.S. | R68 | 82kΩ 10% 2W |
| R24 | 150kΩ 5% H.S. | R69 | 1kΩ 10% |
| R25 | 390kΩ 5% H.S. | R70 | 1MΩ 10% |
| R26 | 68kΩ 5% H.S. | R71 | 2·2kΩ 10% 1W |
| R27 | 10MΩ 5% H.S. | R72 | 68kΩ 10% 2W |
| R28 | 120kΩ 5% H.S. | R73 | 39kΩ 10% 2W |
| R29 | 120kΩ 5% H.S. | R74 | 56Ω 10% 1W |
| R30 | 82 kΩ 5% H.S. | R75 | 100kΩ 10% 2W |
| R31 | 620kΩ 5% H.S. | R76 | 22kΩ 10% |
| R32 | 82kΩ 5% H.S. | R77 | 6·8kΩ 5% 5W w.w. |
| R33 | 1MΩ 5% H.S. | R78 | 82kΩ 10% |
| R34 | 120kΩ 5% H.S. | R79 | 82kΩ 10% |
| R35 | 150kΩ 5% H.S. | R80 | 82kΩ 10% |
| R36 | 390kΩ 5% H.S. | R81 | 82kΩ 10% |
| R37 | 68kΩ 5% H.S. | R82 | 82kΩ 10% |
| R38 | 10MΩ 5% H.S. | R83 | 82kΩ 10% |
| R39 | 120kΩ 5% H.S. | R84 | 82kΩ 10% |
| R40 | 120kΩ 5% H.S. | R85 | 82kΩ 10% |
| R41 | 82kΩ 5% H.S. | R86 | 82kΩ 10% |
| R42 | 620kΩ 5% H.S. | R87 | 82kΩ 10% |
| R43 | 82kΩ 5% H.S. | R88 | 82kΩ 10% |
| R44 | 1MΩ 5% H.S. | R89 | 10MΩ 5% H.S. |
| R45 | 120kΩ 5% H.S. | | |

All ½W carbon unless otherwise stated
H.S. = High stability (cracked carbon type)

**Potentiometers**

VR1 25kΩ wirewound, linear, preset
VR2 100kΩ wirewound, linear

**Capacitors**

| | |
|---|---|
| C1 | 50pF silver mica 500V |
| C2 | 0·001μF paper 1,000V |
| C3 | 0·1μF paper 1,000V |
| C4 | 0·1μF paper 250V |
| C5 | 0·01μF paper 1,000V |
| C6 | 0·01μF paper 1,000V |
| C7 | 0·01μF paper 1,000V |
| C8 | 0·01μF paper 1,000V |
| C9 | 16μF elect. 450V |
| C10 | 100pF ceramic 500V |
| C11 | 4,700pF silver mica 500V |
| C12 | 1,000pF silver mica 500V |
| C13 | 1,000pF silver mica 500V |
| C14 | 2,200pF silver mica 500V |
| C15 | 1,000pF silver mica 500V |
| C16 | 1,000pF silver mica 500V |
| C17 | 2,200pF silver mica 500V |
| C18 | 1,000pF silver mica 500V |
| C19 | 1,000pF silver mica 500V |
| C20 | 2,200pF silver mica 500V |
| C21 | 1,000pF silver mica 500V |
| C22 | 1,000pF silver mica 500V |
| C23 | 2,200pF silver mica 500V |
| C24 | 1,000pF silver mica 500V |
| C25 | 0·01μF paper 1,000V |
| C26 | 0·01μF paper 1,000V |
| C27 | 2μF elect. 500V |
| C28 | 0·02μF paper 1,000V |
| C29 | 0·1μF paper 250V |
| C30 | 8μF elect. 600V |
| C31 | 0·1μF paper 250V |
| C32 | 8μF elect. 600V |
| C33 | 0·25μF paper 1,000V |
| C34 | 0·25μF paper 1,000V |
| C35 | 0·1μF paper 1,000V |
| C36 | 0·1μF paper 1,000V |
| C37 | 1μF paper, 1,500V |

**Inductors**

L1 Smoothing choke 10H 90mA
T1 Output transformer 40mA, ratio 40:1 approx.
T2 Mains transformer. Tapped primary. Secondaries: 350-0-350V 80mA; 6·3V 4A
T3 Mains transformer. Tapped primary. Secondary: 0-250V 25mA

**Switches**

S1 Toggle, s.p.s.t.
S2 Three position: make, off, make; biased off (Bulgin type S.701)
S3 Toggle, s.p.s.t.
S4 Toggle, d.p.s.t.
S5 Rotary, 2-pole 6-way

**Sockets**

SK1 Flush mounting coaxial socket
SK2 4mm socket (red)
SK3 4mm socket (black)
SK4 Mains input socket

**Miscellaneous**

FS1, 2 Fuse cartridges 250mA (2 off)
LS1 Loudspeaker 2½in, 3Ω speech coil
M1 Moving coil meter, 100μA f.s.d.

**Valves**

V1, V2 EF91 or 6AM6 R.F. pentode (2 off)
V3, V5, V7, V9, V11 GS10H Dekatron (Ericsson Telephones) (5 off)
V4, V6, V8, V10 GTE175M Trigger tube (Ericsson Telephones) (4 off)
V12 ECC82 or 12AU7 Double triode
V13, V14 VR150/30 Neon stabiliser (2 off)

**Semiconductors**

D1, D2, D3 OA202 Silicon diode (Mullard) (3 off)
D4-D10 REC.51A Silicon h.t. rectifier (Radiospares) (7 off)

**Sundry Items**

Five B17A sockets (Ericsson); six B7G valveholders; one B9A valveholder; two I.O. valveholders; six valve retainers, B7G type; one valve retainer, B9A type; twin fuseholder; perforated plastics sheet; turret tags; five sub-miniature group panels; four miniature backing plates; five indicator shields N79368 (Ericsson); two pointer knobs; grommets (⅜in and ¼in); sheet aluminium for chassis, case and front panel.

