Practical Electronics

NOVEMBER 1965

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VOL. 1 No. 13
NOVEMBER 1965

Practical Electronics

TECHNOLOGY AND EDUCATION

TECHNOLOGY has now become a fashion word. The creation of a ministry devoted to the promotion of technical advancement in industry has focused much attention on this subject. The need for such Governmental sponsorship is generally accepted; at least, no one is likely to deny the importance of keeping in the van of technical progress.

But much remains to be done to dispel old prejudices in education. Arts and pure science have long been upheld as the highest intellectual attainment, while the practical application of such arts has been stigmatised as a somewhat lower form of human activity.

* * *

Happily, there are signs that a reorientation of ideas is taking place among leading figures in the educational world. And, interestingly enough, these new thoughts are germinating not only in technical circles, but in what one might consider to be conservative areas of influence.

In this year's presidential address to the Education Section of the British Association, Mr. J. C. Dancy, Master of Marlborough College, developed the theme that some experience of creative technology is an essential part of a liberal education.

There were (Mr. Dancy said) both theoretical and practical reasons for regarding technology in secondary schools so highly. The gist of his argument was as follows.

Technology involves a threefold creative activity: of intellect, of hand, and of eye. It thus embraces the skills of the scientist, the craftsman, and the artist. Creative technology is necessary to counterbalance the undue emphasis at present given to analytical faculties as in pure science.

* * *

Dealing with the practical argument, Mr. Dancy first made reference to the fact that creative work does bring its own reward, by satisfying a deep instinct in all of us; then he referred to a sociological aspect that will have increasing importance in the future. It is generally accepted that a reduction in working hours will be the outcome of extensive use of advanced technical processes in industry and commerce. The increased leisure time will tax the resources of everyone. Here then is one of the main tasks of modern education—to prepare us to cope with the leisure of tomorrow.

In the concluding portion of his presidential address, the speaker recognised that the do-it-yourself habit has become part of our way of life and that it will play an increasingly important part in the future. We quote: "So the skills developed in creative activities at school have no lesser scope than a lifetime of fruitful use—in leisure time for some, but for others in their vocation".

THIS MONTH

CONSTRUCTIONAL PROJECTS

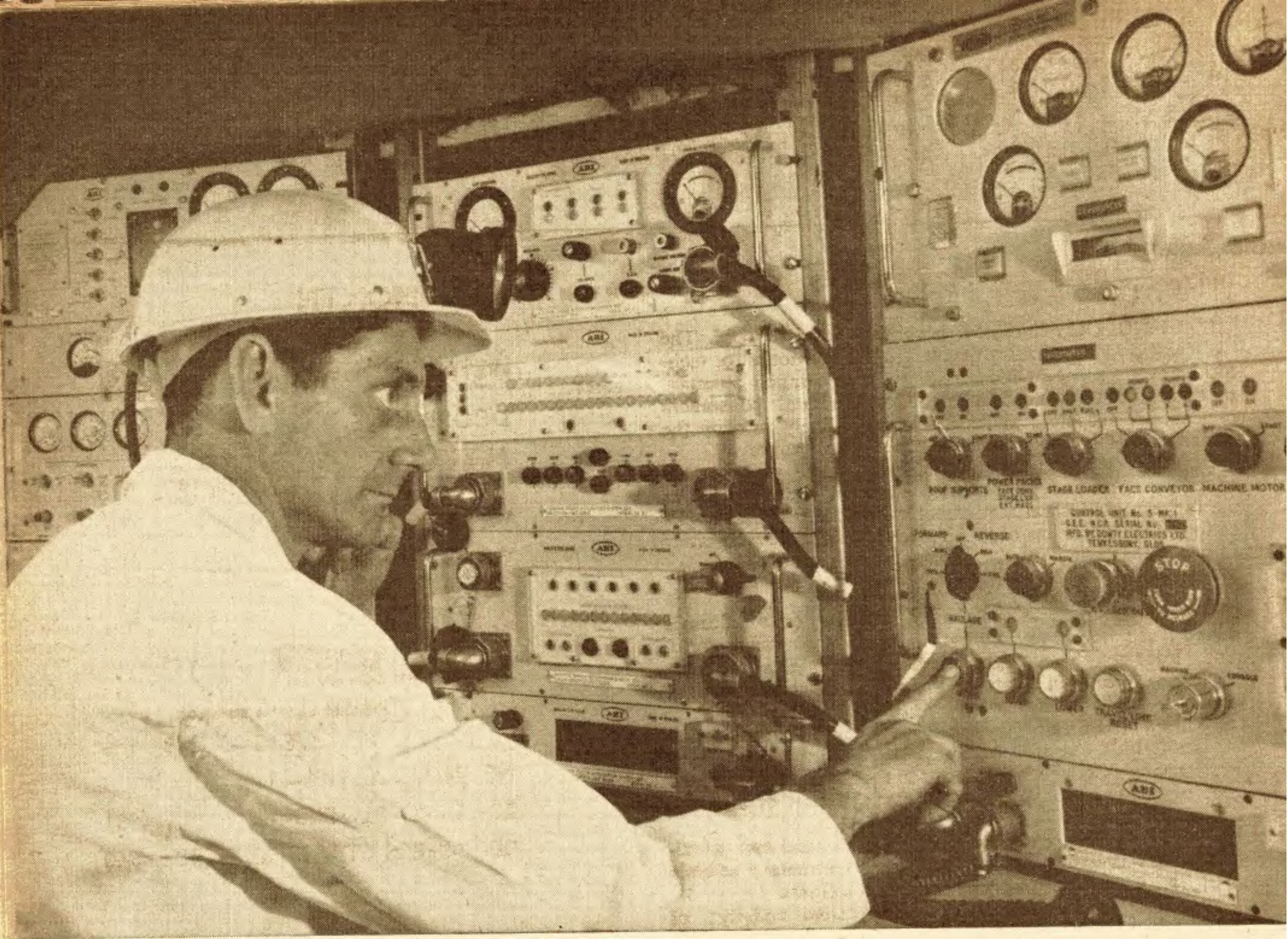
SPECIAL SERIES

GENERAL FEATURES

NEWS AND COMMENT

Our December issue will be published on Thursday, November 11

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, 36s.



ELECTRONICS AT BEVERCOTES

An account of the world's most advanced coal mine. In this "mine of the 21st Century" all the complex coalface machinery is controlled by one white-coated collier sitting at the control panel away from the coalface. Semiconductors make possible the large-scale use of electronics underground.

COALFACE mechanisation is now so widespread that it accounts for more than 80 per cent of the total output from British mines. But just as mechanisation has rendered the pick and shovel obsolete, so will new developments exploiting the opportunities provided by electronics soon make conventional mechanisation out of date—for a revolution is taking place underground, and modern technology is being applied to revitalise one of the oldest industries.

The world's first remotely operated mine at Bevercotes, Notts, will shortly be producing coal for electricity power stations. In addition to being a production unit, Bevercotes is a field laboratory. Here work will continue into the further use of electronics and new developments will be tried out under actual mining conditions. These further developments will be the final steps towards the *fully* automated mine which experts confidently predict will within 10 years account for at least 50 per cent of the National Coal Board's output. New ideas proved at Bevercotes colliery will be extended to other pits wherever possible.

The reason for the National Coal Board's intensive research and field testing of new devices and systems is essentially economic: the need to produce coal at a competitive price in answer to the challenge from other power station fuels, particularly oil—and to achieve this despite a continuing decreasing manpower force in the industry. This apart, there is the very important human factor. The introduction of remotely controlled coal cutting machinery has already reduced the hazards faced by underground workers. As progress continues, a new type of miner will take over the comparatively few tasks remaining to be performed by humans, and he will be a highly skilled technician tending to some of the most sophisticated equipment found in any industry.

SIGNIFICANCE OF SEMICONDUCTORS

A couple of decades ago, before the advent of solid state devices, the large scale use of electronics equipment in a coal mine was entirely out of the question. The nature of vacuum valves, their need for high voltage supplies, the heat they generate, and their physical frailty, make them quite unacceptable for use in the potentially dangerous environment below ground.

In contrast, semiconductors with their meagre appetite for electric current and their general robust nature have made it possible to design and build electronic units that are intrinsically safe against fire or explosion, and that are in all other respects entirely suitable to withstand the conditions peculiar to a coal mine.

Bevercotes is a mine of great interest for the electronics enthusiast. Before briefly describing the principal electronic systems incorporated in this "mine of the future", it will be useful to have a quick look at the general organisation of the mine and to note the progress of the coal from coalface to the special railway train which takes it away to the electricity generating station.

THE MINE IN ACTION

Coal will be obtained from five longwall faces, each approximately 270 yards long. The remotely operated longwall face has been in use in mechanised mines for some eight years; known as ROLF, it is a complex piece of machinery, including mechanical, hydraulic, electrical, and electronic equipment. It is based on an armoured conveyor with a number of self advancing hydraulically powered props, which support the roof. Cutting picks are mounted on a drum and this revolves as it is pulled along above the conveyor, the coal cut from the virgin face being deflected onto the conveyor by a plough attached to the machine. The armoured conveyor delivers the coal to a stage loader in a roadway running at right angles to the longwall face.

Both the power loader and the hydraulic supports are remotely operated from a control console mounted on the remote end of a rail mounted structure known as the pantechnicon which extends back down the roadway. The console is shown in our heading photograph.

From the stage loader, the coal is transported by a belt conveyor system and finally fed into a 1,000 ton capacity [underground bunker. Coal is discharged from the bunker via a skip feed conveyor. The skip is wound some 3,000 feet to the surface, and the coal discharged onto a conveyor feeding the coal preparation plant.

This plant has a capacity of 600 tons per hour and is designed to produce a product having an ash content of 15 per cent and a moisture content of 12 per cent suitable for use in electricity generating stations.

The blended product is delivered to the outloading bunkers which are built over a railway track. When a train is correctly positioned under the bunkers, coal is fed into four weighing hoppers which are weighed automatically before being discharged into four separate rail wagons. The net weight of coal discharged in the wagons is automatically recorded on an advice note. The train is repositioned by the engine driver and the procedure repeated until the whole train has been loaded.

SECTOR CONTROL

Bevercotes is equipped with an extensive remote control scheme, operated from several manned control points. Each controller is responsible for a specific area of operation known as "control sector" and is under the overall direction of the central controller located on the surface.

The sector control positions are as follows:

1. Remotely operated longwall faces. 2. Underground transport (coal, men, material and dirt). 3. Shaft No. 1. 4. Shaft No. 2. 5. Coal preparation plant. 6. Surface and underground ancillaries.

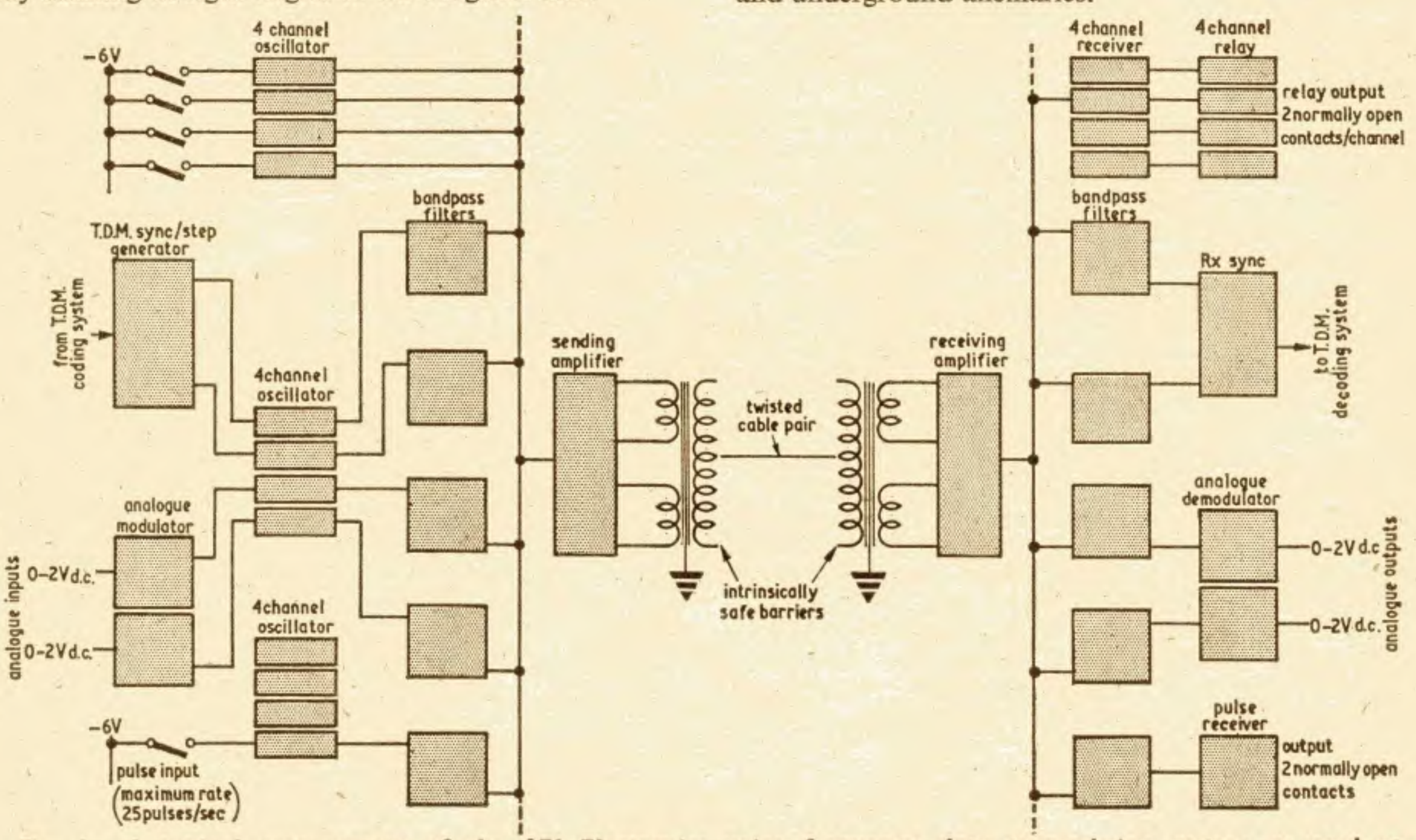
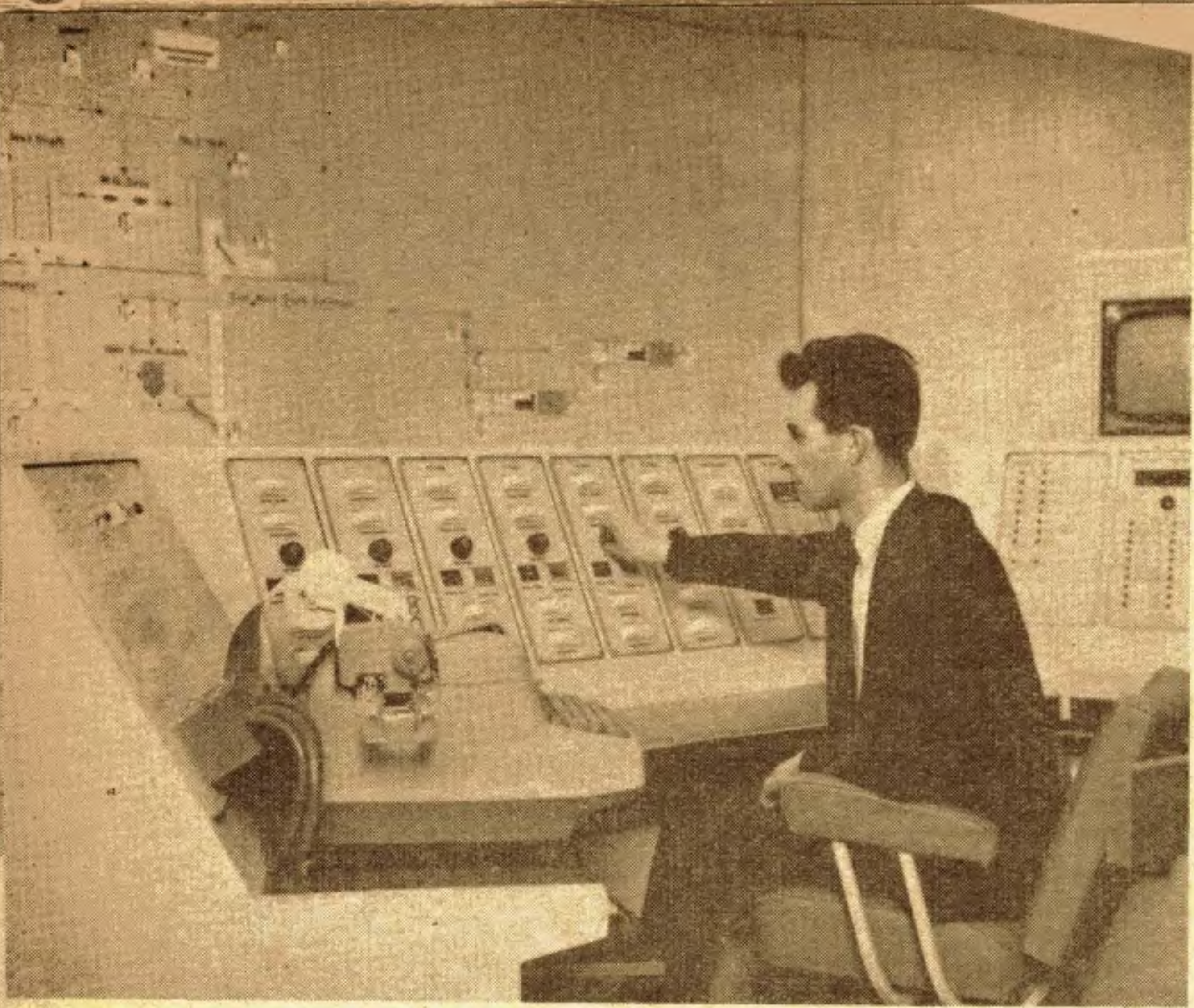


Fig. 1. A typical arrangement of the AEI Electronics voice frequency data transmission system as used at Bevercotes colliery



(Left) Central control room at pithead. The mimic diagram of the complete mine system can be seen on the wall in the background. In the foreground is an electric typewriter, and at the extreme right, the closed circuit television console.