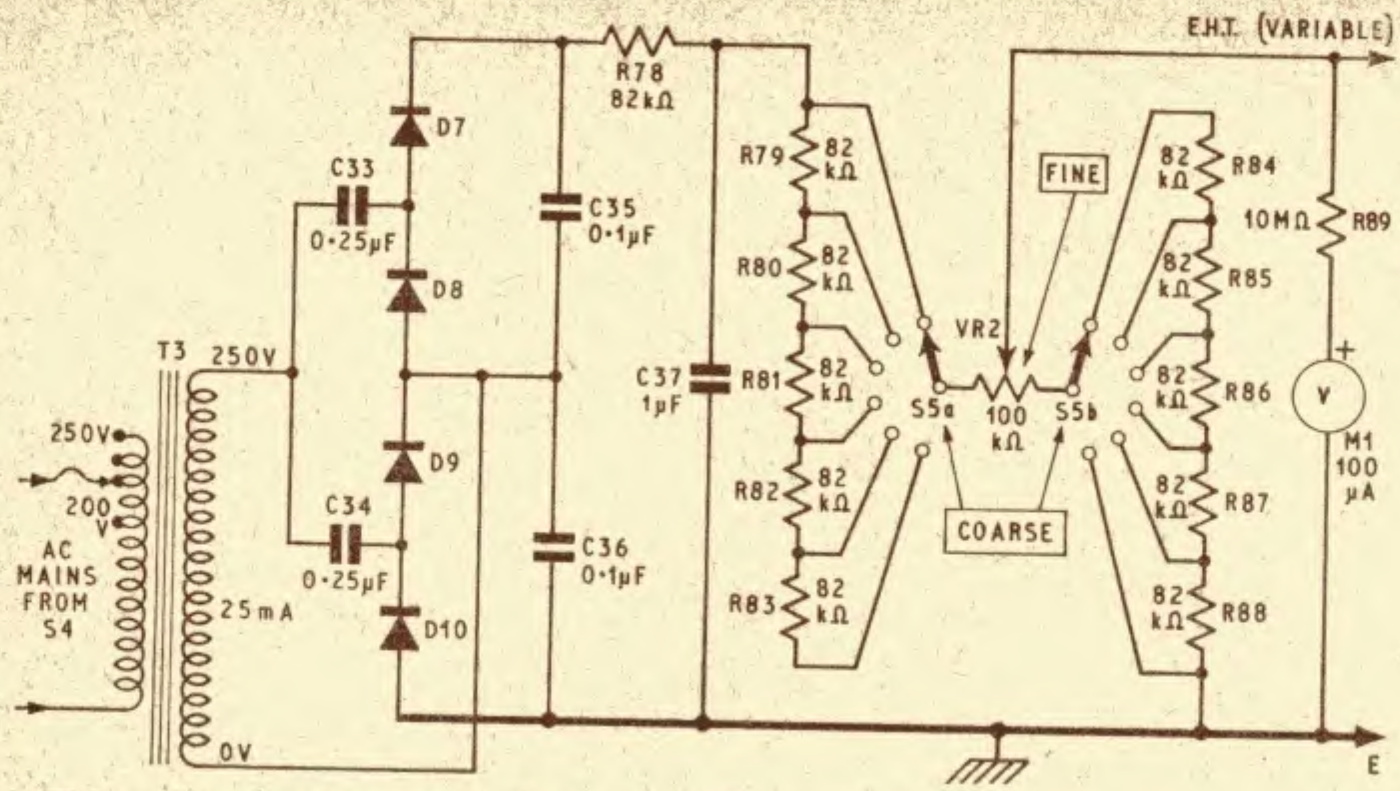



*Fig. 7.* **E.H.T. power supply circuit**

This pulse signal is invaluable in the initial setting up of the apparatus. When not required, the ripple supply is shorted to earth by S1 to prevent hum leaking through to the grid of the first valve (see Fig. 2).

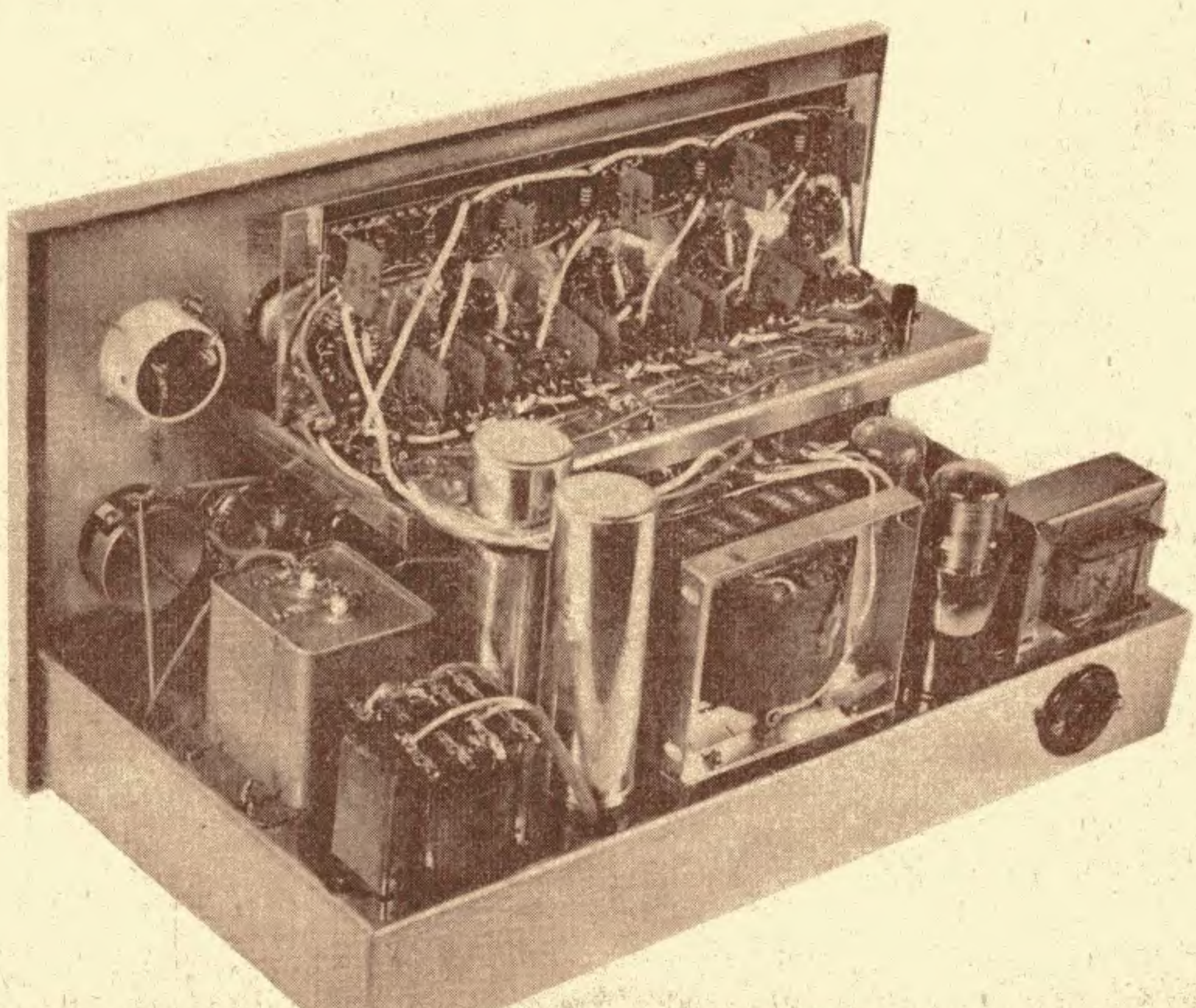
## E.H.T. POWER SUPPLY

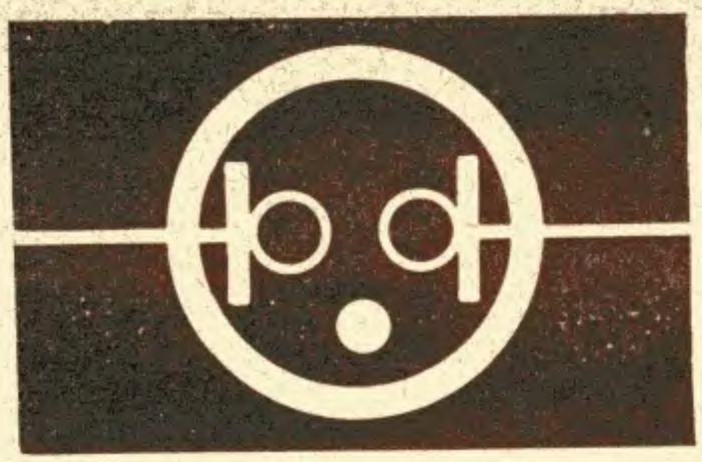
The circuit diagram of the e.h.t. unit is given in Fig. 7.

Geiger Muller tubes require a voltage of about 400V to 800V which must be adjusted to suit the individual tube in use. This e.h.t. supply is obtained from a small inexpensive 250 volt transformer T3 in conjunction with a voltage quadrupler circuit comprising diodes D7 to D10 in association with capacitors C33 to C36. This system increases the safety factor, although care should of course be taken with this voltage.

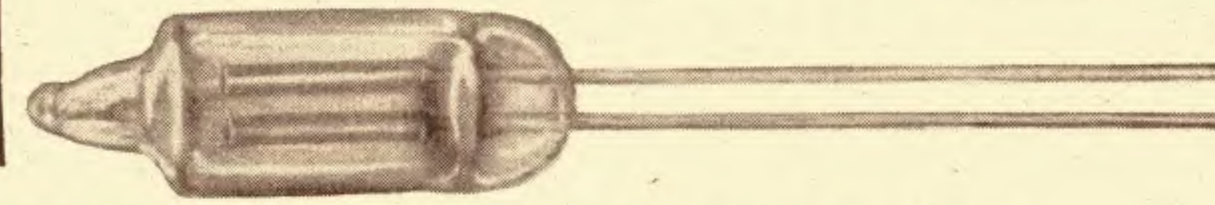
For accurate and reliable control of the output voltage, separate "coarse" and "fine" controls are provided. A wirewound 100 kilohm potentiometer VR2 is used for the *fine* voltage control and a series of resistors R79–R88 in association with S5 for the *coarse* control. A 100 microamp meter M1 with a 10 megohm resistor in series in connected across the output to indicate the voltage. The scale reading must be multiplied by ten and interpreted as volts.

This completes the technical description of the scaler circuit. Next month the mechanical construction will be dealt with. Full details will be given for the preparation of the metalwork and then the mounting of components and wiring will be considered. A complete list of components is included in this present article.