(Far right) Remotely operated Gullick powered supports, with the face conveyors naked. On the right of the picture is the haulage chain, with the coal cutting machine in the background

(Below) Here, partly withdrawn from its place in the mimic diagram control console is one of the numerous electronic boards

Each of these sectors has facilities for remote control of the equipment within the sector from its own console, and can transmit information to and receive information and instructions from central control and other related sectors.

CONTROL AND COMMUNICATIONS SYSTEM

Information regarding the operating state of all plants within all sectors, plant faults, and any hazardous condition, is transmitted to control centres and other sectors by visual eight-light indicators. These indicators are incorporated in a mimic display unit at surface central control and underground transport control centres.

The control and communication system is based on the use of voice frequencies and time division multiplexing techniques which have the desired effect of reducing cores in control cables. The system is operated using standard 3/·029 multi-core telephone cables, allowing two pairs of conductors to receive and transmit all signals for each underground transfer point. Twenty-four v.f.'s may be used for each pair of conductors. The frequencies of the 24 channels range from 420c/s to 3,180c/s with 120c/s spacing, and the signal is transmitted at a level of 100V peak to peak.

INTRINSICALLY SAFE

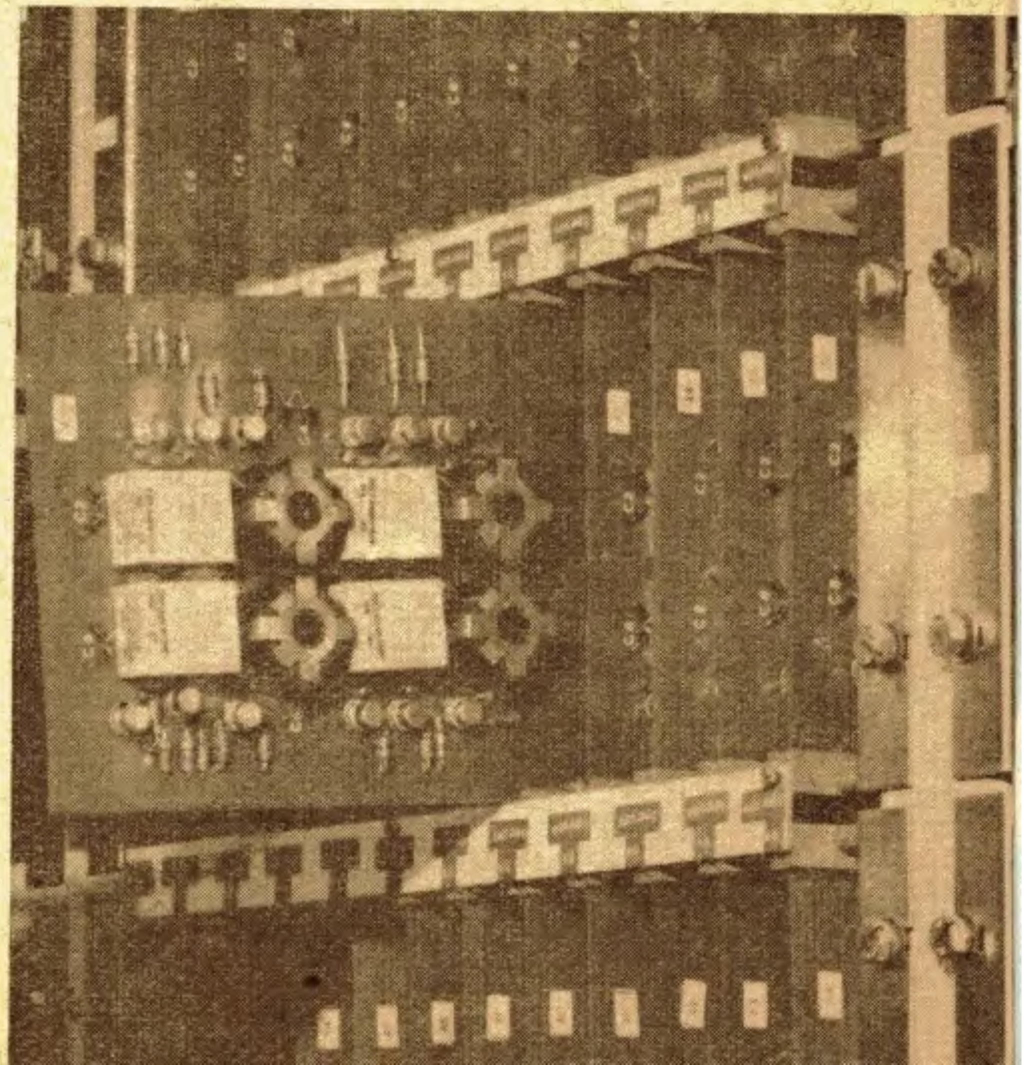
Fire damp (methane with traces of other gases) has always been a serious hazard in coal mines. All electrical apparatus used in mines must either be housed in a flame proof enclosure, or must be intrinsically safe—this means that the voltage and current of the power source must be of such a low value that should sparking occur, the amount of energy dissipated in this way is very limited and presents no danger of ignition of explosive atmospheres.

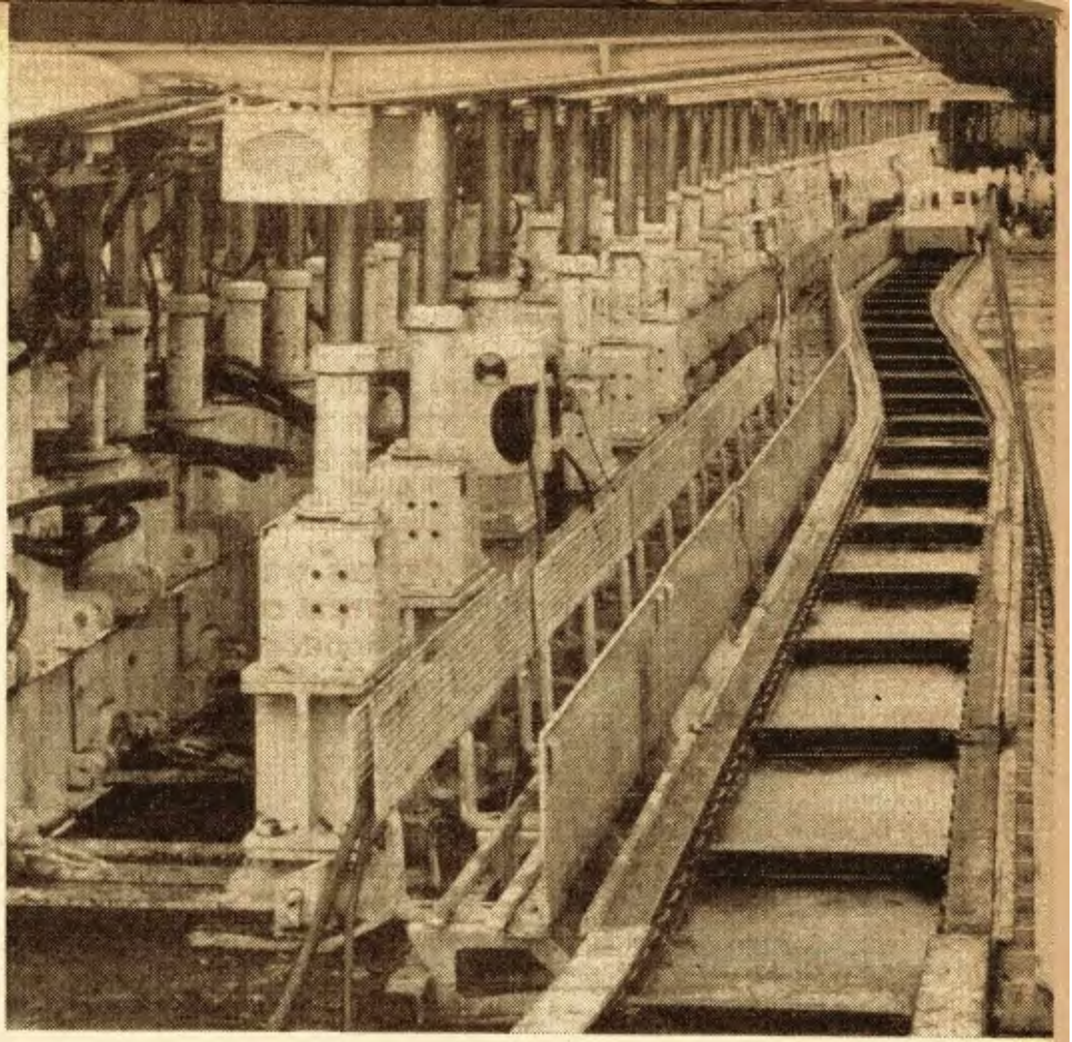
The voice frequency multiplex system for telemetry and control functions at Bevercotes was developed by AEI Electronics. Using solid state techniques, this complex control system is fed by supply units with an intrinsically safe output of +16, 0, −6V.

All tuned circuits employ ferrite pot cores and polystrene capacitors, giving a temperature coefficient of about 100 ppm/°C. The circuits are built on printed boards using gold plated edge connectors. The active components are solid state devices and reed relays.

A typical arrangement of part of the system is shown in Fig. 1. Continuously running LC oscillators are grouped in blocks of four on one printed board, the oscillator outputs being switched by the control element. The outputs are summed by a two-stage transistor amplifier which drives the line transformer.

At the receiving end, a buffer amplifier drives band-pass filters. Each filter covers four adjacent channels and is followed by four single tuned active channel filters. Each filter output is amplified and rectified to drive a two-pole reed relay.





Analogue signals are standardised to 0–2V d.c. and are converted in the analogue modulator to a square wave with a repetition frequency in the range 5–25c/s. This is then used to modulate the carrier frequency. A bandpass filter between the oscillator and the summing amplifier removes all but the primary sidebands.

At the receiving end, a bandpass filter similar to that at the transmitting end follows the buffer amplifier and picks out the modulated carrier. In the demodulator the carrier frequency is removed and the modulation frequency reconverted to a direct voltage in the range 0–2V corresponding to that at the transmitting end.

Pulses at rates up to 30 per second can be transmitted by modulating the carrier. Bandpass filters are used as with the analogue system and at the receiving end the filter is followed by a monostable circuit driving a relay which can be used to drive electromechanical counters and similar devices.

TIME DIVISION MULTIPLEX SYSTEM

In order to accommodate a larger number of channels where low transmission rates are acceptable, a 64-channel time division system is used. Two voice frequency channels are required, one for the multiplexed information and the other for stepping and synch.

At the transmitting end a solid state switch steps round the 64 inputs sequentially at the rate of 25 per second. The information thus derived from the inputs is transmitted as amplitude modulation on one of the v.f. channels. The second channel carries the stepping pulses which drive a second switch at the receiving end in synchronism with that at the transmitter. A number of bistable circuits are set up to correspond to the inputs and these drive changeover relays which form the output circuits.

REMOTELY OPERATED LONGWALL FACE

The ROLF scheme involves remote control and instrumentation of the roof supports, the coal-cutting machine, the face conveyor and various other services. The controls and instruments are all contained in a small cabin on the pantechicon, where the ROLF operator sits. From there he controls all the machinery and interprets the instrumentation display. In the initial phase at Bevercotes no control or instrumentation functions are brought beyond this cabin, although spare channels are available to bring an instrumentation display to the surface if required.

The coal-cutting machine is fitted with transducers to measure main and tail haulage, and a methanometer to sample the air near the cutter drum. The signals from these devices are processed by amplifiers on the machine and transmitted via an auxiliary cable to the cabin. In addition, a methanometer with an electronic transmitter is used to monitor the return air from the face, and power transducers incorporating AEI Hall-effect plates are fitted to contactors to monitor power consumption and to control the machine haulage rate.

CHOCK CONTROL

The roof supports on the first face at Bevercotes have been supplied by Gullick Ltd. They are fitted with a system of remote control and monitoring, made by AEI Electronics to NCB specification. This system consists of a set of control panels in the ROLF cabin which are connected via three heavy duty cables to the switching boxes fitted to the roof supports. On command, each roof support extends a horizontal ram to push the armoured conveyor forward to the coalface, then retracts from the roof, and using the conveyor as an anchor pulls itself forward and resets to the roof.

The chock control system controls this action remotely by operating electrohydraulic valves on the support. Two processes are needed, namely selection of a support and control of the sequence of pushing the conveyor and advancing the supports for the whole face. The supports are divided into sections of 20, a unique address being achieved by selecting any section and any chock number between 1 and 20. Selection is by the same process in each case, signals on two out of five wires in the chock cable and the section cable causing coincidence circuits to operate and close the correct switching box relay. Direct current of either polarity may then be supplied via the third cable to operate either the push or advance valves,

The important function of deciding which support should be operated, and the overall sequence, is carried out automatically by the snake control panel. This panel has a series of ring counters which are wired to suit the individual requirements of each coalface, and which keep in step with the whole operating sequence.

BELT WEIGHER

A conveyor belt weigher suitable for use underground has been designed. It is basically a high accuracy integrating device for producing a figure of total tons weighed. Differential transformers supplied with a stabilised primary current are used to measure the deflections of a pair of cantilevers which support an idler roller set, over which the belt passes. The signals from these transformers are added, converted to d.c. and applied to a "ramp" type analogue-to-digital converter. This converter assesses the load on the idler set and converts it to an intermittent pulse train, the pulse frequency being determined by a crystal oscillator and the number of pulses being proportional to the idler deflection.

This process is repeated each time the belt moves six inches, so that the total number of pulses produced in a period is proportional to the material carried. A binary counter divides the pulse rate down to a level suitable to drive a counter calibrated in tons.

CONVEYOR CONTROL

The whole coal transport system in the mine is controlled by one man situated in the underground transport sector control room.

A klaxon gives warning when the conveyor motors are about to be started. A microphone picks up the sound from the klaxon and feeds this signal to the control unit; the conveyor system will not start unless the klaxon has been sounded for a pre-set period.

Temperature protection, oil level and flow protection, and bad belt fault detectors are fitted to each conveyor. These two-state protection devices transmit a faulty/healthy state indication to the central control.

Belt transfer points are also monitored by television cameras in a closed loop circuit with a display at the underground transport control and in central control on the surface.

METHANE DRAINAGE

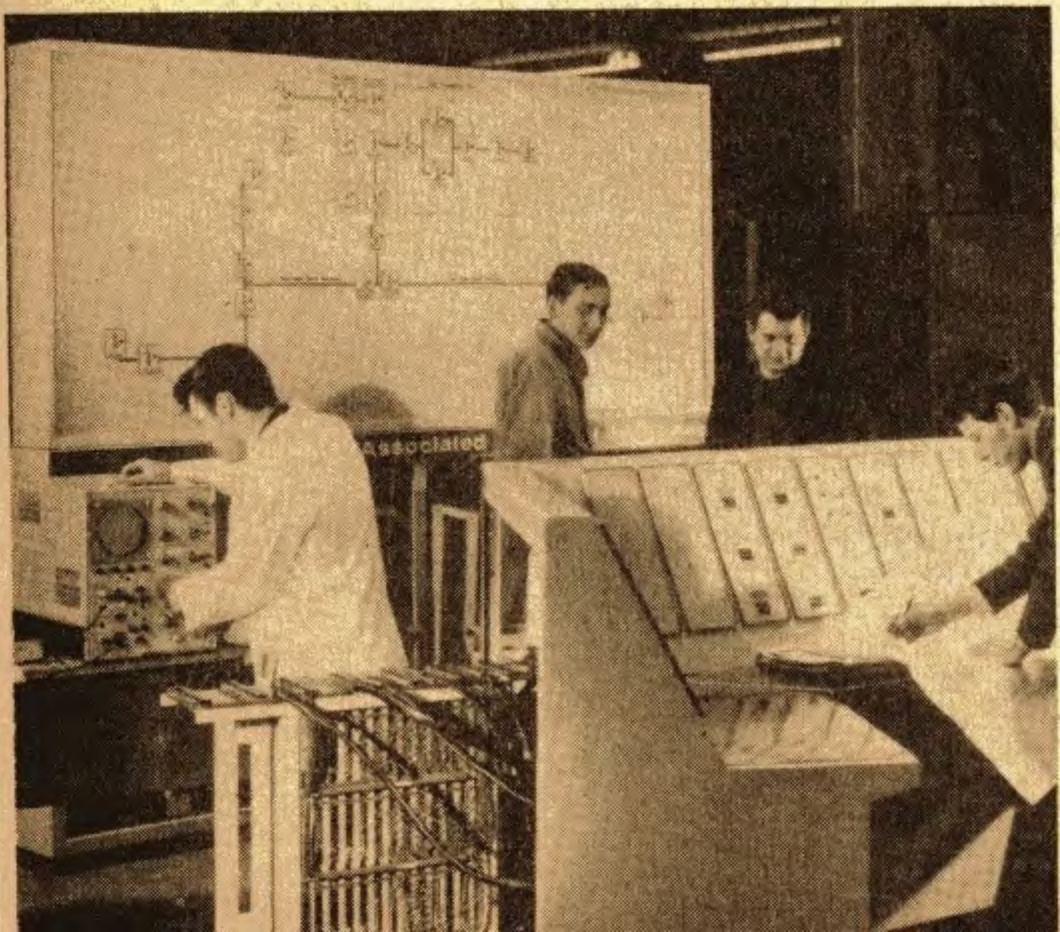
The present methods of longwall face mining break up the overlying strata, causing entrapped methane (fire damp) to be liberated so that it eventually travels through to the ventilated roadways. Drilling bore holes up into this strata enables exhausters to extract this methane and dispose of it on the surface so that the main ventilation stream is not overloaded.

Transducers developed by the NCB are used to measure the methane purity and flow rate and these may operate valves at monitor and control stations in the event of abnormal conditions. It is necessary to send control signals from the surface to these points and also to receive signals from them, at the surface. The AEI v.f. signalling system is used for this purpose, transmitting four alarm signals from, and six control signals to, each double control station. The methane flow and purity information is processed so that it is similar to the standard v.f. signals and common transmission equipment may be used.

PERSONNEL COMMUNICATIONS

At Bevercotes every modern form of communication known in mining is being applied, each fulfilling a particular role in the integrated scheme.

Electronic modules for the control console being assembled in the AEI Electronics factory at Leicester



A 200-line PABX telephone exchange serves th whole colliery. Party line working, priority and emergency calling are incorporated. The central control is linked with certain outstations by a management control loud-speaking telephone system. A two-way "clear-call" industrial communications system operating through the PABX exchange is installed for paging any person on the surface.

Key persons underground carry a one-way receiver and can be paged from the surface manual exchange. Signals are transmitted on a 30 kc/s carrier and radiated from a loop erected in the mine roadway. On receipt of the appropriate tone, the receiver emits a series of loud "bleeps". The person called then contacts control via the nearest telephone.

Another inductive loop communication system provides two-way speech communication between the underground transport controller and the drivers of locomotives.

TRANSMISSION OF INFORMATION

Production data in digital form from the central control desk (and any other desired information) is fed into an electric typewriter in central control and transmitted simultaneously to a slave typewriter situated in the general manager's information room.

COAL PREPARATION PLANT CONTROL ROOM

Apart from the out-loading bunkers, all equipment in the coal preparation plant is remotely controlled from the control room within the plant.

The mimic panel indicates every drive condition; positions of all valves, together with tonnages throughout the plant, specific gravity of media, tank levels, bunker levels, and air pressures are also indicated.

MANPOWER DEPLOYMENT

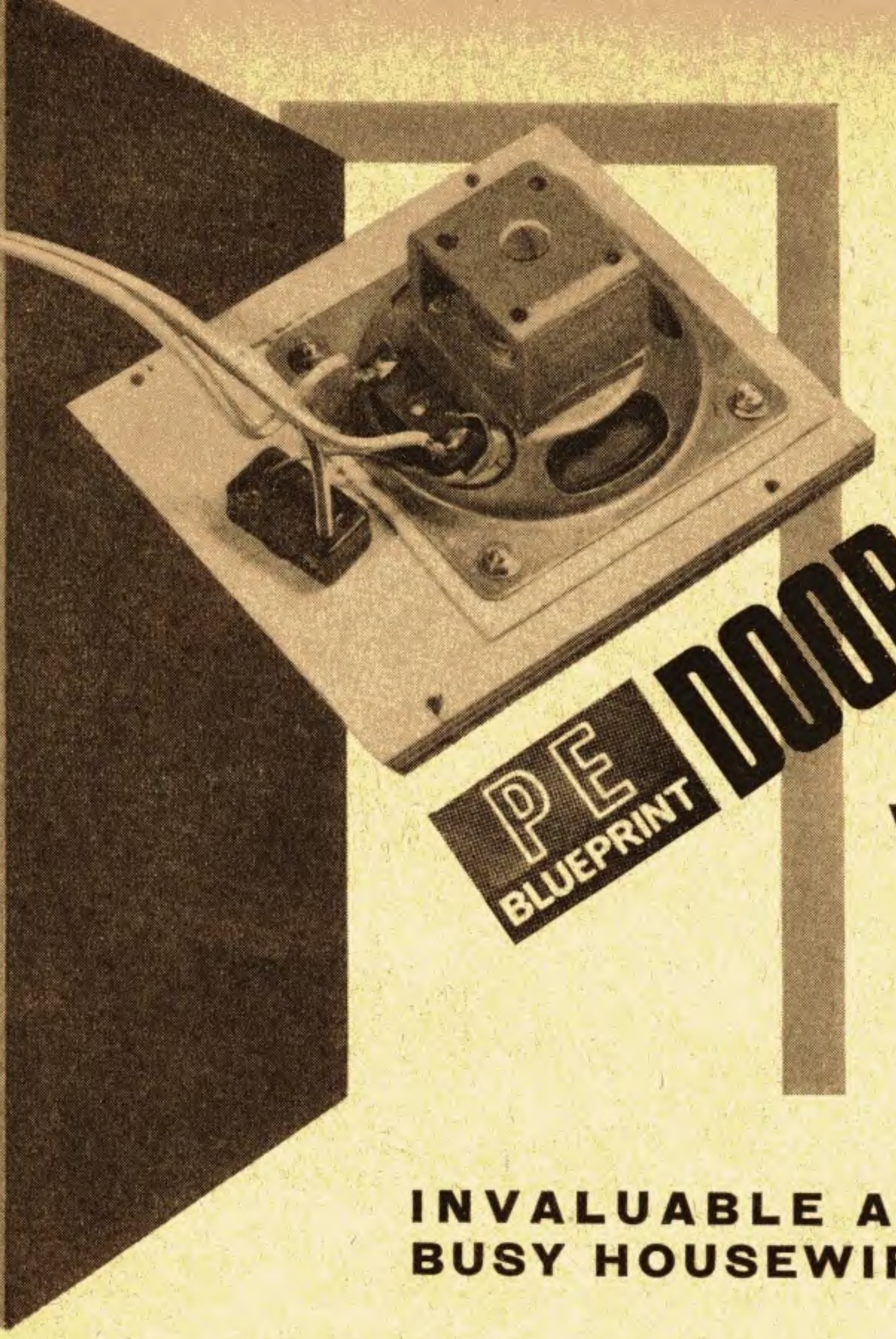
An indicator unit in central control shows the state of manpower deployment of surface and underground sectors. The signals are manually initiated from the facsimile board in the manpower deployment centre.

The centre is designed round an electronic deployment system, specific reporting positions being provided for each district or sector of the mine. An information plug is provided for every underground worker. Each plug is labelled and coded with the worker's personal number and other information concerning his trade, etc. The plug contains up to 25 steel pins, the number and position of which indicate the required details.

On reporting for duty at the commencement of a shift, the worker takes his personal plug from a parking board and hands it to the deploying officer who inserts it into a frame identified with a particular sector of the mine.

The frames are eventually fitted onto the deployment boards of the electronic scanner. Associated with each pin socket on the scanner are a pair of conducting loops. One of these loops is energised from a 6kc/s signal during the scanning operation. The presence of a pin will result in the production of a flux which in turn will induce a voltage in the second loop, and this output signal is applied to the control unit. Here it is converted into a suitable form to operate a teleprinter and punched tape machine.

The records thus produced are used as the basis for a time keeping system and from the punched tape the NCB divisional computer centre will produce the weekly payroll without further direct labour. ★



DOOR PHONE

two-way loudspeaking intercom with an audible calling signal

By *R. E. F. Street*

INVALUABLE ASSET FOR THE BUSY HOUSEWIFE AND INVALID

One of this month's blueprints shows the details for making an intercom system designed for use between the front door of a house and the kitchen. A busy housewife is thus able to convey messages to tradesmen without the need to leave a particular chore or child unattended. It has been found to be a considerable asset to an invalid or handicapped person who is left alone in the house.

No doubt readers will be able to find a host of applications for the system, since it is entirely self-contained in two units and does not rely on an external source of supply.

A "calling" system is also incorporated so that the caller at the front door can attract the attention of the occupant, so dispensing with conventional bell and knocker systems. Alternatively, the calling system may be omitted if the conventional systems are preferred. Even with the calling system, the number of interconnecting wires is kept to a minimum; there are only three wires used here.

CIRCUIT DESIGN

The circuit of the unit is shown in Fig. 1 on the blueprint. Basically, it consists of a four-transistor amplifier having a maximum output of about 500mW. The amplifier is conventional in circuitry, apart from R5, the function of which will be explained later.

When designing the unit, the aim was to employ readily available components, and this meant that 3Ω loudspeakers were called for. It was decided to use a single loudspeaker at each end of the two-way intercom system and use them alternately as microphones and loudspeakers. The switching necessary to accomplish this procedure is carried out by a four-pole, three-way switch, S1. The three positions of the switch, which is situated at the same end of the system as the amplifier, correspond to " off ", "speak", and "listen".

When either loudspeaker is used as a microphone, it is matched into the first transistor TR1 by means of a transformer T1. The transformer suggested is a miniature type having a ratio of 50 : 1 and originally intended for use in the output stage of a valve radio receiver. It is connected to provide a step-up ratio of 1 : 50 to the base circuit of TR1. A conventional microphone transformer of ratio 35 : 1 was tried but was much larger, more expensive, and did not give such good results as the type specified.

SWITCHING

The input and output circuits of the amplifier, and the loudspeakers, are switched by S1a and S1b respectively. The "off" position of S1 connects the loudspeakers in the same manner as the "listen" position as will be seen from the circuit diagram.

The remaining sections of S1 (S1c and S1d) are used for switching the battery supply. The negative side of the battery is permanently connected to the negative line of the amplifier while the positive side of the battery is wired to the wiper of S1d. In the "speak" and "listen" positions of S1, the positive side of the battery is connected to the positive line of the amplifier, but in the "off" position, it is connected to the third wire of the three-core cable connecting the door unit to the amplifier unit.

The door unit is fitted with a push-button switch S2 and when this is pressed, even if the main unit is in the "off" position, power is applied to the amplifier. Switch S1c is used to render the push-button S2 inoperative when the main unit has been switched to "speak" or "listen".

COMMON IMPEDANCES

It will be seen that on the circuit diagram wire B from T1 and wire G from T3, and one side of each loudspeaker, have been joined together at a single point, which is then connected to the positive line of the amplifier. This procedure is most important; if the wiring is not carried out in the fashion indicated in Figs. 1 and 3, there is likely to be a small impedance common to both the input and output circuits of the amplifier. Since the amplifier has a very high gain, if only a few inches of wire are common to both input and output circuits, severe feedback will result and the symptoms can be most bewildering if they are not expected.

It was thought when designing the unit that it would be useful if there could be some means of "calling" the amplifier unit from the door unit. When S2 is operated, power is supplied to the amplifier when the amplifier unit is in the "off" position. Since the "off" position of S1 places the loudspeakers in the same configuration as in the "listen" position, it might be thought that pressing S2 would enable the person using the door unit to speak and be heard from the loudspeaker in the amplifier unit. However, this is not so if the previously mentioned "common impedance" remarks are observed and "earthing" connections are adhered to.

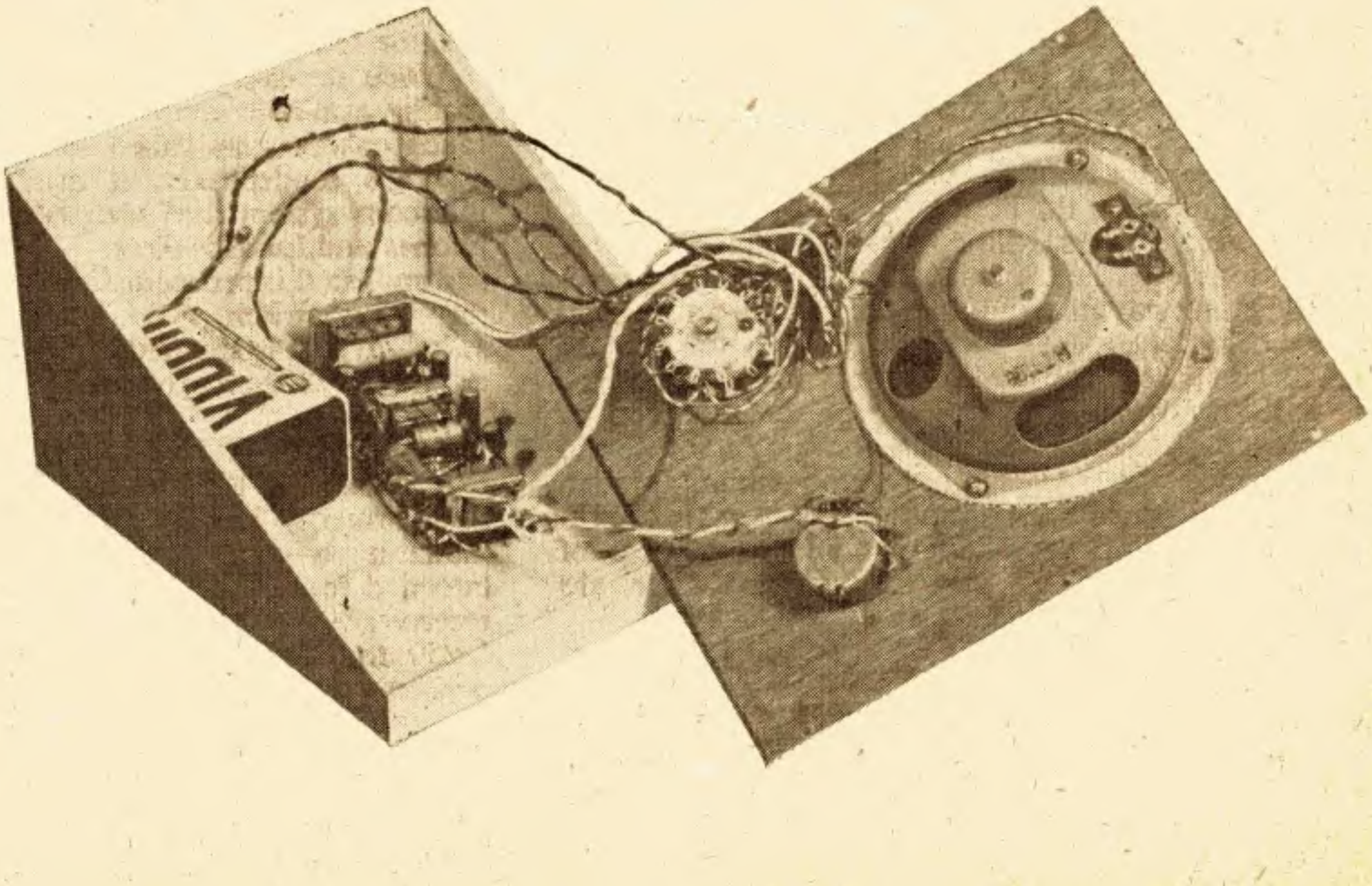
The supply from the positive terminal of the battery passes via one of the leads of LS2, and the lead is thus common to the input circuit of the amplifier and the battery supply. The resulting "howl" of feedback is sufficient to attract the attention of anyone near the amplifier unit. Of course, the person at the amplifier unit then uses S1 in the normal way to speak to the person at the door unit.

This simple system using feedback to produce an audible signal is quite adequate. Its main disadvantage is that the note produced is not particularly harmonious, but this will not normally be disturbing since it is only heard momentarily.

CALLING SIGNAL

For the system to work satisfactorily, the volume control of the amplifier must not be at its minimum setting. R5 is inserted so that, when VR1 is at minimum volume setting an output will still be obtained if a signal is applied to the input of T1. The value of R5 can be varied in the light of experiments; if the howl produced on pressing S2 is too low or too high in volume, R5 can be increased or decreased slightly as appropriate. The value (39 ohms) was found to give adequate volume of howl under normal conditions. There may be a bell-push and bell associated with the front door already in use. If so, then obviously, the "call" system described here will be of little value, and may be omitted. The cable linking the amplifier unit to the door unit can then be of two-core type, wire L being omitted.

If required, a miniature buzzer could be fitted in the cabinet of the main unit and wired to function when S2 is operated. It would be advisable to use a separate battery for the buzzer since the specified battery would have insufficient capacity; S1c could still be used to prevent S2 from having any effect when S1 is in the "speak" or "listen" position. The buzzer would be



Main amplifier unit and control panel

wired between the wiper of S1c and the wire which goes to S2, and the lead joining "O" on S1c to "O" on S1d would be disconnected. The battery for the buzzer would then be connected with the negative lead to "O" on S1c and the positive lead to the positive line of the amplifier.

AMPLIFIER CONSTRUCTION

The amplifier itself is built on an 18-way component groupboard but it should be noted that if parts larger than those shown in Fig. 2 on the blueprint are employed, it may prove difficult to accommodate them on the board. Full details of the wiring are given on the blueprint and it is recommended that the components be fitted to the groupboard first, as indicated in Fig. 2, omitting for the time being the connecting leads A to I. The mounting lugs of T1, T2 and T3 are soldered to tags on the groupboard. This is important in the case of T2 because the transformer clamp provides a link between R13 and the common positive line. The transistors should be wired in last, taking due precautions against damage from the heat of the soldering iron by using a suitable heat shunt.

When the amplifier has been built, it can be tested, after connecting the volume control and the two loudspeakers to the appropriate points. Having established that the amplifier works satisfactorily, it can be wired up to the switch S1 as shown in Fig. 3.