# NEON NOVELTIES



THIS is the second of a series of short articles illustrating some of the many uses of neon lamps. The neons employed are all miniature wire-ended types as shown above.

Two examples which are ideally suited to these applications are those supplied by Radiospares (striking voltage 65 volts), and the Hivac type 3L general purpose neons. The latter type requires a striking voltage of 80 volts and maintaining voltage of 60 volts.

Some neon indicators have a resistor wired in series with one of the neon wires to make them suitable for mains voltages. These would normally be unsuitable for the circuits described unless the resistor is removed or short-circuited.

## TWO HEADS OR TAILS by R. Bebbington GRAD.I.E.R.E.

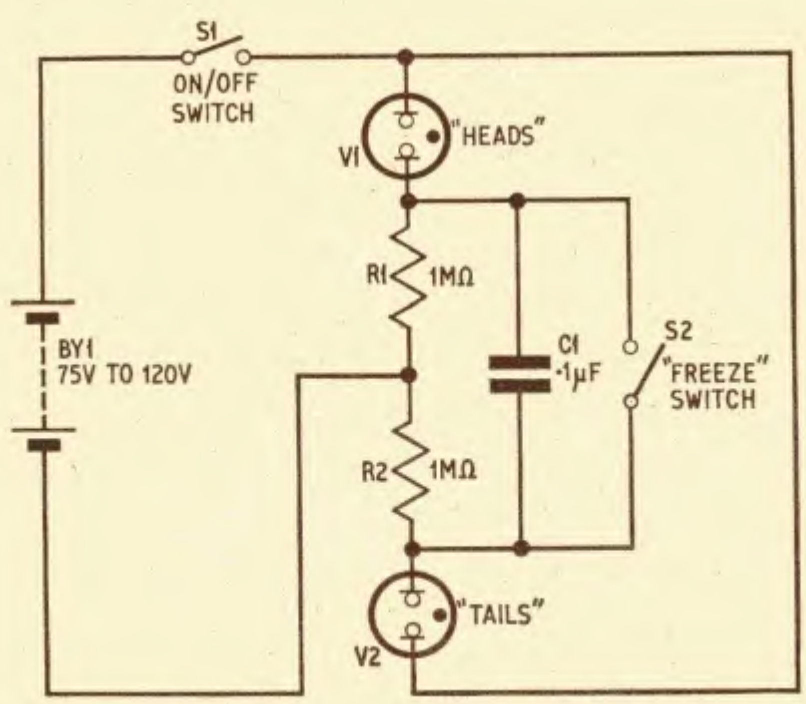



*Fig. 1*

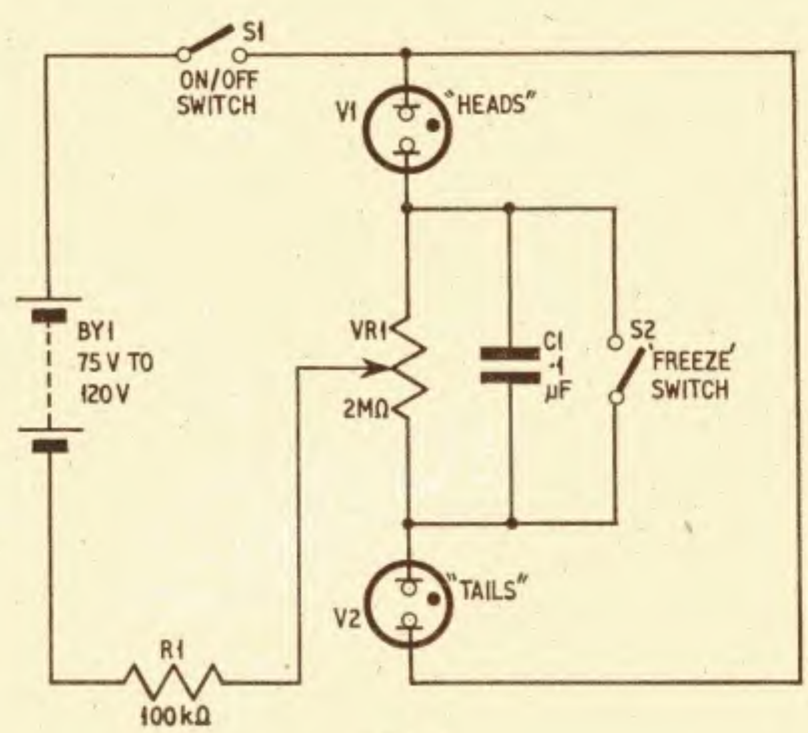



*Fig. 2*

A SIMPLE circuit for the "heads or tails" game is shown in Fig. 1. On connecting the battery the two neon lamps will commence to flash alternately at a rate of about 16 flashes per second. When the "freeze" button is depressed the flashing will cease and whichever neon is "struck" at the instant of pressing, this will remain alight. With the values of the components chosen, the flashing rate is too fast for there to be any degree of skill whatsoever in determining the result. Hence the title, "Heads" or "Tails" circuit. If a slower flashing rate is preferred, larger values of R and C should be employed; some measure of skill is then introduced into the game.

The two 1 megohm resistors may be replaced by a single 2 megohm potentiometer as a means of introducing a "handicap" which can be varied as required since the neons will flash unequally as the potentiometer is adjusted off-centre (see Fig. 2). The battery feed should be applied to the slider via a 100 kilohm limiting resistor as the current through one of the neons would be excessive with the slider at one end of its travel.

A possible variation on the original theme is to duplicate the "freeze" switch so that either player may have an equal chance of making a decision as to when the flashing should be stopped. This would be more exciting at the slower rate as the players could use their skill to "freeze" when the flash was in their favour.

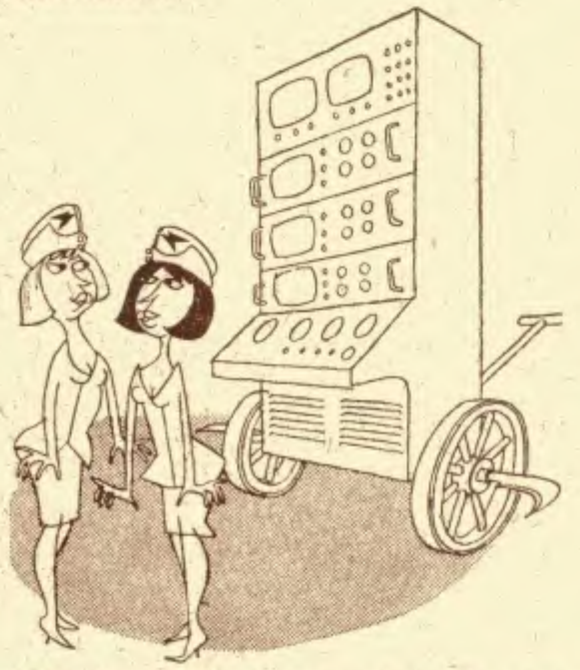
There are several alternative uses to which the basic circuit can be put, especially as the Christmas season looms not too far distant. Winking eyes for large teddy bears or some form of shop window attraction that the would-be customer can control at the touch of a button are just two of the many possibilities.

# DETACHED PARTICLES
## By John Valence

### BIG DECISION

HUMBLE wage slaves like myself have no real idea of the immense problems that face the high ranking executives of industry or commerce. But occasionally the veil is partly lifted and we get a momentary peep behind the scenes at their earnest deliberations. Take BOAC for example. Our major airline has just decided to spend a cool £3½ million on a computer that will enable it to face competition in the jet age with equanimity. Finding the money . . . well that was not really the problem. The real problem was what to call the merchandise.

We have it on the authority of the Corporation that much heart searching went on before the name BOADICEA was finally arrived at. If you can't be bothered to work it out, let me explain that this stands for British Overseas Airways Digital Information Computer for Electronic Automation.



*"Mind you the bottom part is completely British . . . but it plays havoc with your nylons"*

As I have already hinted, this was not the first name proposed. Apparently the BOAC people are not particularly worried over the sex question and "she" might have quite happily become "he" if one of the early suggestions had been adopted: this was BERT (BOAC Electronic Reservations Tabulator).

More surprising was the revelation that Computerised Automation by Electronic System with Automated Reservations was for a time seriously considered. Now what would that intrepid, audacious defender of British soil have thought of *that*. I hate to think. In any case, she would no doubt be highly indignant at this present use of her own name, seeing that BOAC's computer is no native of these isles.