Note that S1 consists of two two-pole, five-way, make-before-break wafers. The switch is a Radiospares "Maka-Switch" type and the movable "stop" should be positioned to convert the wafers into two-pole, three-way types. The diagram (Fig. 3 on the blueprint) makes clear which tags on the wafers are disregarded. It is important that the switch obtained is of the make-before-break variety; if it is not, then damage may result to the two output transistors if at any time the secondary winding of T3 is left open-circuited while there is an input signal to T1. The use of an m.b.b. switch ensures that the secondary winding of T3 is always loaded, a necessary requirement to prevent TR3 and TR4 "running away".

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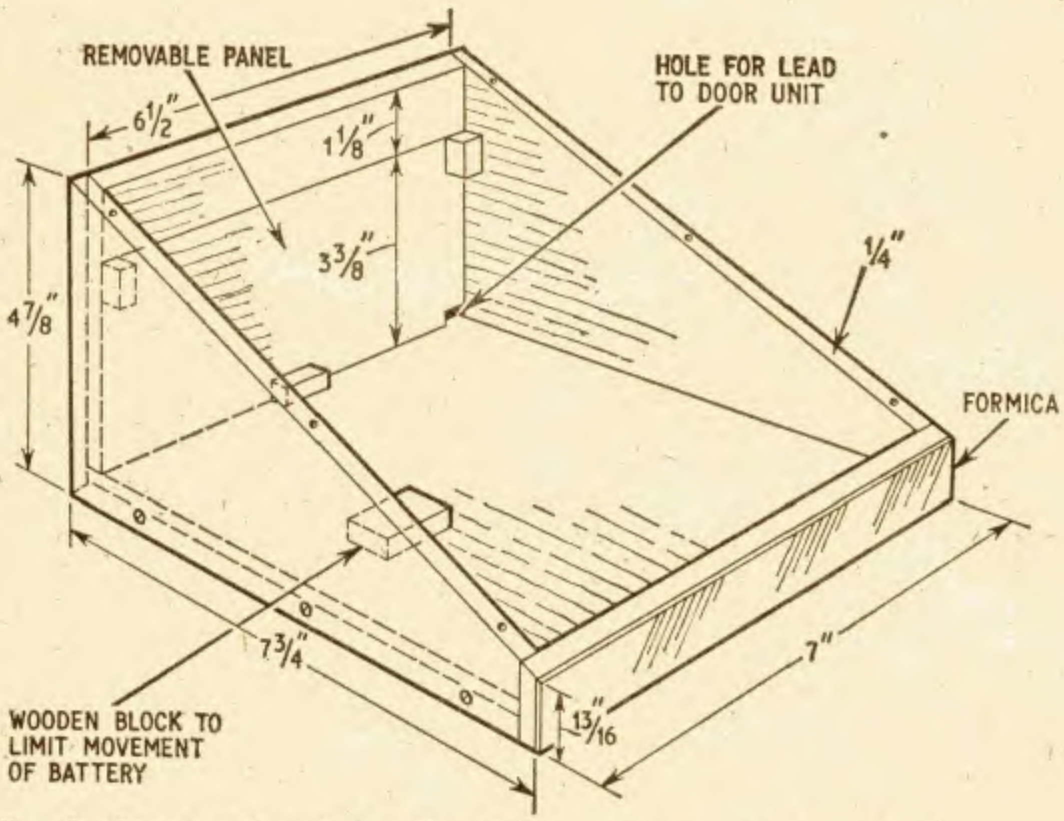


***Fig. 6.** Constructional details of the main amplifier unit, made from ¼in thick plywood and covered with a plastic laminate. The removable panel provides easy access to the battery. All parts are glued and screwed.*

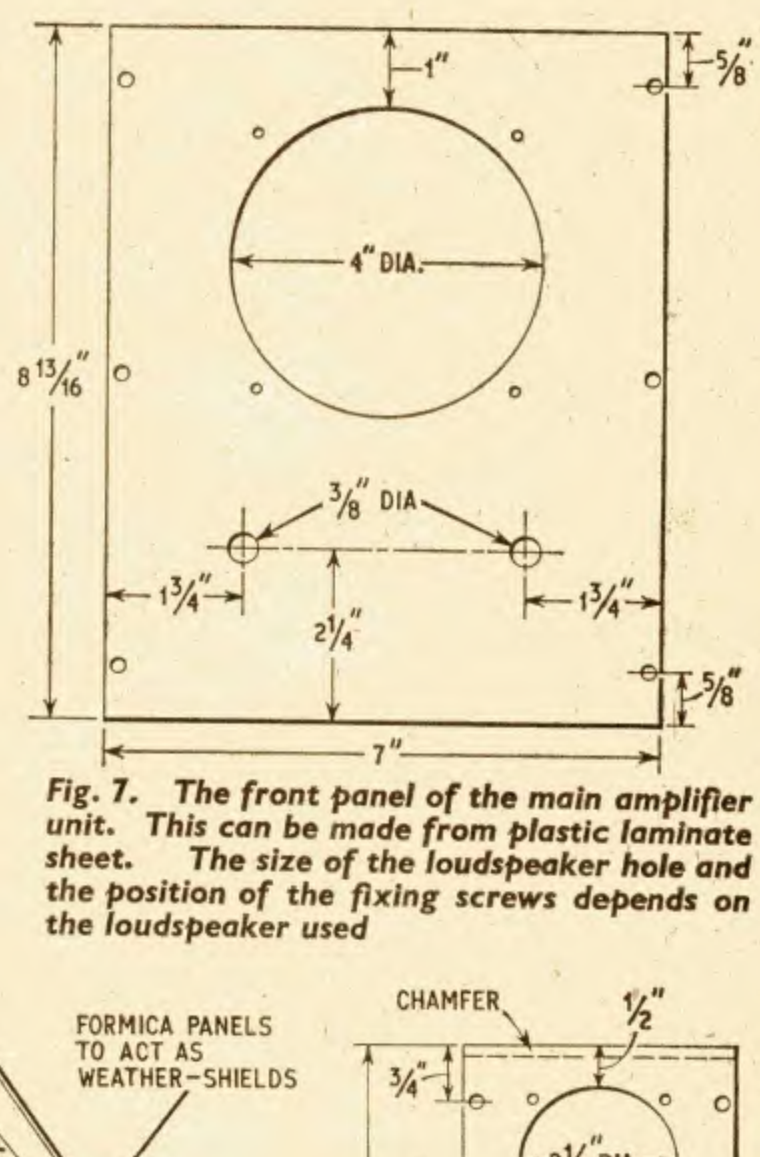


***Fig. 7.** The front panel of the main amplifier unit. This can be made from plastic laminate sheet. The size of the loudspeaker hole and the position of the fixing screws depends on the loudspeaker used*

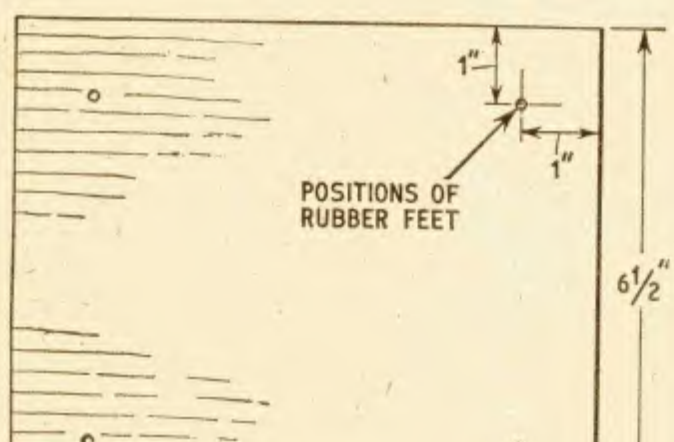
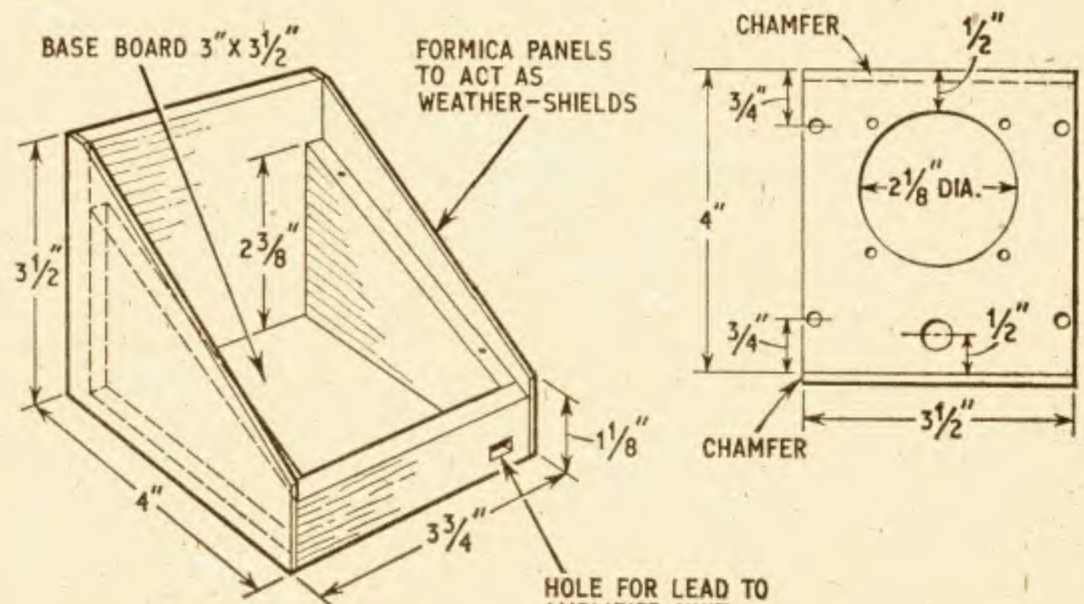
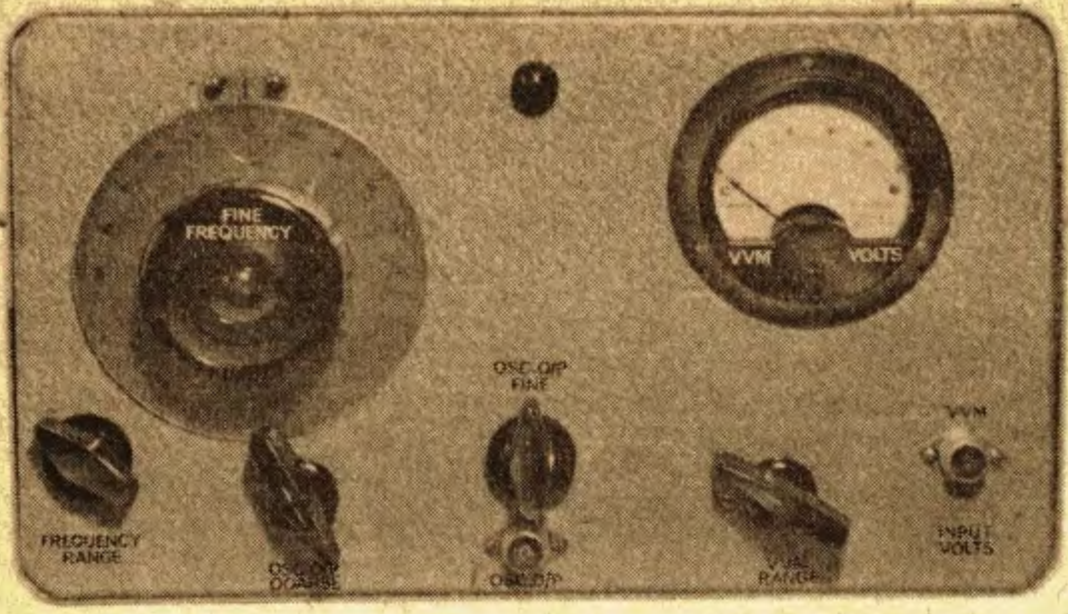


***Fig. 8.** Baseplate of the main amplifier unit. Four rubber or plastic feet are fitted to prevent damage to paper or paintwork on the wall*



***Figs. 9 and 10.** Constructional details of the extension or door unit made in a similar style to the main unit. Notice that the front panel is chamfered to fit in a recessed position in the case. All parts are glued and screwed*



AUDIO OSCILLATOR & VALVE VOLTMETER

PART ONE

By H. T. KITCHEN

SPECIFICATION

Oscillator

Frequency Range	Output
1. 25c/s to 250c/s	1. 10 volts
2. 250c/s to 2,500c/s	2. 1 volt
3. 2,500c/s to 25kc/s	3. 100 mV
4. 25kc/s to 250kc/s	4. 10 mV

The range and output are continuously variable.

Distortion 0·2% 100c/s to 25kc/s;
0·5% 25c/s to 100kc/s
Frequency response ±1dB 25c/s to 50kc/s;
±2dB 25kc/s to 150kc/s

Valve Voltmeter

Input Range
1. 500 volts
2. 50 volts
3. 5 volts
4. 0·5 volt
5. 0·05 volt

Frequency response on ranges 3, 4, and 5 only:
±1dB 25c/s to 50kc/s;
±2dB10c/s to 150kc/s

Many amateurs who take audio seriously, progress to the stage where they want to carry out tests on equipment they already possess, or may be building to perform a particular task. In order to make these tests, suitable equipment is necessary and it is at this stage that the short-comings of the multi-range testmeter are often revealed owing to the shunting properties of the relatively low resistance meter coil. The acquisition of a valve voltmeter can prove to be an expensive proposition, unless one is able to build such an instrument himself.

This article sets out a suitable specification which combines an audio frequency oscillator with a valve voltmeter in one cabinet, without incurring excessive expense, while at the same time being reliable and reasonably simple to construct. Care had to be exercised to avoid instability in the h.t. line by using generous smoothing and decoupling arrangements to reduce this to an immeasurably low value. All the components are conservatively rated to provide long life, to minimise heat dissipation, and to obtain good frequency stability of the a.f. oscillator.

It is not intended to give point-to-point instructions, since it is felt that the complete unit will appeal more to the advanced constructor, who will not only be able to work from the information given, but will most probably modify it to suit his own requirements and whatever components he has to hand. The less experienced constructor however, should be able to build the unit provided he is capable of working from a circuit diagram used in conjunction with a wiring layout.

Standard, easily obtained components are used throughout with one exception—the thermistor. It is the author's experience that an order placed for the thermistor may take up to six weeks to materialise although some shops do stock them. With regard to the other components, buying new, or carefully and thoroughly tested old ones, is the best guarantee of success; too much otherwise excellent equipment may be rendered virtually useless because of salvaged and untested components being used.

CASCODE

Several commonly used circuits were considered and the reason why the present circuit was chosen may prove of interest. There are two basic forms of a.c. voltmeter using valves or transistors.

The first type the "rectifier/amplifier" is commonly used for r.f. measurements and usually consists of a diode rectifier followed by a high gain d.c. amplifier. The d.c. amplifier has to be carefully designed to guard against drift, and the rectifier requires several hundred millivolts across it to provide a reasonably linear scale, this precluding all very low voltage measurements. This type, therefore, is almost automatically excluded for most audio frequency work.

The second type is the "amplifier/rectifier" and is most suited for audio frequency measurements, for with careful design, a full scale deflection can be obtained for an input as low as 1mV. Some very expensive commercial instruments are even more sensitive but are seldom necessary to most amateurs.

The "amplifier/rectifier" meter can again be divided into two basic types: cascade amplifiers and cascode amplifiers. A glance at the circuit diagram of a television turret tuner will show that the r.f. amplifier is almost always cascode connected, providing high gain and good bandwidth, this being the reason for the present choice of circuit shown in Fig. 1.

Cascade amplifiers are capable of providing very high gain, but due to "Miller" and other esoteric effects, the h.f. response is rather restricted and decreases further as more stages are added to try to increase the overall gain. Cascode amplifiers on the other hand have an enhanced h.f. performance for a given gain and with care can be made very stable.

METER CIRCUIT

Referring to Fig. 1., V1 is the cascode stage where V1a, which has R8 as its anode load, acts as the anode load of V1b. Resistors R1 to R5 form the input potential divider and should be of the best quality possible, for any change of resistance or noise generated here will affect the meter reading. C1 serves to block any d.c. voltage which might be present, such as the ripple voltage on an h.t. line which is being measured. R10 and R12 form the bias resistors for V1a and V1b, and also the potential divider for applying negative feedback. C3 is the normal cathode decoupling capacitor.

The signal from the anode of V1a is direct coupled to the grid of V2a, which functions as a cathode follower. Since its input impedance is high V1b is only lightly damped to prevent undue loss of h.f. performance. Lack of phase reversal in V2a means that negative feedback can be applied from the anode of the output stage (V2b) to the cathode of V1b.

The amplified output from the anode of V2b is applied via C7 to four GEX34 germanium rectifiers connected in bridge form to the meter. C8 is provided to damp the needle movement.

C6 is the cathode bias capacitor connected across R16 and has the low value of 1μF. At low frequencies C6 has very little effect on the gain of V2b, since its reactance is high in comparison with R16. As the frequency across C6 increases, its reactance decreases shunting R16 more and more, hence increasing the gain of V2b and compensating for voltage losses at high frequencies. The junction of D3 and D4 is returned to the junction of C3, R10, and R12, via R11.

During calibration R12 is adjusted so that the meter reading corresponds to a given input. In the prototype a value of 33 ohms was just right, but due to component tolerances it may require adjusting in subsequent models. It may be easier to substitute a wirewound potentiometer with a resistance of 50 or 100 ohms.

OSCILLATOR

Fig. 2 gives the circuit of the audio oscillator, which is based on a conventional Wein bridge with three EF80 valves, the first two forming the oscillator proper and the third being arranged as a cathode follower.

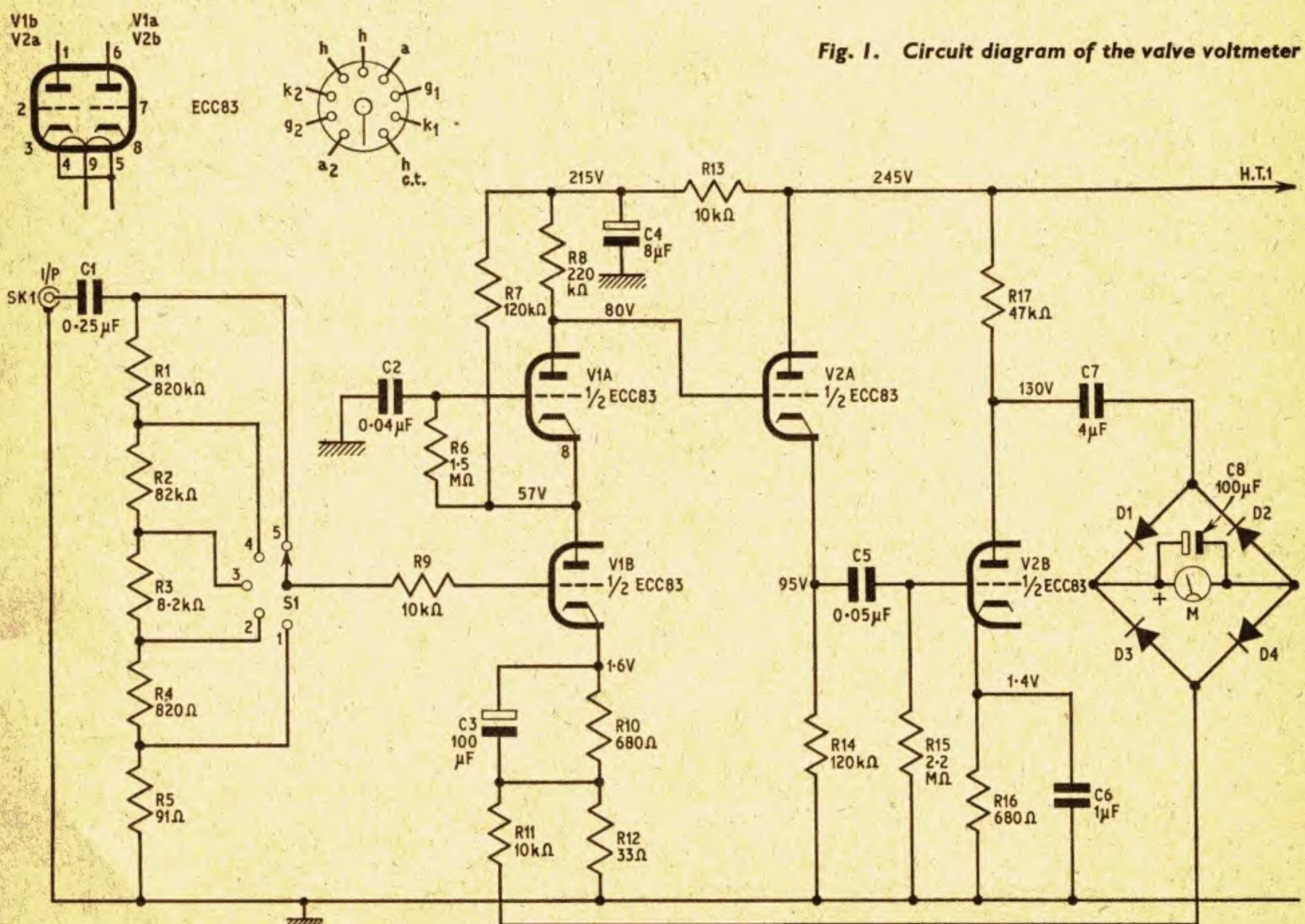
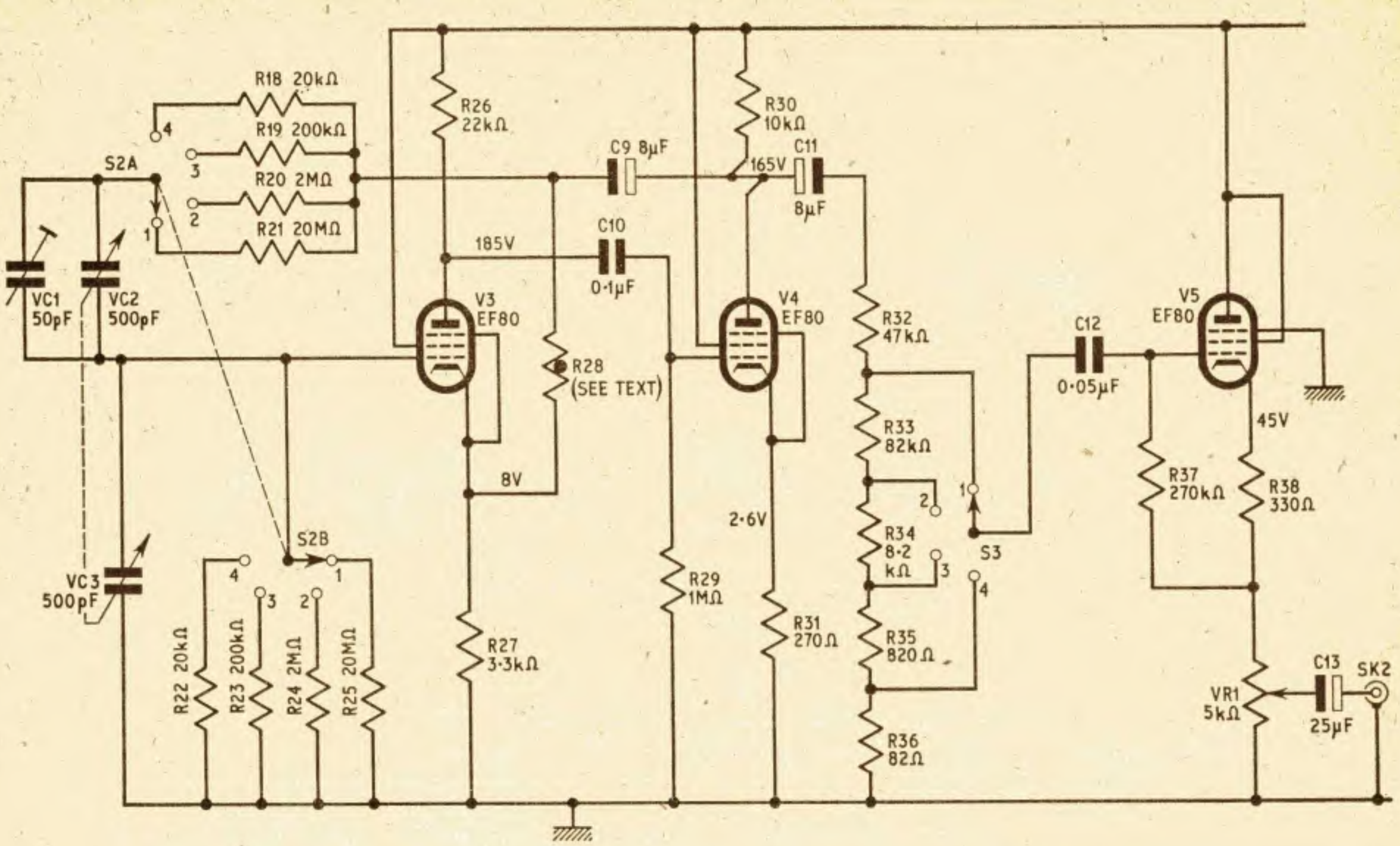


Fig. 1. Circuit diagram of the valve voltmeter



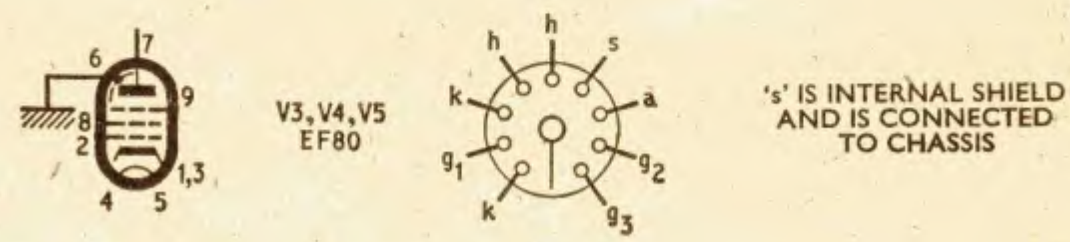


Fig. 2. Circuit diagram of the audio oscillator

Although the ouput could be taken from the anode of V4 the small extra expense of a cathode follower is well worth while, since it completely isolates the oscillator section from the effect of varying loads, so preventing unwanted deviations in frequency.

The cathode follower loads, from infinity (open circuit) to zero (short circuit), have no noticeable effect on the frequency and in fact the output can be connected directly to a loudspeaker under test, although the applied voltage will be very low.

V3 and V4 are used to form the oscillator, of which the frequency determining components are VC2, VC3 and R18 to R25, the resistors being selected by S2a and S2b. The lowest frequencies are obtained with the highest value resistors (range 1) and with VC2 and VC3 at maximum capacitance. The frequency of oscillation is given by

$$f_0 = \frac{1}{2\pi\sqrt{(R_1R_2C_1C_2)}}$$

where R_1 includes the valve and load resistances in parallel. The required voltage gain is

$$N = 1 + \frac{R_1}{R_2} + \frac{C_2}{C_1}$$

Since $R_1 = R_2$ and $C_1 = C_2$, f_0 is inversely proportional to R and C and the output voltage is a third of the input, or 9·5dB. If the gain of the oscillator valves, and their phase shift, can be kept at 9·5dB and zero degrees respectively, the valves will oscillate at a frequency equal to f_0. From the anode of V3 the signal is passed to the grid of V4, which brings about the phase reversal necessary for oscillation, and returns the signal to V3 via C9 and the frequency determining components.

To minimise unwanted phase shift in the oscillator valves, which could upset the oscillator frequency, negative feedback is introduced into the cathode of V3 by means of thermistor R28. This also stabilises the oscillator output keeping the amplitude constant within 2dB over the entire range and within 1dB up to 50kc/s.

From the anode of V4 the signal is fed via C11 to a coarse attenuator which introduces 60dB attenuation in three 20dB steps, providing outputs of 10V, 1V, 100mV and 10mV, which can be further attenuated by VR1 acting as a fine output control.

POWER SUPPLY UNIT

Fig. 3 shows the power supply circuit which is quite simple and calls for no special comment. C16, and C17 in conjunction with the l.f. choke form the main smoothing components, while R38, C14, R39 and C15 provide further smoothing and assist in decoupling the two h.t. supplies which are considerably ripple free. Cross-modulation between the oscillator and meter circuit via the h.t. has not been detected.

CHASSIS

The chassis should be constructed from a sheet of 18 s.w.g. aluminium 16¼in × 11¼in drilled and bent in accordance with Fig. 4. The valve holder and

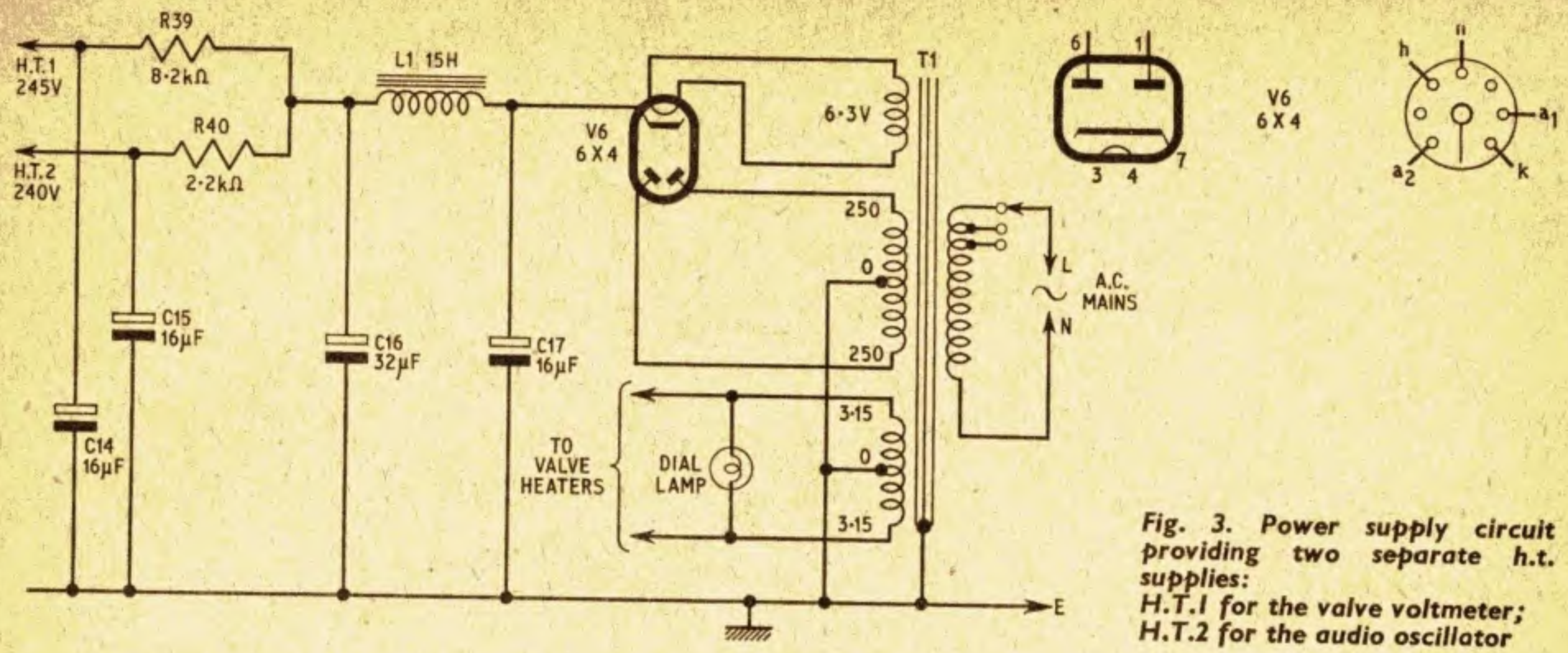


Fig. 3. Power supply circuit providing two separate h.t. supplies: H.T.1 for the valve voltmeter; H.T.2 for the audio oscillator

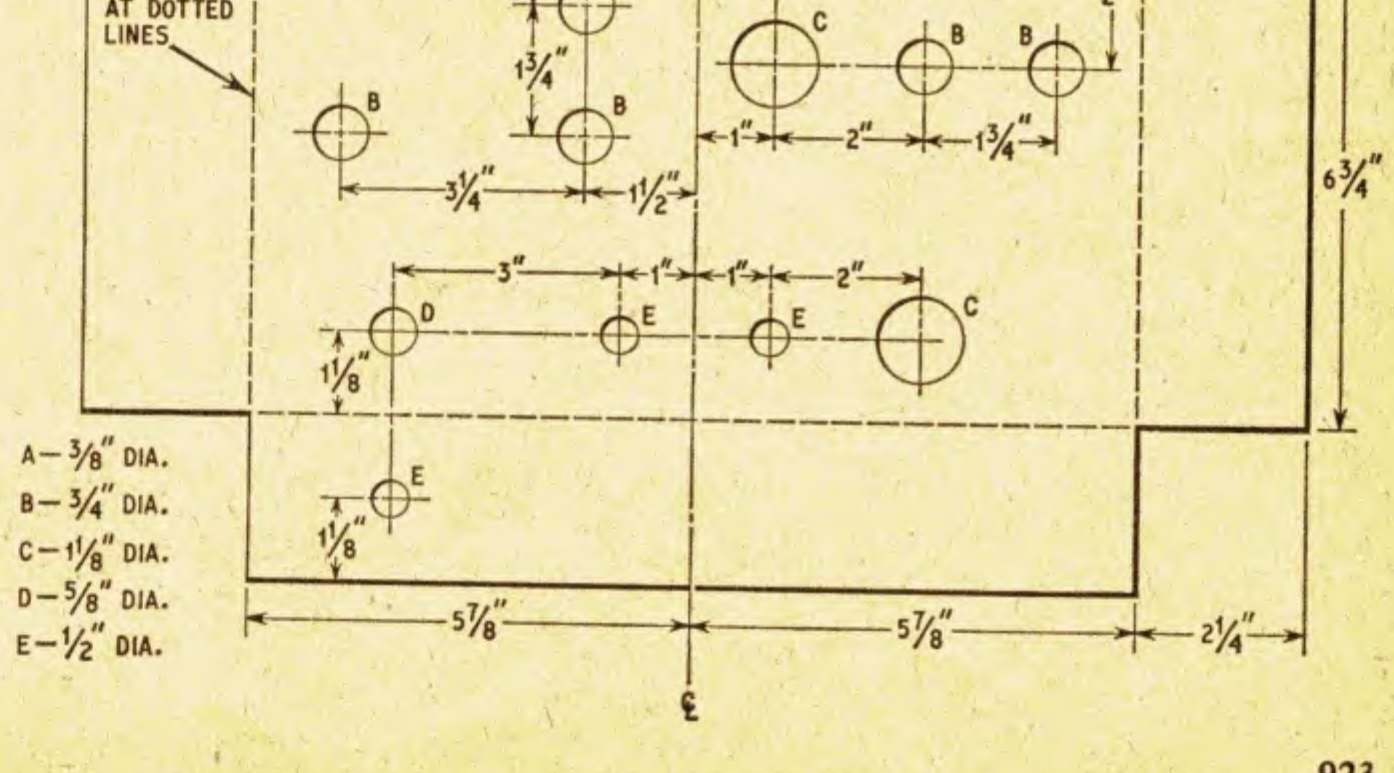
smoothing capacitor holes should be positioned as shown. The remaining components should then be placed in position and the positions of the fixing holes marked and drilled or filed out. Although the controls along the front of the chassis are shown staggered, they can if so desired be placed in a straight line, the size of the components actually used being taken into consideration.