Here in all fairness, and in the interests of Anglo-American relations, let me put the record straight. The major British firms did have the chance to tender for this unique installation, but all had to confess their inability to meet the target date. So that was that, or rather . . . IBM.

Do I see the Minister of Technology wincing each time he passes the defiant statue of this female warrior when on his way to the House?

No, BOAC, not altogether a tactfull choice of name, I guess.

### PERSONALITY CULT

WHY do we give names to computers? This practice, of course, follows naturally enough on from our older custom of naming aircraft and tanks and such like. The Americans on the other hand seem quite happy with impersonal code numbers to identify different craft and equipment. Although, in this connection, I seem to recall that one of the earliest electronic computers built in the U.S. was known as "Maniac". Not exactly flattering.

Perhaps in personifying a computer by giving it a name we are subconsciously accepting its human (or rather superhuman) qualities and recognising that it—he or she—is taking over more and more from us old-fashioned flesh and blood types.

In this "names game" the G.P.O. have had an easier task than BOAC. As automation proceeds apace the postal authorities are building up a nice little family. Already there is ALF (automated letter facer) and ELSIE (electronic scanning equipment). Further happy events are predicted. Oh, I almost overlooked older brother ERNIE. A disappointing lad actually. He has never come up to my expectations.

Finally, I think it must be handed to the Applied Mathematics Dept. of Liverpool University. Their English Electric KDF9 proudly bears the name RINGO. Is this a fluke, or has it been cunningly contrived by these Liverpudlians?

### 25 YEARS AGO

IT does seem almost incredible that a quarter of a century has now lapsed since the Battle of Britain was fought out over and around the south-east corner of our Isle.

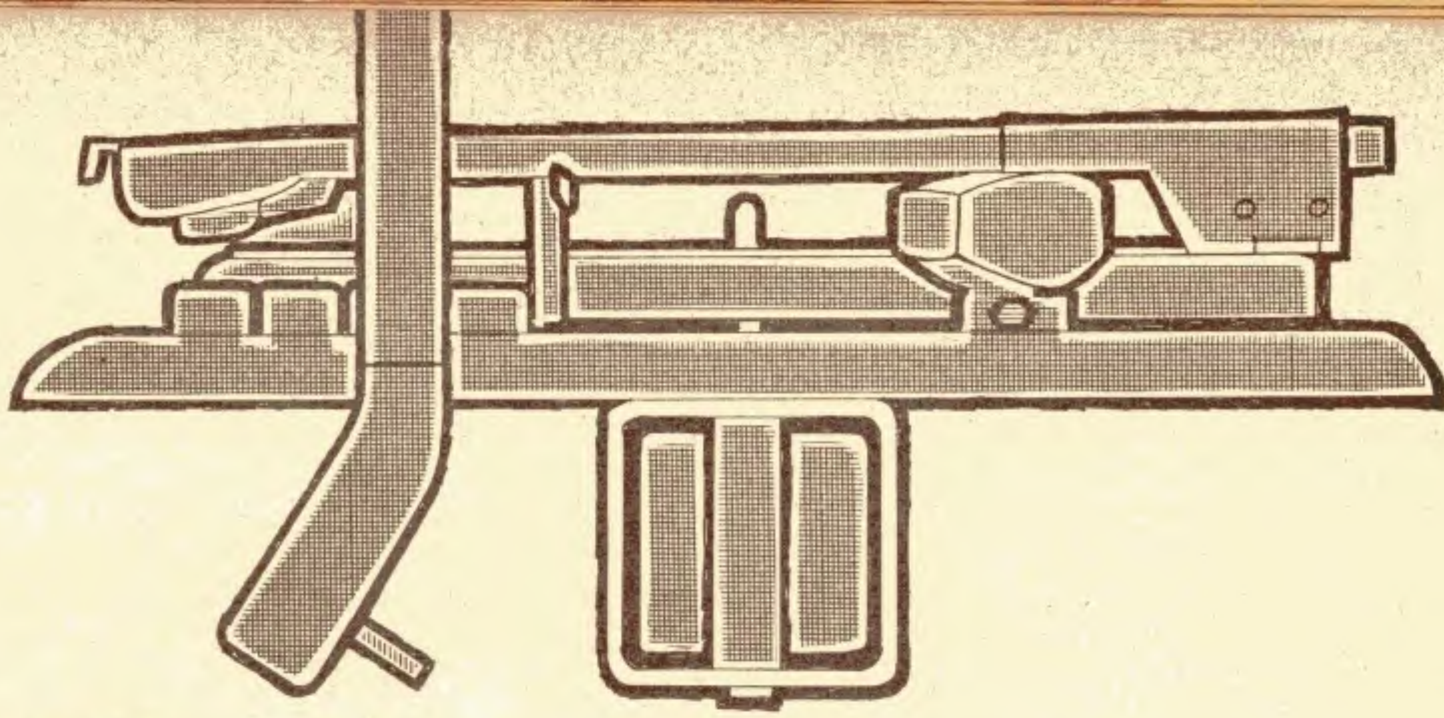
The great air offensive launched on 15 August 1940 culminated in the decisive daytime battle of 15 September. Two days later Hitler called off the proposed invasion operation "Sea Lion".

Of these facts, we are all well versed, perhaps from personal experiences, or at any rate from the recorded history of those momentous days. What is not so generally known is the essential part electronics played in determining the outcome of this desperate struggle.

From later testimony of German air aces, we know that the Luftwaffe was surprised and alarmed by the way our Hurricanes and Spitfires were accurately directed on to their fighter and bomber formations. The secret of this was our advanced electronic technology.

Thanks to our extensive Radar installations the enemy aircraft were under surveillance from the moment they took off from their bases on the Continent. With this intelligence literally before their eyes, the R.A.F. ground controllers were able to plan their tactics and deploy their limited resources of fighters to the best advantage. The link between the ground and the fighter pilot was the then quite revolutionary v.h.f. radio telephone.

To certain far-seeing Ministers and Air Ministry officials who between the wars organised research into the problem of interception of hostile aircraft, and to the teams of backroom boys or "boffins" who got to grips with the problem at a practical level, some of our gratitude for this victory is rightly due. Without this timely harnessing of the free electron in our defence system, today's story would be rather different . . .



# GETTING STARTED WITH DISCS

THERE IS no denying that, as things stand, disc records provide the most generally satisfactory performance in high-quality audio reproduction systems. That is to say, one stands a better chance of securing a *consistently* high standard if care is taken over the choice of equipment and records. High fidelity from f.m. radio is obviously much cheaper, but only occasionally is the all-round quality as good as that from the best of discs (ignoring, for the moment, the question of stereo).

It is not just a matter of frequency response, although even here the use of land lines to carry the signal from studio to radio transmitter often means that the top limit falls far short of the official 15,000c/s target. If realistic results are the aim, dynamic range—the range from quietest to loudest sounds—is at least as important as response. A very good disc will have a range of about 50dB, but the best of broadcasts do not approach this.

As for tape, much depends on the sound sources used. If most of the recordings are taken from the radio, in order to build up a music library, then obviously the results are only as good as the programme material. If the user depends on commercial tape records, he is in for a rather expensive time. Admittedly, if he has a flair for making "live" recordings, then the results may well be as good as those from discs.

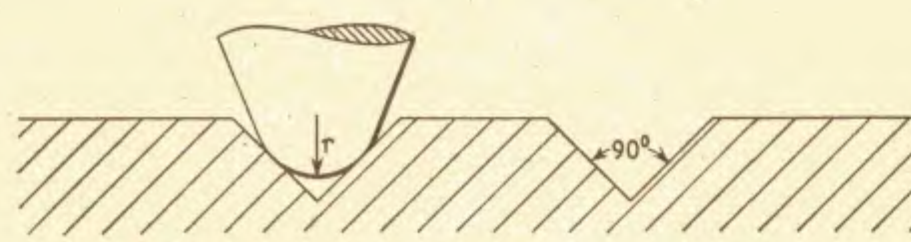
But if the requirement is simply a very wide variety of professionally recorded sound—music, drama and so on—then discs win. The recorded repertoire is enormous; discs are convenient, and competition has cut prices to some extent. (Some of the cheap label issues, at under £1, are very good.)

All this may seem somewhat partisan. Of course, one cannot dismiss tape so lightly. Readers will need little reminding that tape is outstandingly attractive to those seeking a hobby—one that has some very special qualities and technical features. Yet is disc reproduction so very far behind? Although there is no scope for the amateur producer and editor, there is still plenty for the practical man to get to grips with.