When the last hole has been cut out the chassis should be cleaned and painted; hammer-finish paint is quite attractive but is by no means essential.

Dimensions for the front panel are not given since they depend on the meter actually used and upon the height of the tuning capacitor spindle from the chassis. Jackson Brothers supply a small template with the dial so no difficulty should arise on this score. The holes for the controls and coaxial sockets are accurately marked out by aligning the finished chassis with the front panel and scribing through. The greatest care should be exercised when working on the front panel and cabinet, for nothing looks worse than scratches and gouge marks where the file or drill slipped.

Two small screens should be made from aluminium to enclose the two range switches S1 and S2, these being shaped and dimensioned as required. The screen round S2 could perhaps be dispensed with without any ill effects but the screen round S1 is essential, because any hum picked up by the range resistors will show up as

Fig. 4. Drilling details of the whole chassis giving the positions of the main components to be mounted. Small holes for nuts and bolts are not detailed since they can be marked from the components used



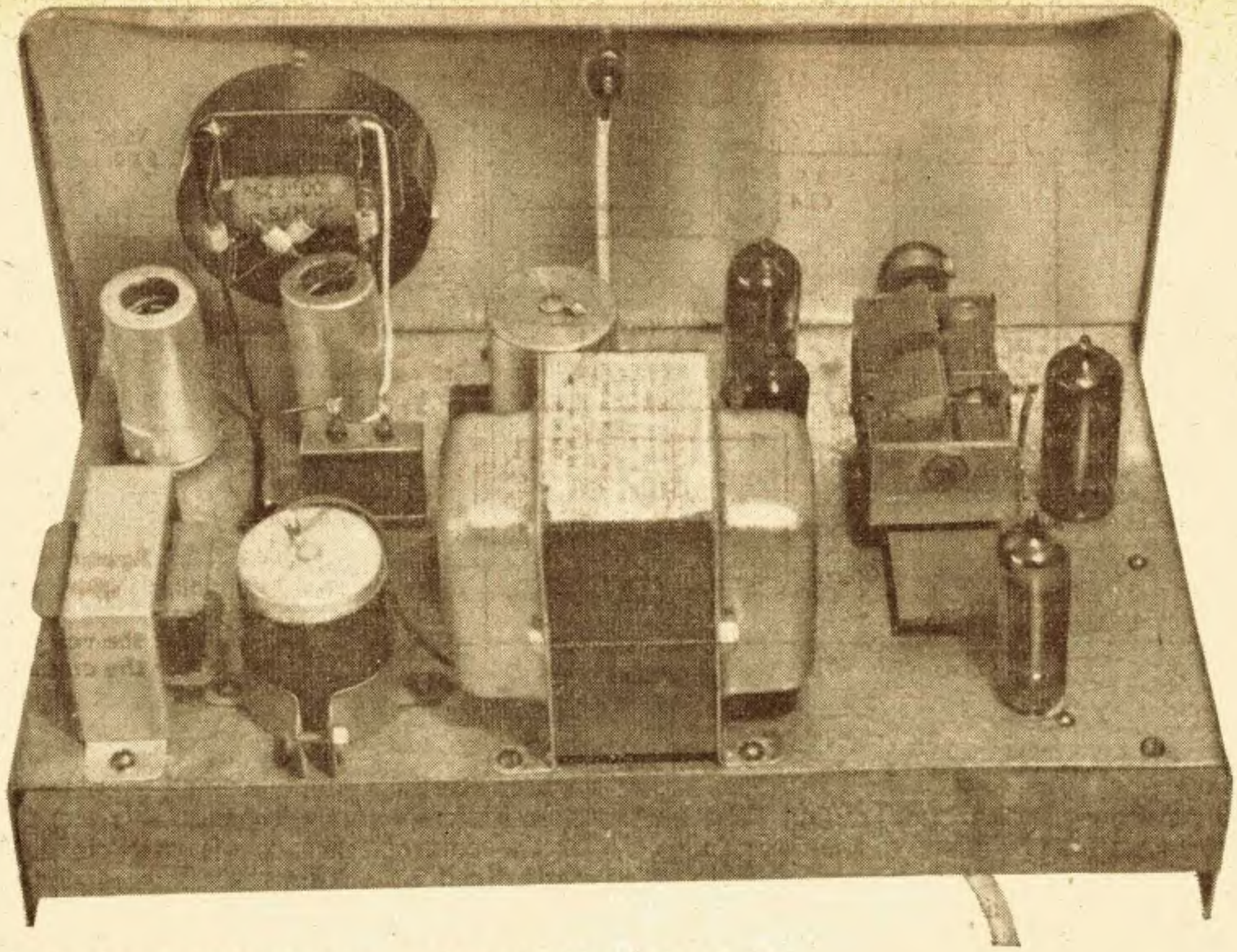
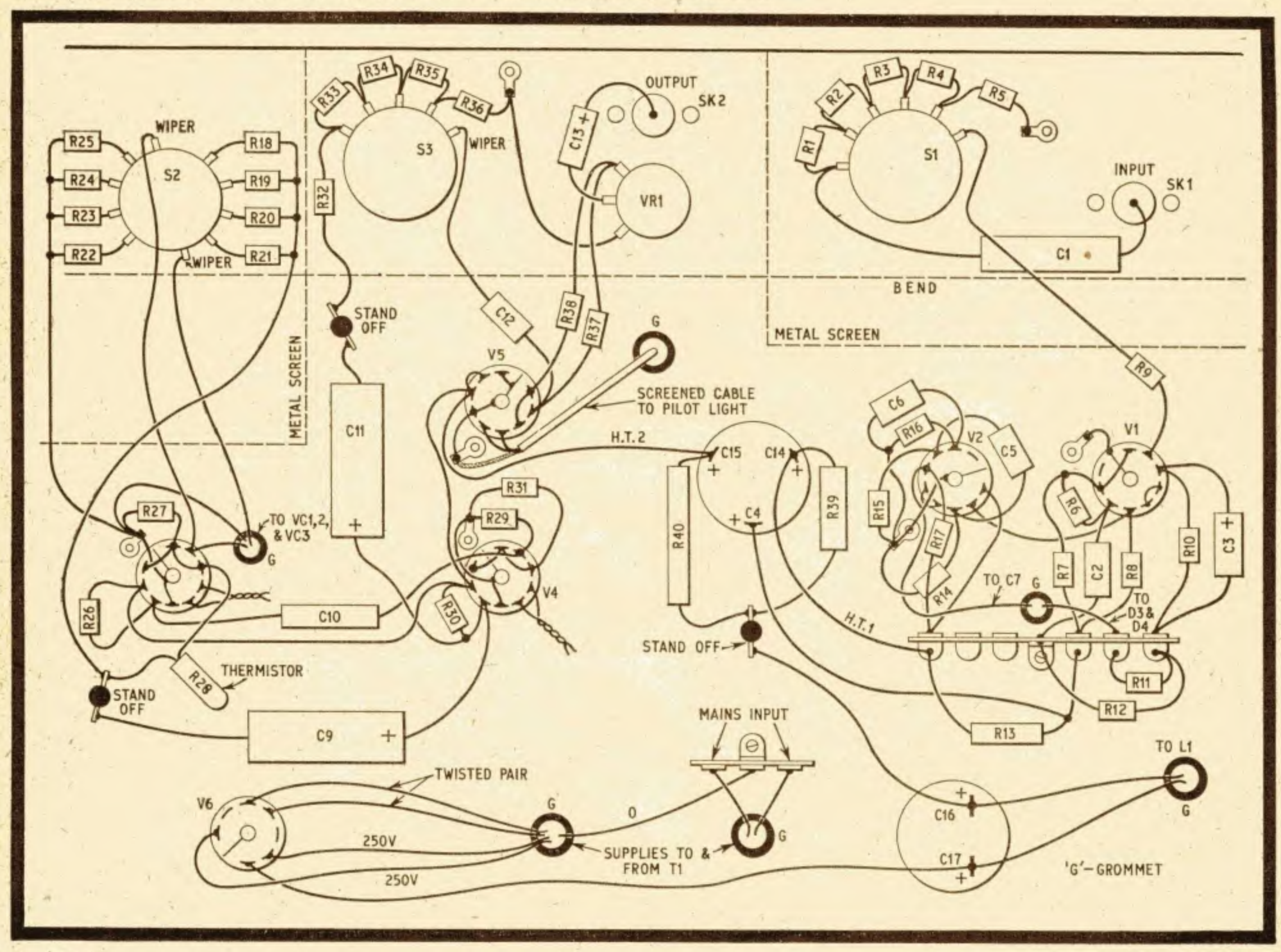


Fig. 5 (below). Layout of components on the underside of the chassis



COMPONENTS . . .

Resistors

R1	820kΩ	1% high stab. ½ watt (R1–R5)
R2	82kΩ	
R3	8·2kΩ	
R4	820Ω	
R5	91Ω	
R6	1·5MΩ	5% ½ watt. (R6–R11)
R7	120kΩ	
R8	220kΩ	
R9	10kΩ	
R10	680Ω	
R11	10kΩ	
R12	33Ω (see text)	
R13	10kΩ	10% 1 watt
R14	120kΩ	5% ½ watt (R14–R17)
R15	2·2MΩ	
R16	680Ω	
R17	47kΩ	
R18	20kΩ	1% high stab. ½ watt (R18–R25)
R19	200kΩ	
R20	2MΩ	
R21	20MΩ	
R22	20kΩ	
R23	200kΩ	
R24	2MΩ	
R25	20MΩ	
R26	22kΩ	5% ½ watt
R27	3·3kΩ	5% ½ watt
R28	200kΩ	Thermistor type A5513/100 (S.T.C.)
R29	1MΩ	5% ½ watt (R29–R31)
R30	10kΩ	
R31	270Ω	
R32	47kΩ (see *Calibration* in part 2)	
R33	82kΩ	1% high stab. ½ watt (R33–R36)
R34	8·2kΩ	
R35	820Ω	
R36	82Ω	
R37	270kΩ	5% ½ watt
R38	330Ω	5% ½ watt
R39	8·2kΩ	10% 2 watt
R40	2·2kΩ	10% 2 watt

Potentiometer

VR1 5kΩ linear carbon miniature

Capacitors

C1	0·25µF paper 500V
C2	0·04µF paper 500V
C3	100µF elect. 25V
C4	8µF elect. 350V (in same can as C14 and C15)
C5	0·05µF paper 250V
C6	1µF paper 150V
C7	4µF paper 250V
C8	100µF elect. 25V
C9	8µF elect. 450V
C10	0·1µF paper 350V
C11	8µF elect. 450V
C12	0·05µF paper 250V
C13	25µF elect. 25V
C14	16µF elect. 350V (in same can as C4)
C15	16µF elect. 350V (in same can as C4)
C16	32µF elect. 350V
C17	16µF elect. 350V
VC1	50pF trimmer
VC2	500pF twin ganged miniature
VC3	500pF twin ganged miniature

Valves

V1a and V1b ECC83
V2a and V2b ECC83
V3, V4, V5 EF80 (3 off)
V6 6X4

Diodes

D1–4 GEX34 or OA79 (4 off)

Switches

S1 Single-pole, 5-way rotary
S2 Two pole, 4-way rotary
S3 Single pole, 4-way rotary

Transformer

T1 Mains transformer. Secondary windings: 250–0–250V 60mA; 3·15–0–3·15V 2A; 6·3V 2A (Ellison type MT161)

Inductor

L1 15H 50mA l.f. choke

Miscellaneous

M1 1mA f.s.d. 100Ω moving coil meter LP1 6-volt miniature indicator lamp (Bulgin)
Five B9A valveholders with screens, two of which should have p.t.f.e. bases for V1 and V2
Chassis and metal case 12in × 7in × 7in (H. L. Smith & Co. type Y)
Dial type 4489 (Jackson Bros.). Two clips for mounting large capacitors (see photograph)
Coaxial input and output sockets (with plugs) 7-way and 3-way tag strips
Rubber grommets; knobs; 4B.A. and 6B.A. nuts, bolts, and solderings tags.

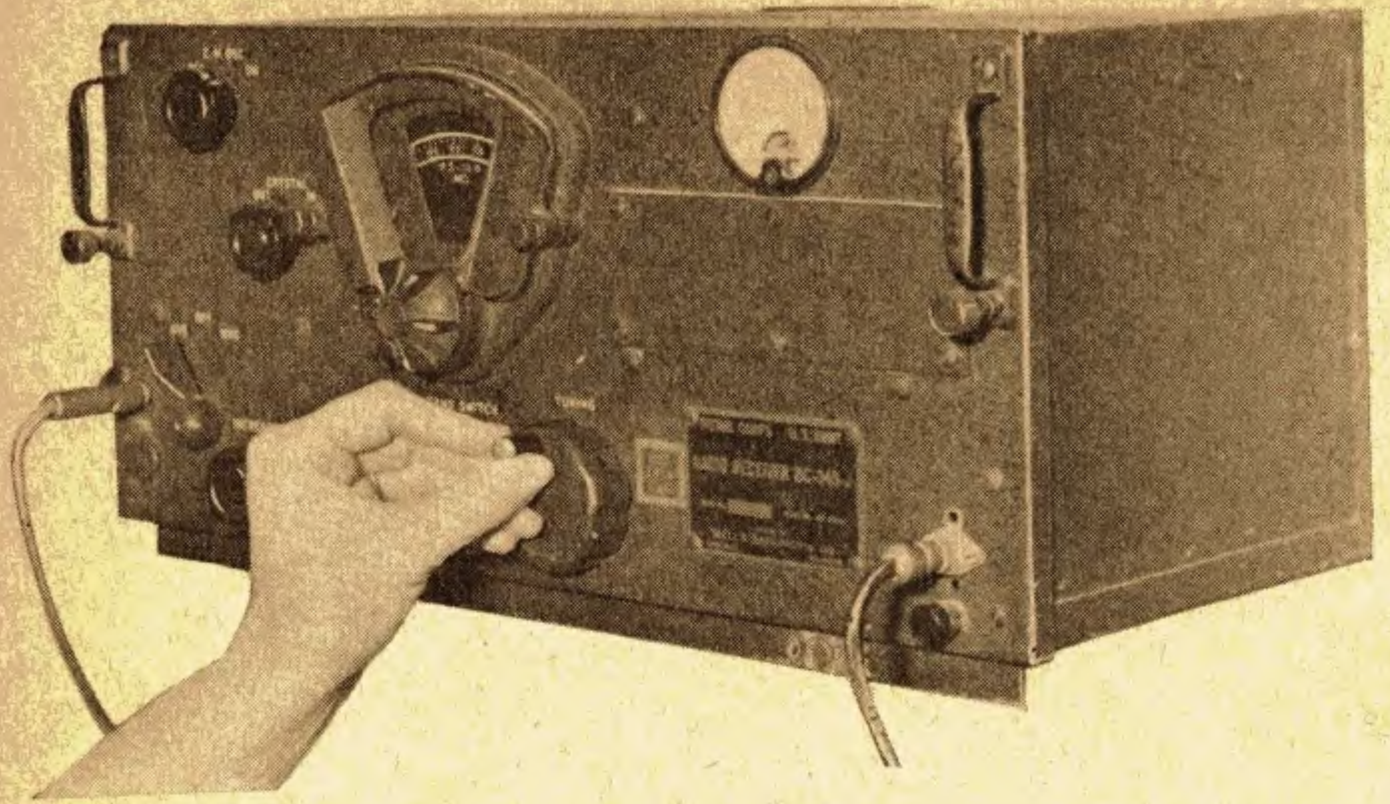
a deflection on the meter. A small hole should be drilled in the screen of S1 directly in line with the wiper tag of S1 and the "grid" tag of V1a. R9 should be passed through it, and wired as near to the grid as possible.

Two small pieces of s.r.b.p. or perspex sheet are required to carry the tuning capacitor and the four germanium diodes on the meter (Fig. 6). The frame of the tuning capacitor is connected to the grid of V3. It must be insulated from the chassis by being bolted to the s.r.b.p. or perspex which is in turn bolted to the chassis. The size used in the original was 4in × 1in, this was bolted to the chassis by means of a 4 B.A. screw at each end, the front screw serving to hold the screen round S2 under the chassis. An *insulated* coupler is essential between the tuning capacitor spindle and the dial which is earthed.

The piece of perspex or s.r.b.p. used for the meter diodes is 2in × 1½in, four holes being drilled in it, two 6 B.A. clearance and two 2 B.A. clearance. A 6 B.A. earth tag is screwed to each of the two smaller holes; the s.r.b.p. is attached directly to the meter terminals by means of the two larger holes, a 2 B.A. tag being placed on each terminal before the fixing nuts are tightened. The diodes are then soldered directly to these tags using heat shunts and leaving the leads as long as possible. Note the polarity of the diodes.

If the diodes are made to stand away from the panel room will be found for C7, which is soldered across the two 2 B.A. tags, again observing polarity. With the GEX34 the red end corresponds to the cathode of a thermionic diode and should therefore go to the positive terminal of the meter, as should the positive end of C7.

Next month: Calibration



THE BC 348 Classic

Origin

THIS receiver, widely used in most American and many British aircraft from 1942 onwards, was mass-produced in the United States by numerous sub-contractors, whose identity may be ascertained from the suffix to the type-number on the front panel, *e.g.*, BC348J comes from Wells-Gardner.

Several detail differences occur in models from different "stables". For example, some versions incorporate an aerial alignment trimmer while others do not. Basically, however, almost all versions conform with the details given below.

Basic Circuit

Two r.f. amplifiers, both	6K7
First detector	6L7
Separate local oscillator	6C5
First i.f. amplifier	6K7
Second i.f. amplifier and beat frequency oscillator	6L7
Third i.f. amplifier and second detector	6B8
Output valve	6K6
Voltage regulator to oscillator valve	RCA991

COMMENT: This valve line-up is a representative one, although numerous permutations occur among different models. In one version the c.w. oscillator is combined with the second detector and there are two i.f. stages. In another the luxury of three i.f. stages is achieved by putting the c.w. oscillator on to the second i.f. while the second detector and third i.f. are combined in one valve. The importance of securing the correct circuit diagram for the particular model purchased is self-evident.

The claimed sensitivity for the three-i.f. version is as good as 3 to 7 microvolts overall on all bands, this for 10 milliwatts output into a 4,000 ohm load.

Waveranges covered

Band no. 1	200–500kc/s
Band no. 2	1·5–3·5Mc/s
Band no. 3	3·5–6·0Mc/s
Band no. 4	6·0–9·5Mc/s
Band no. 5	9·5–13·5Mc/s
Band no. 6	13·5–18·0Mc/s

COMMENT: Having 200 kc/s available is extremely useful: it furnishes the standard frequency BBC Light Programme transmission against which a 100kc/s crystal calibrator may be compared. The remaining ranges embrace the 1·8, 3·5, 7 and 14Mc/s amateur bands, and it is these that most BC348 purchasers will require. To cover the 21 and 28Mc/s amateur bands—and of course all allocations higher—external converters will be needed.

Intermediate Frequency

915kc/s.

COMMENT: Users of the BC348 in the Greater London area may experience i.f. breakthrough from the 140kW transmitter at Brookmans Park on 908kc/s. Injected into the i.f. chain, this signal can at worst produce a continuous high pitched whistle on all bands.

The cure (in most cases): by-pass all supply leads to chassis through 0·01μF capacitors, and insert in the h.t. lead a medium wave coil used as an r.f. choke. Additionally, insert in the aerial lead a wavetrap consisting of a medium wave coil tuned to the frequency of the offending signal.

Power Requirements

In its original condition the BC348 comes with a 28 volt dynamotor that is likely to be of little or no value to the average enthusiast.

COMMENT: The space made available when the dynamotor is removed will comfortably accommodate a mains power unit of sufficient size to deliver the 200 volts at 50mA and 6·3 volts at 2·5A required by this receiver. A slightly larger mains power supply unit can be installed if a reserve is required for external converters or a crystal calibrator.

Controls

In the centre is the bandchange knob. The range in use is registered in the dial window above it. Below is the reduction-drive tuning knob actuating a four-gang capacitor: to the left, gain control and c.w. oscillator pitch control. Above them: the crystal gate switch and the c.w. oscillator on/off switch. Extreme left: manual or automatic gain control lever switch. Top right: dimmer for dial lights. Far right: aerial alignment control (when fitted).

So-called "war surplus" models are still available in great quantities, as advertisers' announcements and dealers' shop windows declare, and the communications enthusiast seeking to select one may be left in a state of some confusion as to which model he should buy.

To give him some guidance **PRACTICAL ELECTRONICS** will publish a short series of articles that will evaluate the more popular of these receivers. The aim will be to summarise the merits and demerits of each model, and suggest what basic modifications can be usefully made to improve its operational capability.

It must be emphasised that these articles will **NOT** cover the detailed changes (if any) that may need to be made to such receivers. The supplier should be consulted before a purchase is completed and his assurance obtained either that the set is in working order or that the necessary modification details can be supplied.

These articles will in no sense meet servicing requirements: such information comes in the appropriate handbook—ask your supplier to find you one.

COMMUNICATION RECEIVERS

COMMENT: Ergonomically, the BC348 earns high marks for the intelligent placement of controls. While the right hand rotates the tuning knob, either directly or with the little handle fitted to it, the left-hand has all other needful user-controls within short reach. No cross-hands performance is called for!

Being a general coverage receiver the BC348 does not offer electrical bandspreading of the type required for use on the crowded amateur bands. Those bands occupy on the tuning scale 1 inch (1·8Mc/s), 2 inches (3.5Mc/s), ½ inch (7Mc/s) and 1½ inches (14Mc/s). However, the order of tuning knob rotation called for to cover each of these bands is:

BAND	REVOLUTIONS
1·8Mc/s	10
3·5Mc/s	16¼
7·0Mc/s	4½
14·0Mc/s	8

It might be added that when the receiver is used as a 4–6Mc/s i.f. strip for a 144–146Mc/s converter this span of 2Mc/s is covered in no less than 66 revolutions.

Recommended Basic Modifications

Heaters: In the original model with 28 volt dynamotor the valve heaters are wired in a complex series-parallel arrangement to allow 6·3 volt valves to operate from 38 volt aircraft batteries. It is recommended that the existing heater wiring (generally pins 2 and 7 on I.O. valve holders) be removed and a complete re-run made to parallel all heaters for 6·3 volt operation from a mains power unit.

Aerial Input: Because most receivers will be fed from an aerial tuning unit via low impedance cable it is recommended that the existing aerial terminal be removed and replaced by a Belling-Lee coaxial socket.

Use with External Converter: The provision of a coaxial input circuit is especially essential when the BC348 is fed from a converter, to minimise i.f. break-through.

Separating the Gain Controls: To facilitate reception of single sideband signals it is desirable to fit separate a.f. and r.f. gain controls. In the original there are two ganged potentiometers of 20,000 ohms (front) and 350,000 ohms (rear) operated simultaneously by the front panel gain control knob. It is no difficult matter to disconnect the 20,000 ohm potentiometer—it controls the second r.f. stage—and reposition it in place of the dial light dimmer, not generally required.

Gain Equalizer: In some models a variable resistor rotates with the gang-capacitor shaft. Its purpose is to equalise the gain over the entire tuning range. It may be removed with profit.

Capacitors—a warning: Most BC348 receivers purchased today will be at least 20 years old, and some deterioration in the condition of the fixed capacitors may have occurred. This will sometimes be self-evident either through failure of a stage or stages to function, instability, or more dramatically by short-circuits on the h.t. line. To disconnect and test every one of the dozens of capacitors in this model is a tedious business but probably worth while in the long run.

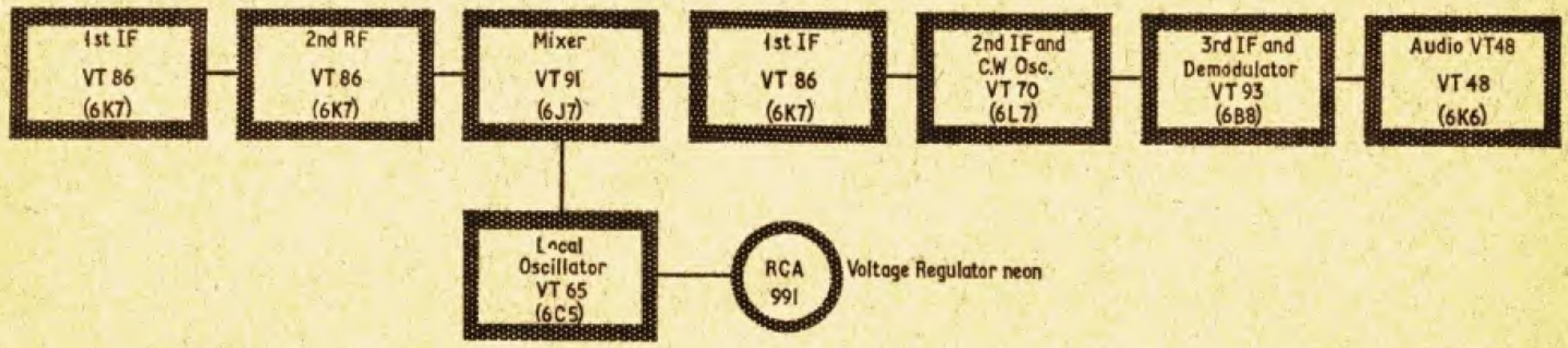
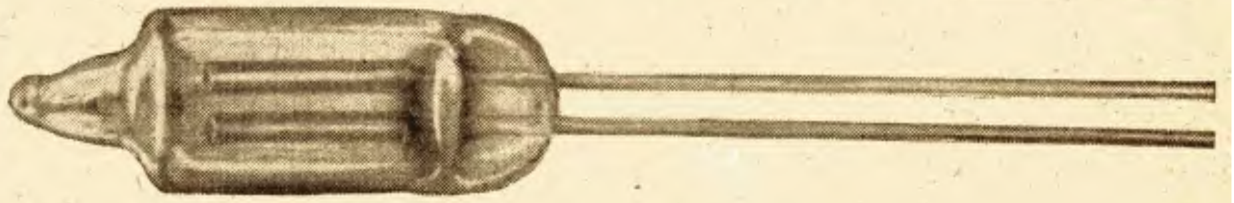


Fig. 1. Block diagram showing the basic BC348 circuit arrangement

NEON NOVELTIES



THIS is the third 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.

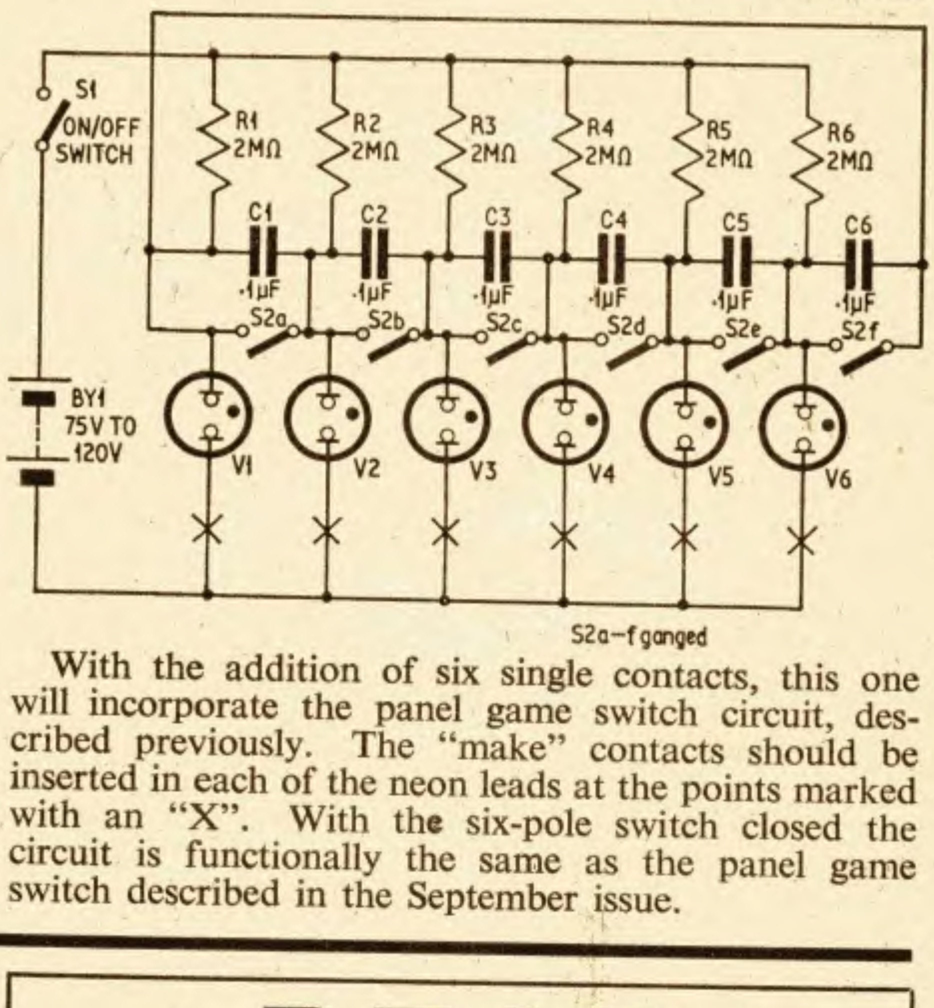
Some neon indicators have a resistor wired in series with one of the neon wires to make them suitable for mains voltages. These would normally be unsuitable for the circuits described unless the resistor is removed or short-circuited.

THREE ELECTRONIC DICE by R. Bebbington GRAD.I.E.R.E.

THIS is merely an extension of the "heads or tails" principle that was described last month. Six miniature neons are used in a ring circuit with six associated capacitors and resistors. When the battery is connected the neons will flash sequentially at a rate determined, as before, by the choice of the R-C time constants of the circuit.

In order to "freeze" the flashing, all six capacitors must be short circuited simultaneously and this is the only problem that the circuit presents. Any differences in the times taken for the separate contacts of the six-pole two-way switch to close will "load" the dice in favour of certain numbers. This is accentuated if the speed of flashing is rapid, so if this trouble is encountered then the values of the R-C networks should be increased.

A chassis type of construction is best for this circuit with the six neons inside peeping through six holes patterned in true dice-fashion on the uppermost surface. Since only one neon lights at any one time they will have to be numbered one to six. A wafer switch has been used successfully in this circuit, the contacts being doctored where necessary to ensure that all switches are "made" in the same time.



With the addition of six single contacts, this one will incorporate the panel game switch circuit, described previously. The "make" contacts should be inserted in each of the neon leads at the points marked with an "X". With the six-pole switch closed the circuit is functionally the same as the panel game switch described in the September issue.

ELECTRONIC BUILDING BLOCKS

PART EIGHT

by R. A. DARLEY

THIS month's article will look briefly at the formation and deflection of a cathode ray tube trace, and go on to describe methods of achieving a suitable waveform for timebases.

OSCILLOSCOPE TRACE

Fig 8.1a shows the graph generally known as a sine wave drawn against two axes, one vertical and the other horizontal. The vertical, or "Y" axis, represents volts, and the horizontal, or "X" axis, represents time, usually in seconds.

A cathode ray tube may be used to display a similar graph or any others based on voltage and time. An electrostatic cathode ray tube has a "gun" which fires a very narrow stream of electrons on to a phosphorescent screen; at the point where the electrons "hit" the screen the phosphor "glows", appearing as a pin-point of light. Interposed between the "gun" and the screen are four electrodes: two X plates and two Y plates. Fig. 8.1b shows the arrangement of these electrodes, when viewed from the screen end of the cathode ray tube. By applying a potential between Y1 and Y2 the electron stream, and hence the pin-point of light appearing on the screen, can be moved vertically in the "Y" axis; similarly, the beam may be moved in the "X" axis by applying a potential between X1 and X2. By applying a sine wave voltage to the "Y" axis, and a voltage that rises linearly with time to the "X" axis, a "graph" can be traced out as shown in Fig. 8.1a.

The width of the tube face is limited, and so is the time period that can be displayed. In practice, a time "scan" sufficient to show only a few cycles is made, the "timebase" voltage rising linearly from zero to, say, 10 volts and then resetting itself to zero again and "scanning" the tube again. In this way, succeeding "cycles" of the timebase trace out similar "graphs", one over the other. If approximately 25 or more such scans are made per second, the moving spot of light appears as a continuous line and the illusion of a true graph is obtained.

TIMEBASE WAVEFORM

The "timebase" waveform that is applied to the X plates is shown in Fig. 8.1c and is generally referred to as a "sawtooth" waveform. In an ideal waveform the voltage rises steadily from zero to a maximum in a pre-determined time, and then drops *instantly* to zero again. In practice the waveform takes a small but definite time to drop to zero as shown in Fig. 8.1c. This part of the waveform is used to return the spot on the screen to the beginning of the trace as rapidly as possible; it is referred to as the "flyback" period.

Circuits that generate a sawtooth waveform are usually called "timebase" generators, "sawtooth" oscillators, "sweep" generators, or "ramp" generators.