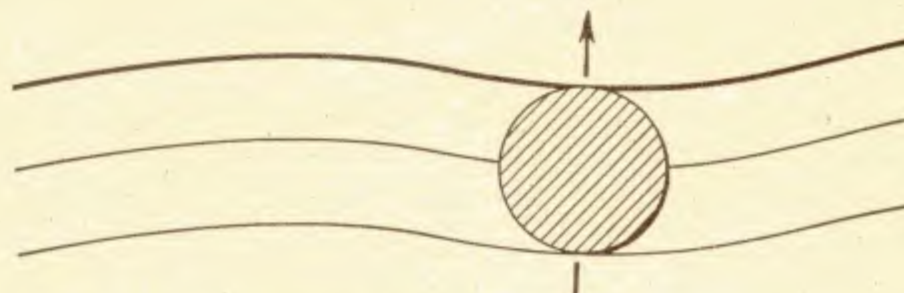
The enthusiast will get the best from his discs by selecting and using components with care; he will take the trouble to acquaint himself with new developments so that he can confidently extend his field of interest. So let us examine the disc and the components used to reproduce it, giving special attention to practical points which will help those turning to audio for the first time.

## GROOVE SHAPE

Although the reasons for the development of stereo hardly come within the scope of this article, it is as well to look at the main features of a stereo disc. It certainly cannot be taken for granted that the interested amateur fully appreciates how, for example, such a disc is traced by the stylus or how the pick-up functions.




*(a) Tip resting in groove; r is the tip radius*



*(b) Stylus moves laterally in a mono groove*

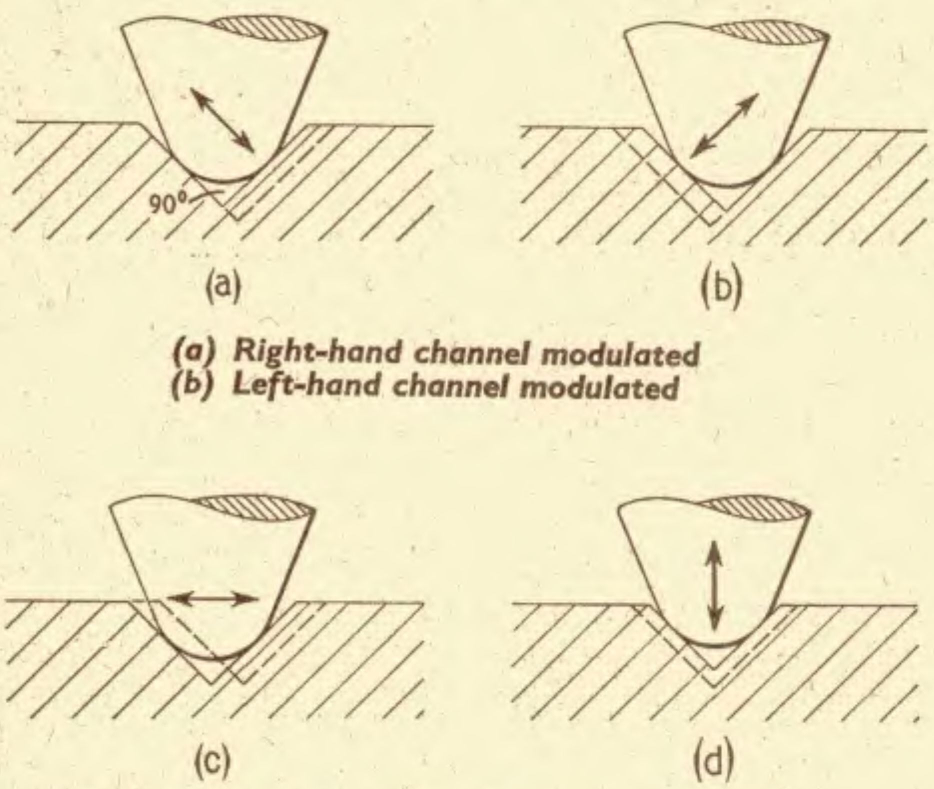
*Fig. 1 Stylus tip and groove*

Compared with mono, the stereo groove—and therefore the movement of the stylus that traces it—is of course quite complex. In monophonic recording a groove is formed in the disc (actually a lacquer blank, at the start of the manufacturing process) by a cutter which moves laterally—that is, side to side. A cross-section of the groove together with the tip of the stylus is shown in Fig. 1a.

Thus the stylus moves laterally when tracing this groove, as shown in Fig. 1b and it is clear that this is the only movement needed for the reproduction of a single channel of information. The depth of the groove does not change.

In stereo recording an unmodulated groove would be essentially the same as a mono groove. But it is necessary to accommodate two separate channels of information in such a way that they can be traced by one stylus. Note that two channels are the limit. Multi-channel recording can be done on tape, and indeed it is often undertaken in the recording studio; but whatever the techniques used there, the signals

***Fig. 2 Movement of stylus in stereo groove***




***(a) Right-hand channel modulated***
***(b) Left-hand channel modulated***

***(c) Both channels modulated equally and in phase***
***(d) Both channels modulated equally and in opposite phase***

must be presented in two channels when the time comes to record the disc. Therefore one signal is cut on each groove wall; each "modulation" is geometrically at 90 degrees to the other but at 45 degrees to the surface of the disc.

This is called the "45/45" system, which has now been adopted as standard practice by the recording companies. The simplest way of visualising the system is to study the four basic modes of stylus movement, as indicated in Fig. 2.

When the right-hand channel is modulated, the stylus is pushed up and across at 45 degrees to the surface of the disc; and with left-hand modulation the movement is up and across in the other direction. If both channels are in phase and equally modulated, the width and depth of the groove remain constant and the stylus is moved sideways (this is the same as mono); but if the channels are in opposite phase, the groove width and depth change and the stylus moves upwards. Of course, a music signal is complex, and the stylus is moved in an unimaginable variety of slanting, vertical and lateral directions, depending on the relative amplitudes and phases of the signals.

## STYLUS SIZE

This brings us to the question of stylus size—or rather, the size of the tip which fits into the groove. It is a matter on which there is often misunderstanding, and certainly it is one on which the beginner needs guidance. The stylus is in most cases conical with a spherical tip and, in the interests of long life and reduced record wear, it is of diamond in practically all but the cheapest pick-ups. A modern development is the elliptical stylus, but for simplification of the argument this type must be disregarded for the moment.

The best tip size for stereo is 0·0005in radius (otherwise known as a "half-thou"), and it is advisable to use this size for most high-quality applications, including the more modern mono discs. But remember that this is not the dimension across the tip: it is the *radius* of the tip, as indicated in Fig. 1. The stereo tip is half the size of that used for mono.

An important qualification has to be introduced here. The half-thou tip is the one to use if the playing weight of the pick-up is suitably low—about 3 grammes or less. If the tip radius is half of that used for mono, the tip area is smaller by another factor of two. Therefore the pressure on the stereo groove is four times that on its mono counterpart, and the stereo pick-up must track at a suitably low weight.

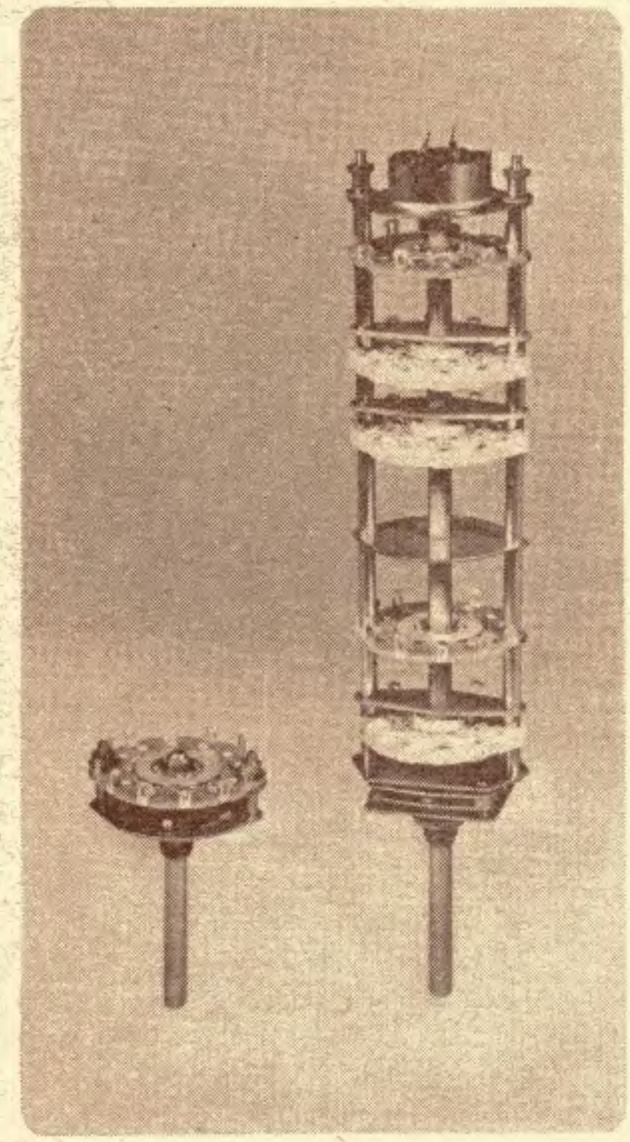
It is perhaps unlikely that the serious hi fi enthusiast will use a playing weight substantially higher than about 3 grammes; but if he does he should fit a stylus with bigger radius. A tip radius of 0·0007in is usually offered. It is more useful to think of stylus size and playing weight in this way than to regard the 0·0007in tip as a compromise that is vaguely somewhere between the mono and ideal stereo sizes.

In fact it is not a bad idea to have a separate pick-up head with the 0·0007in tip for the reproduction of a mono collection, especially if this includes older discs. But if the stereo pick-up is a good lightweight model, a half-thou tip is essential, and this can be used successfully on very many mono discs as well as for stereo. What it amounts to is that the stereo pick-up can also be regarded as a mono pick-up: it is only a matter of the way in which its outputs are connected; the amplifier mono/stereo switching usually takes care of this aspect.

These matters raise others in turn, such as the advantages of the elliptical stylus and the special requirements for an arm which will enable a stereo pick-up to track at a very low weight. Above all there is the question of choosing between an ever-increasing variety of pick-ups. Shall it be magnetic or ceramic? How will its characteristics affect the amplifier you wish to construct?

A later article will return to such points as these. For the moment it is appropriate to conclude with a reminder—needed by the uninitiated—that a mono pick-up must *not* be used on a stereo disc. It will destroy much of the stereo information and cause a good deal of damage. A stereo pick-up is safe on any microgroove disc, but whether it gives a satisfactory performance will depend on whether the stylus used is the right one for the job.

# NEW PRODUCTS



## "Custom-built" Switches

**Specialist Switches Ltd., 23, Radnor Mews, London, W.2.**

Our photograph shows just two of the many switches that have been built to individual requirements by Specialist Switches Ltd. These switches can be made up as required for prototype apparatus and the large switch shows a range of s.r.b.p. and ceramic wafers, inter-wafer screening, mains switch and heavy duty click mechanism that are available. The small switch is a single-wafer, 6-pole, on/off s.r.b.p type.

The price of switches complete with one wafer ranges from 7s 3d to 9s 5d according to type. Additional s.r.b.p. wafers cost between 3s 2d to 5s 2d. For switches with ceramic instead of s.r.b.p. wafers, 3s 0d per wafer is added to the price of the switch.

This "one-off" service will obviously please a number of experimenters as this gives greater scope when designing equipment. Rather than having to restrict himself to using standard switches, the designer can consult the above firm to see if it is possible to make up the type of switch he wishes to use.

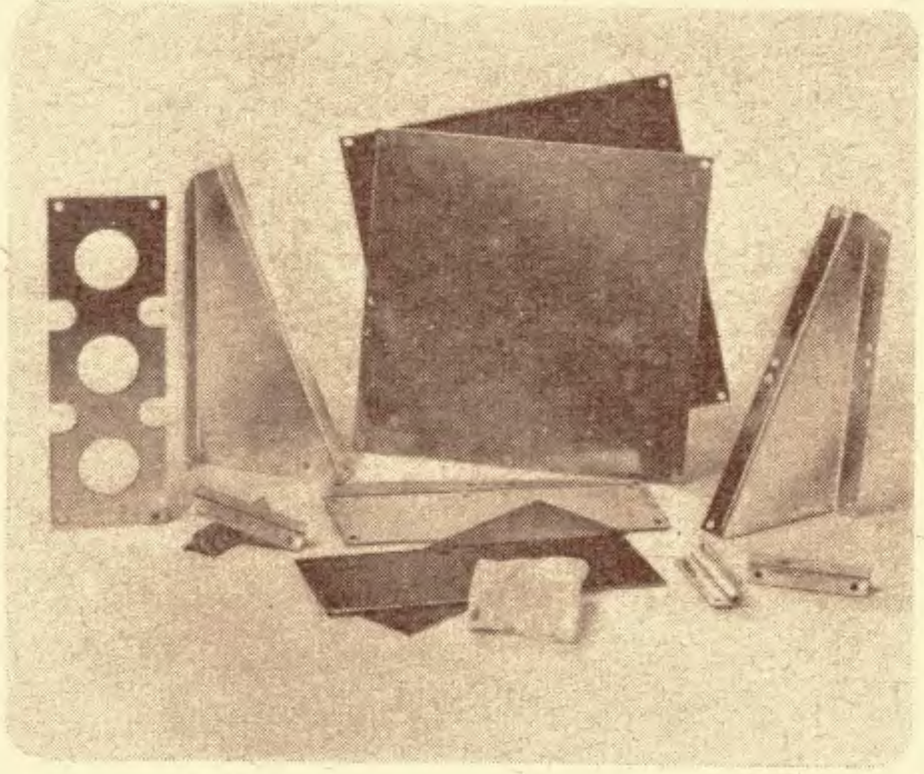
## "Masterbox" Kits

**Cockrobin Controls, 36, Villiers Avenue, Surbiton, Surrey.**

The rather strange looking items depicted in the photograph are just a few of the new "Masterbox" components. This new type of box has been designed to help amateurs as well as professionals to build small switchboards and indicator panels from a kit of parts. The principle on which "Masterboxes" are built up should be of particular appeal in experimental work where frequent alterations and extensions are required.

The boxes are built up from standard units making two sizes: 3in by 3in by 2·03in and 6in by 6in by 2·03in. Any number of units may be assembled together to build up almost any desired size of panel within the limits of multiples of the basic sizes. Alterations to the layout of equipment can be made by replacing the standard 0·08in thick aluminium alloy face panel. If new face panels are used they can be cut and drilled to the new dimensions with provision made for cable entry.

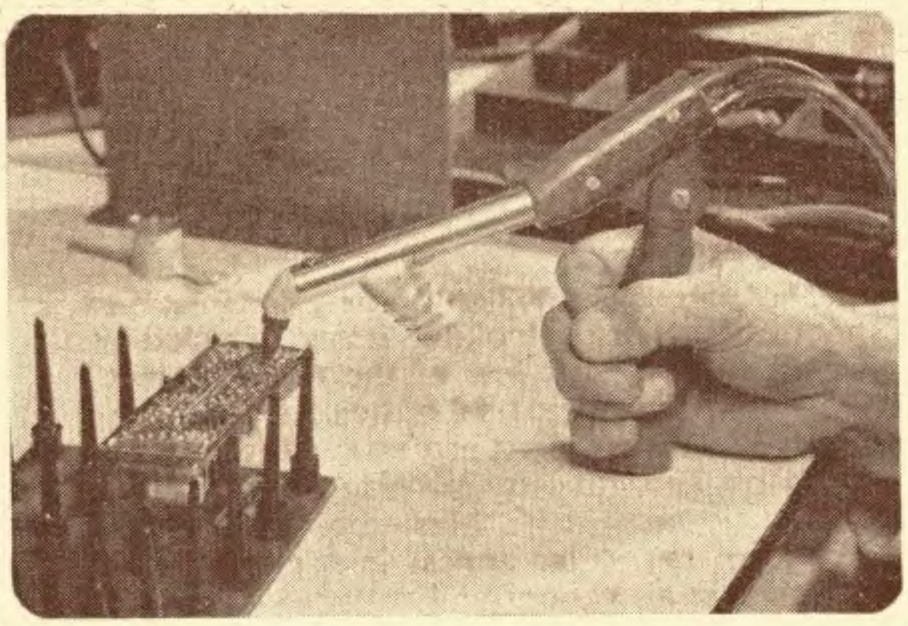
Parts are supplied either separately or in kit form. The standard kit contains four aluminium alloy corner posts, four 0·05in thick steel plates with dark green p.v.c. laminated finish, and front and back panels of aluminium alloy. A packet of cadmium plated steel nuts and screws are included to make up a complete kit.



Additional kits are available to supplement the standard kit. These are the extension type, given the suffix "X", and the corner type with the suffix "Z".

The "X" kit contains only two side panels and one 0·1in thick aluminuim alloy perforated panel, for wiring within units. The "Z" kit has no side panels but has two partition walls. The appropriate screws and nuts are provided.

Special mounting brackets are available for mounting at an angle of 22½ degrees from a horizontal or vertical position.



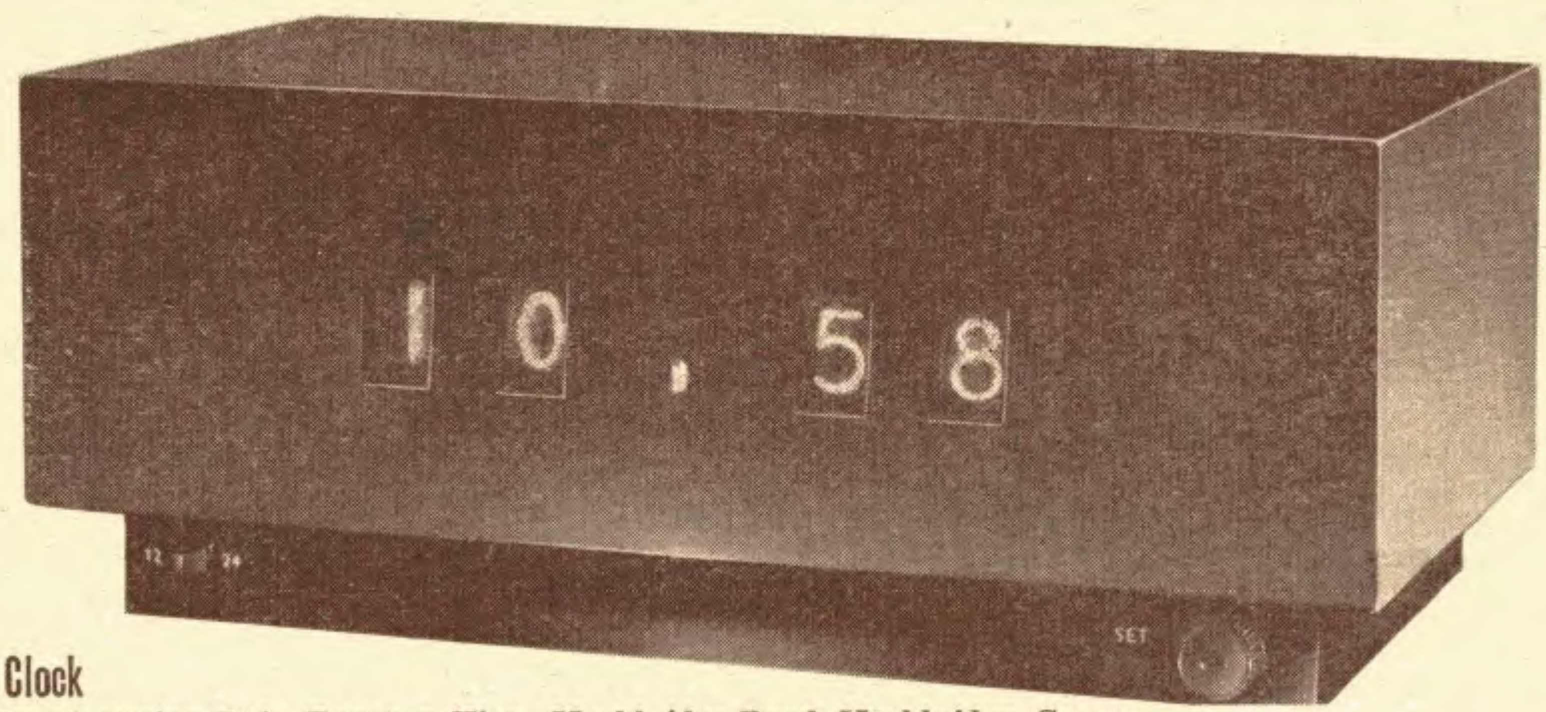
An aspirated soldering iron, which was first demonstrated in prototype form last year, is now readily available from all official Philips service agents. This new tool has been specially developed to simplify the removal of components and solder from printed circuit boards during servicing work.

Our photograph shows how the hollow copper-beryllium bit is placed on the joint to be unsoldered, the solder being sucked away as it is melted. Air suction is applied by a connected footpump; the solder is stored in the solder pot screwed to the barrel of the iron for removal later.

The complete unit comprising the iron, stand, spanners and footpump costs £6 17s 6d net. There are three versions available, 230/250, 200/220, and 110/125 volts. Orders should quote the code number HY. 140.83 and voltage.

## Aspirated Soldering Iron

**Philips Electrical Ltd., Century House, Shaftesbury Avenue, London, W.C.2.**




## Electronic Clock

**Darang Manufacturing Ltd., Restmor Way, Hackbridge Road, Hackbridge, Surrey.**

The first of its type to be produced for general sale, the "Digicron" electronic clock offers a highly efficient method of showing and recording the time. The clock displays the time on four digitron tubes showing the hours and minutes in illuminated figures.

The design makes use of a number of plug-in printed circuits; 12- or 24-hour display can be selected by operating a switch located on the front panel. A second control sets the digits to the required time.

The clock has accessible built-in fuse protection, the consumption of the clock being approximately 25 watts. Power and timing are derived from the 50 cycle mains supply, the operating voltage of which can vary from 190 volts to 260 volts without affecting the accuracy. The retail price is in the region of £90.

## Lantern Torch

**Vidor Ltd., Erith, Kent.**

Vidor Ltd. announce a new and improved version of their popular lantern type torch.

Known as the CN 9005A, it is an improved version of the CN 9005 lantern. The main differences are the main beam swivel head, all metal chrome plated casing, preset handle positioning to eight angles, and an interchangeable red or clear dome for the flashing beacon.

The CN 9005A torch has numerous uses, both indoors and outdoors, and retails at 17s 6d.

# Readout—
## A SELECTION FROM OUR POSTBAG

### It's a puzzle

Sir—Mr. S. C. Hooson's circuit ("Powerless Experience", August *Readout*) will work without a battery due to the leakage of C3 (200$\mu$F). Likewise, V1 will be cut off by the application of the battery. The voltage available to work TR1 comes from the cathode bias network of V1. The 2·2M$\Omega$ grid leak acts as a collector load.

For satisfactory results, C3 should be reduced to about 0·1$\mu$F as the input of V1 is high and not low impedance.

There are other and better low and high impedance matching circuits, but this will work provided C3 is reduced as outlined above.

A. M. Levett,
Horley,
Surrey.

Sir—Regarding S. C. Hooson's "Powerless" pre-amplifier, it seems to me that originally he was operating the transistor with no collector load at all, which would result in no signal being developed across the coupling capacitor C3, as well as over-running the transistor. When he put in the 10k$\Omega$ load all was well.

As to operating it with no power at all, this is, of course, a wrong assumption. The collector voltage is being applied by the few volts of negative bias through the 2·2M$\Omega$ resistor in the valve grid circuit due to the leakage of the 200$\mu$F coupling capacitor.

N. Sanders,
Langley,
Bucks.

### . . . so is this

Sir—Reading S. C. Hooson's account of a "Powerless" amplifier reminded me of an amusing experience of my own.

During the war I constructed a simple l.f. oscillator, using a battery triode valve and an intervalve transformer, for the purpose of morse practice. A rheostat was used to vary the filament voltage and thus the pitch of the note and h.t. was supplied by an old a.c. battery eliminator.

On switching on, the oscillator "fired" immediately and I turned the rheostat to vary the note. This increased in pitch up to about 1,000 c/s. When the rheostat slider reached the end of its travel, I then noticed that the slider had left the winding and was in effect open circuit.

A voltmeter placed across the filament pins read zero. Removal of the valve made no difference to the performance, the oscillator continuing to function without it. The explanation presented itself to me after a few astonished minutes.

T. Howells,
Newhaven,
Sussex.

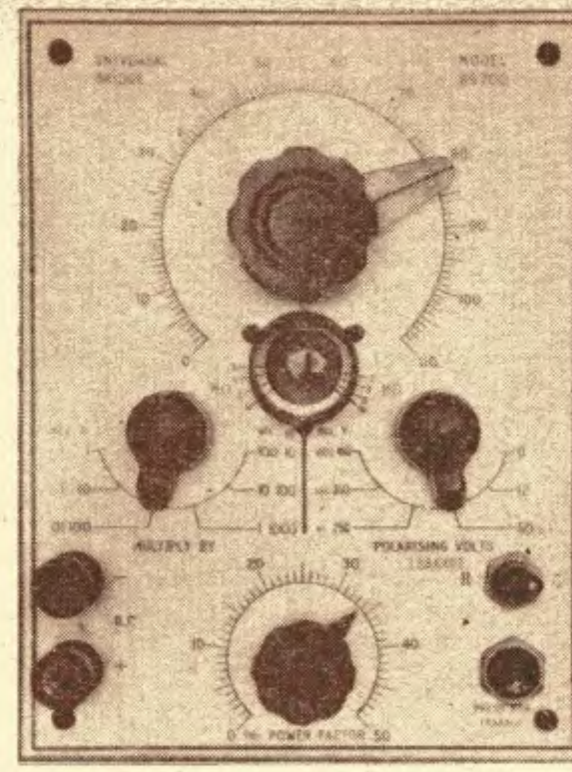
### An invitation

Sir—This Society is holding its seventeenth Exhibition of Cardio-Pulmonary Apparatus at the Londoner Hotel, Welbeck Street, W.1, from 4.0–9.0 p.m. on Friday, 5th, and from 9.30 a.m.–1.0 p.m. on Saturday, 6th November, 1965.

Approximately twenty exhibitors will be showing the latest equipment in this specialised field. I shall be pleased to send complimentary tickets to anyone who would like to visit the Exhibition.

I feel sure this will be of interest to many of your readers.

Margaret Hale, F.S.C.T.,
Exhibition Secretary,
The Society of Cardiological
Technicians of Great Britain,
Cardiac Research Dept.,
Guy's Hospital,
London, S.E.1.



### Recognise this?

Sir—I enclose herewith a photograph of an R–C bridge with which I am having trouble. Could any of your readers please advise me of the manufacturer to enable me to obtain repair information.

E. E. Gatenby,
Kloof,
Natal, S.A.

### Who's for tennis?

Sir—I strongly disagree with John Valence's remarks (*Detached Particles*, June issue) concerning the dubious advantages of electrically powered lawnmowers.

I have used one of these machines for over 10 years now. The cable is 150ft long and provided you turn the right way at the end of each row, according to where the power point is situated, there is no danger whatsoever.

In my opinion the battery powered lawn mower has dubious advantages in that it will only do approximately two tennis courts before it needs recharging, if the grass is long it will do considerably less. If one has limited storage space you cannot tip the battery mower on its back like the electric one because the acid will spill out of the battery.

So I think John Valence should think again before condemning the electric mower in future.

B. B. Jacques,
Holmesfield,
Nr. Sheffield.

# Readout—
## A SELECTION FROM OUR POSTBAG

*continued*

## Testing diodes

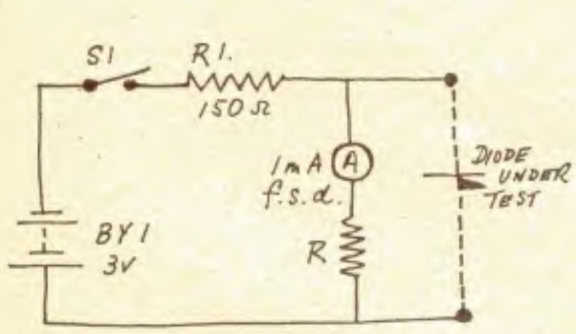
Sir—In your feature, *Ingenuity Unlimited*, the section on Testing Diodes by B. J. McNaughton (August issue) was, I thought, very good. But I am afraid the writer has put unnecessary limitation on his very original circuit.

To quote the relevant paragraph: "A 6V 60mA lamp gives a calculated power dissipation of 360mW. Clearly any diode rated at about ½ watt or above could be safely tested". This is the power in the lamp and not in the diode under test. The power dissipated in the test diode is calculated from the current flowing and the forward voltage drop $V_f$ in the test diode. Typical values for $V_f$ are given in the table.

This does not mean that the diodes cannot be damaged. 60mA is quite a high current to test small signal diodes.

Another simple test circuit is shown below, where the $V_f$ is measured at 20mA. The meter is scaled 0–3 volts and reads the $V_f$ directly. $R$ will be 3 kΩ less the meter resistance. On reversing the diode, the meter should read f.s.d.

| GERMANIUM | | | SILICON | | |
|---|---|---|---|---|---|
| CODE | Vf | POWER | CODE | Vf | POWER |
| GD8 | 3V | 180m/W | OA202 | 1V. | 60m/W |
| GD11 | 2V | 120 | SX641 | 1·3V | 78m/W |
| OA10 | ·4V | 24m/W | | | |
| OA5 | ·37V | 22m/W | | | |




A. Thomas,
Potters Bar,
Herts.

## Equivalents please

Sir—I feel that other readers would appreciate it if you could give equivalents to diodes, transistors, and more details about transformers than you do at present. There are several such pieces that we are unable to obtain in New Zealand.

It would also be of great help if you could publish more details about particular pieces of equipment, for example, average noise levels, frequency response, etc., of the prototypes of the magazine articles.

R. C. Harris,
Hamilton,
New Zealand.

## Vacuum v solid state

Sir—Mr. Gay (August *Readout*) has missed the point regarding relative values of valves and transistors! I speak as one who has built many hi fi amplifiers of both types.

The figures he quotes are meaningless in isolation! What kind of associated equipment is used? Will his speaker reproduce 150 kc/s at 0·05 per cent distortion? What is the response of his radio, gramophone pick-up and tape recorder?

How many parasitics has his amplifier got? (I, too, have used EL34's—'nuf sed!)

The first thing that strikes one on hearing one's first high power transistor amplifier is the wonderful clarity — no unexplained "rattles", no muzziness in the upper register (my ears cut off at 13·5 kc/s!) due to the absence of inductive components, of course.

No, I shall never use valves again for audio.

R. G. Young,
Peacehaven,
Sussex.

Sir—Mr. Gay's letter in the August issue must not go unchallenged. The attainment of low values of distortion using power transistors is not a function of the devices used, but of overall loop gain and the amount of negative feedback usable.

Mullard have published a circuit diagram of a 10 watt stereophonic amplifier with 0·06 per cent distortion and as recently as June this year I constructed a 15 watt amplifier whose distortion was below 0·025 per cent—the lowest value I could measure with the equipment available. The frequency response is not an important factor, since linear amplification from d.c. to 100 Mc/s is easy with transistors.

I repeat, valves are "old hat" except for special applications. Mr. Gay too had better get with it!

D. R. Bowman,
R.A.F., Henlow,
Bedfordshire.

# AUTUMN LECTURES

### *Radar and Electronics Association*

The first lecture of the Radar and Electronics Association for Autumn 1965 is entitled "Transmitting Aerial Systems for Television Broadcasting on U.H.F.", the lecturer being Mr. C. G. Platts, B.Sc., who is a member of the B.B.C. Engineering Division.

The meeting will be held on Tuesday, 12 October 1965 at The Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2., commencing at 7 p.m., with refreshments available (2/6) from 6.30 p.m.

### *The Television Society*

The opening meeting of the 1965/66 Lecture programme to be given on Thursday, 30 September 1965 by Mr. I. F. Macdiarmid, A.M.I.E.E., of the Post Office Research Station will be "An Introduction to Waveform Testing Methods in Television".

This meeting will be held in the I.T.A. Conference Suite, 70 Brompton Road, London, S.W.3. commencing at 7.00 p.m.

This is the first of two tutorial dissertations intended for the engineer who wishes to broaden his understanding in fields of television engineering outside that of his own specialisation.

Members and visitors are cordially invited to attend this meeting and tickets for non-members may be obtained from the Administrative Secretary, The Television Society, 166 Shaftesbury Avenue, London, W.C.2.