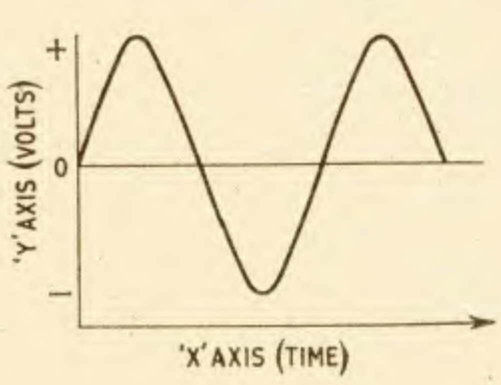


Fig. 8.1a. Sine wave shown in graph form plotted against an "X" and "Y" axis

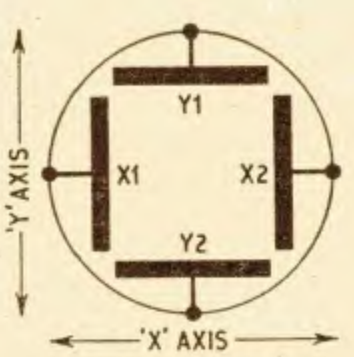


Fig. 8.1b. Position of the "X" and "Y" plates in a cathode ray tube looking at the "screen" end of the tube

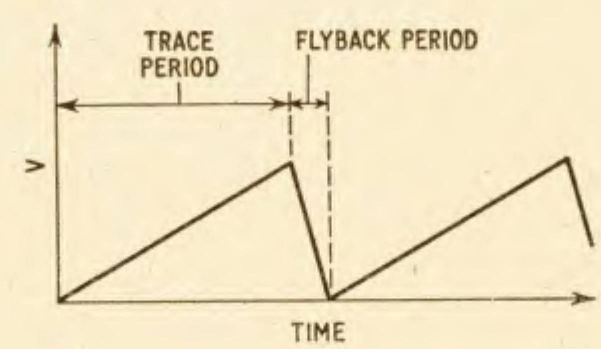


Fig. 8.1c. Sawtooth waveform showing the "trace" and "flyback" periods

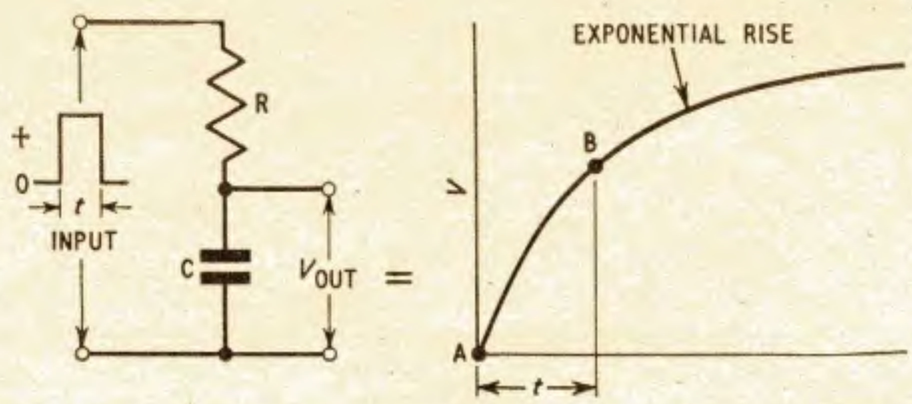


Fig. 8.2a. Simple RC circuit to convert a square wave input to an exponential output. Note that the most nearly linear part of the curve is that part nearest the origin

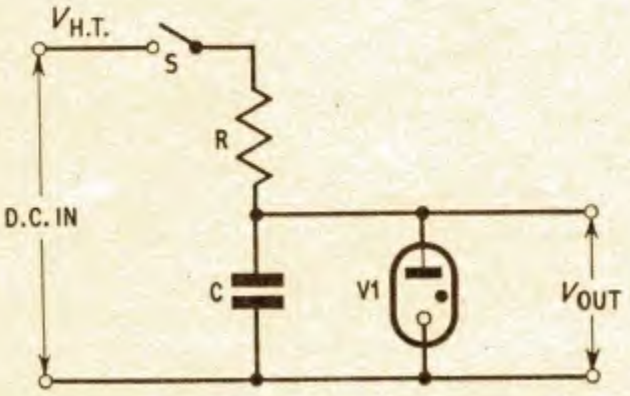


Fig. 8.2b. Modified RC circuit using a gas-filled diode to limit the output voltage

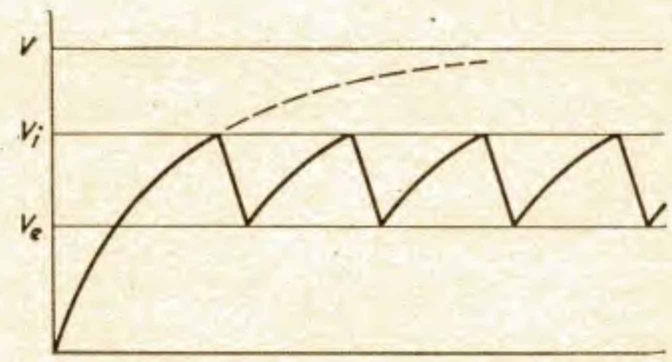


Fig. 8.2c. Output waveform from the circuit in Fig. 8.2b. V_i is the "striking" voltage and V_e the "cut-off" voltage of the gas-filled diode

BASIC SAWTOOTH OSCILLATORS

If a resistor and capacitor are connected in series, as shown in Fig. 8.2a, and a square wave is applied across the combination, the output taken from across the capacitor only will be exponential. If the duration of the input square wave is short compared to the time constant of the CR circuit, the output signal will vary from zero to maximum volts almost linearly. If the duration of the input signal is less than one tenth of the CR time constant, the deviation of the output from linearity will be less than 5 per cent. By using only a short part of the exponential rise a useful sawtooth waveform can be obtained.

One practical way in which this principle can be achieved is shown in Fig. 8.2b. The resistor and capacitor are again wired in series, but in this case a d.c. supply is connected across them. A gas-filled diode, or voltage regulator tube V1, is connected across the capacitor.

When a low voltage is applied across a gas-filled diode, the gas does not conduct and the diode is a virtual open circuit. As the voltage is increased, a point is reached at which the gas "ionises" and conducts heavily. The voltage at which ionisation occurs is called V_i. If the applied voltage is then reduced from V_i the gas will continue to conduct until, when a certain voltage level is reached, ionisation ceases. This second voltage is referred to as V_e.

At the instant when the d.c. is applied the output voltage across C is zero, but as time passes the voltage rises exponentially (see Fig. 8.2c) until it reaches the "striking" voltage of V1. At this point, V1 ionises and conducts, effectively short-circuiting and discharging the capacitor. As the output voltage falls to "cut-off" (V_e) conduction ceases and the short circuit across C is effectively removed. The capacitor is charged up again to repeat the cycle of events. The rise time of the waveform is dictated by the time constants of the circuit, while the decay time depends on the time constant derived from the effective resistance of V1 in series with the resistor, and the capacitance of C.

At fairly low frequencies the decay time will be short compared to the rise time; the frequency of operation is virtually dictated by the rise time between the "striking" (V_i) and "cut-off" (V_e) voltages of V1.

BASIC "BOOTSTRAP" SAWTOOTH OSCILLATOR

For many applications, a sawtooth waveform that has a perfectly linear rise voltage, is essential. Such a voltage can be obtained by passing a constant current through a capacitor.

One circuit that relies on this principle is shown in Fig. 8.3a, this being the basic version of the circuit known as the "bootstrap" sawtooth oscillator. Transistor TR1 is an emitter follower, with an emitter load resistor R1. Resistor R and capacitor C are the time constant components, and R1 is an isolating resistor. Capacitor C1 provides a.c. feedback from TR1 emitter to the junction of R and R1.

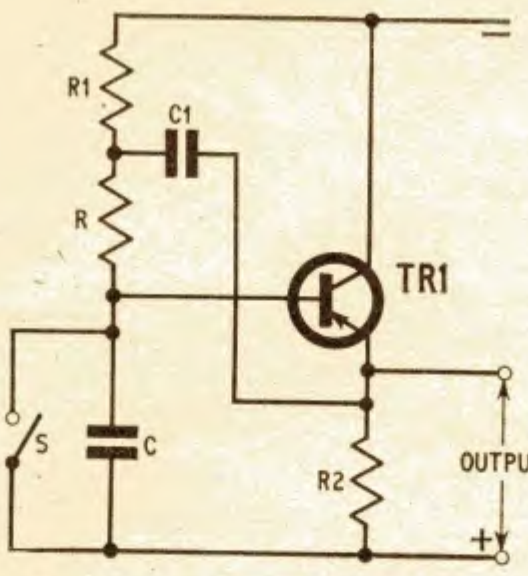


Fig. 8.3a. Basic "bootstrap" sawtooth oscillator

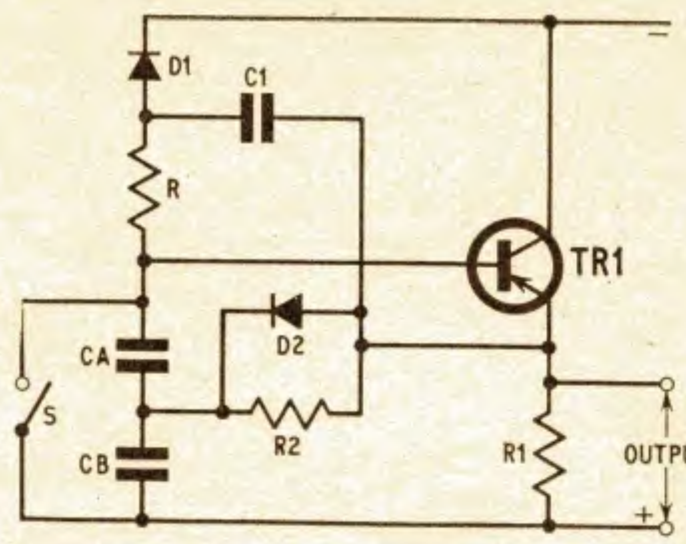


Fig. 8.3b. Improved "bootstrap" sawtooth oscillator

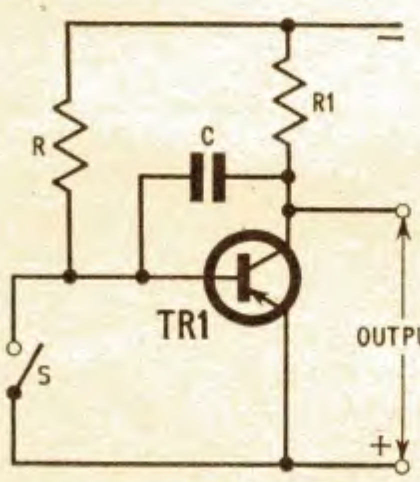


Fig. 8.4a. Basic "Miller integrator" sawtooth oscillator

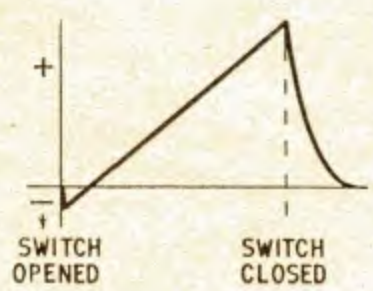


Fig. 8.4b. Output waveform of the Miller integrator circuit

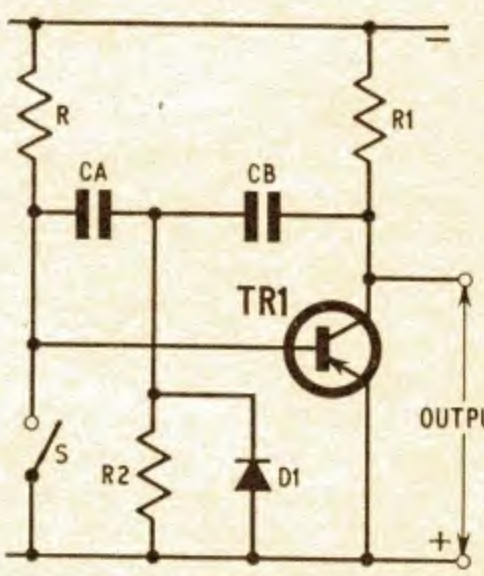


Fig. 8.4c. Improved version of the Miller integrator circuit

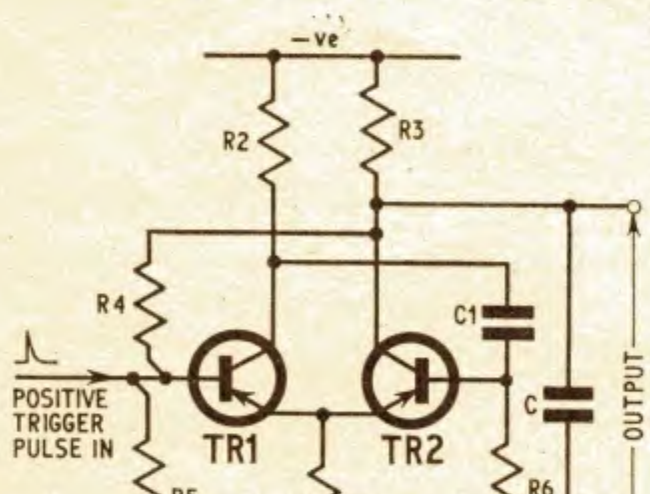


Fig. 8.5a. Sawtooth oscillator based on the monostable multivibrator triggered by an incoming pulse

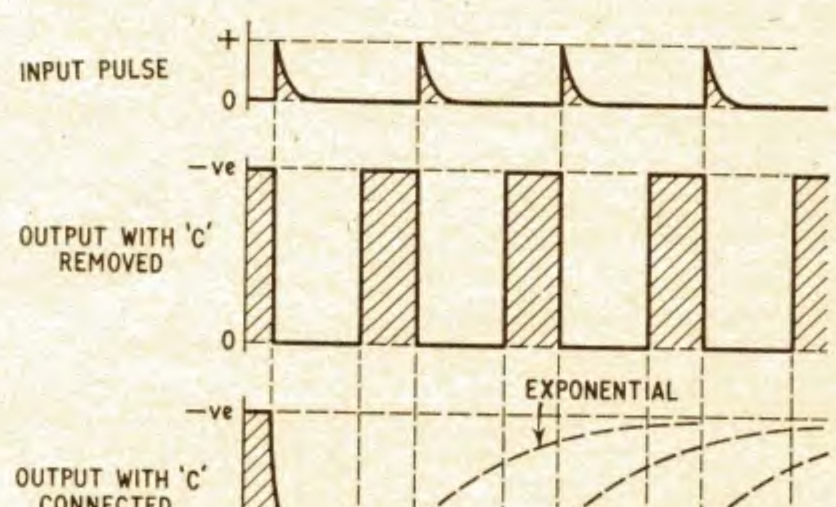


Fig. 8.5b. Input and output waveforms of the circuit shown in Fig. 8.5a.

With switch S1 closed the capacitor C is short-circuited and TR1 base is held at "earth" potential; TR1 is thus "cut off" and its emitter is at "earth" potential. If S1 is now opened, the capacitor begins to charge up in a negative direction, through R and R1. As the voltage across C becomes more negative, so does the base and emitter of TR1.

The changing voltage at TR1 emitter is transmitted via C1 back to the R–R1 junction. Thus, as the voltage at the CR junction rises, so does the voltage at the R–R1 junction, with the result that no change in voltage takes place across R. Consequently, as the voltage across R is constant and the value of R is fixed, the current through R, and therefore through C, is constant and the output voltage, taken from across the emitter resistor R2, rises linearly.

After a certain time, S1 is closed again, short circuiting C; the output voltage decays to zero in a time dictated by the time constant of R1 + R2 and C1.

For satisfactory operation of the bootstrap circuit as described it is essential that the input impedance of the transistor circuit should be high, taking only a negligible current from the CR chain; the signal fed back to the junction of R and R1 should come from a low impedance source; the feedback amplifier must have unity gain. These three requirements are met by the emitter follower circuit with little difficulty.

In practice, this simple circuit does not give perfect linearity; a considerable improvement can be obtained by making a few modifications, as shown in Fig. 8.3b.

Here, the timing capacitor is replaced by two capacitors, usually of equal value, and an additional feedback signal is fed to their junction from the emitter of TR1 via R2; this feedback resistor causes a slight non-linearity of signal at the junction, due to the time constant of this resistor and the timing capacitors. R2 is usually made a variable resistor which is adjusted on test to give good linearity. The distortion that is introduced at this point tends to cancel any distortion that occurs at the R–D1 junction due to the C1–R1 network.

Resistor R1 of Fig. 8.3a is replaced in the modified circuit by diode D1. This diode serves two purposes: (i) it prevents the sawtooth voltage rising to too high a value, i.e. if a feedback voltage of sufficient magnitude to raise the R–D1 junction above the negative rail voltage is applied, D1 will be reverse-biased and the charging current will be cut off; (ii) when the reset or flyback part of the waveform occurs the diode is forward biased and thus has a low effective resistance; the reset time constant is thus reduced from that obtainable with the resistor of Fig. 8.3a and a sharper cut-off is obtained. D1 is sometimes called the "speed-up" diode. Diode D2 also acts as a "speed-up" diode in discharging CA and CB.

BASIC MILLER INTEGRATOR TIMEBASE

Another circuit that is commonly used to give a linear timebase voltage is the Miller integrator, shown in basic form in Fig. 8.4a.

If there is capacitance between the collector and base, either in the form of inter-junction capacitance in the transistor or as provided by an external capacitor, the resulting feedback causes the effective value of that capacitance to be increased by a factor β, where β is the gain of the transistor. Thus, the time constant of the circuit becomes $R \times C \times \beta$. This apparent increase in C is known as the Miller effect, from which name this particular sawtooth generator gets its title.

By referring to the Miller circuit of Fig. 8.4a, a voltage, equal to the voltage applied to the base multiplied by the voltage gain of the transistor circuit, appears at the collector. The signal appearing at the output of the circuit is the same as would be obtained with a simple RC circuit, in which the time constant is $RC\beta$, and the applied voltage is the negative rail voltage times the voltage gain. The output of the Miller circuit cannot exceed the negative rail voltage, so in effect we have only a very short part of an exponential waveform, which can be considered as practically linear by virtue of its "shortness".

By making the value of R1 smaller than that of R, a comparatively short re-set or flyback time can be obtained.

The linearity of waveform can be improved even further by modifying the circuit as shown in Fig. 8.4c. Here, additional linearising networks have been included, their functions being similar to those already outlined for the improved bootstrap circuit of Fig. 8.3b. Diode D1 is a "speed-up diode", giving an improved flyback time.

In practical circuits, the switch is replaced by one or more transistors, and the circuit is made self-energising.

TRIGGERED SAWTOOTH GENERATORS

In the bootstrap and Miller circuits so far described, the circuits depend on the opening or closing of a switch to initiate and maintain the generation of a waveform, the period for which the switch is held open dictating the length of the sawtooth rise period. These circuits may be referred to as "driven" generators since, when the "drive" is removed, no output is available. Other sawtooth generator circuits exist, in which the length of the rise period is independent of the duration of any external switching; these generators require only a short input "pulse" to start the sawtooth generating cycle, which is then self-sustaining until one cycle is complete. Such circuits may be referred to as "triggered" sawtooth generators.

One version of a triggered sawtooth generator is shown in basic form in Fig. 8.5a, this particular circuit being based on the monostable multivibrator. (The operation of the monostable circuit will be described in detail in a later part of this series.)

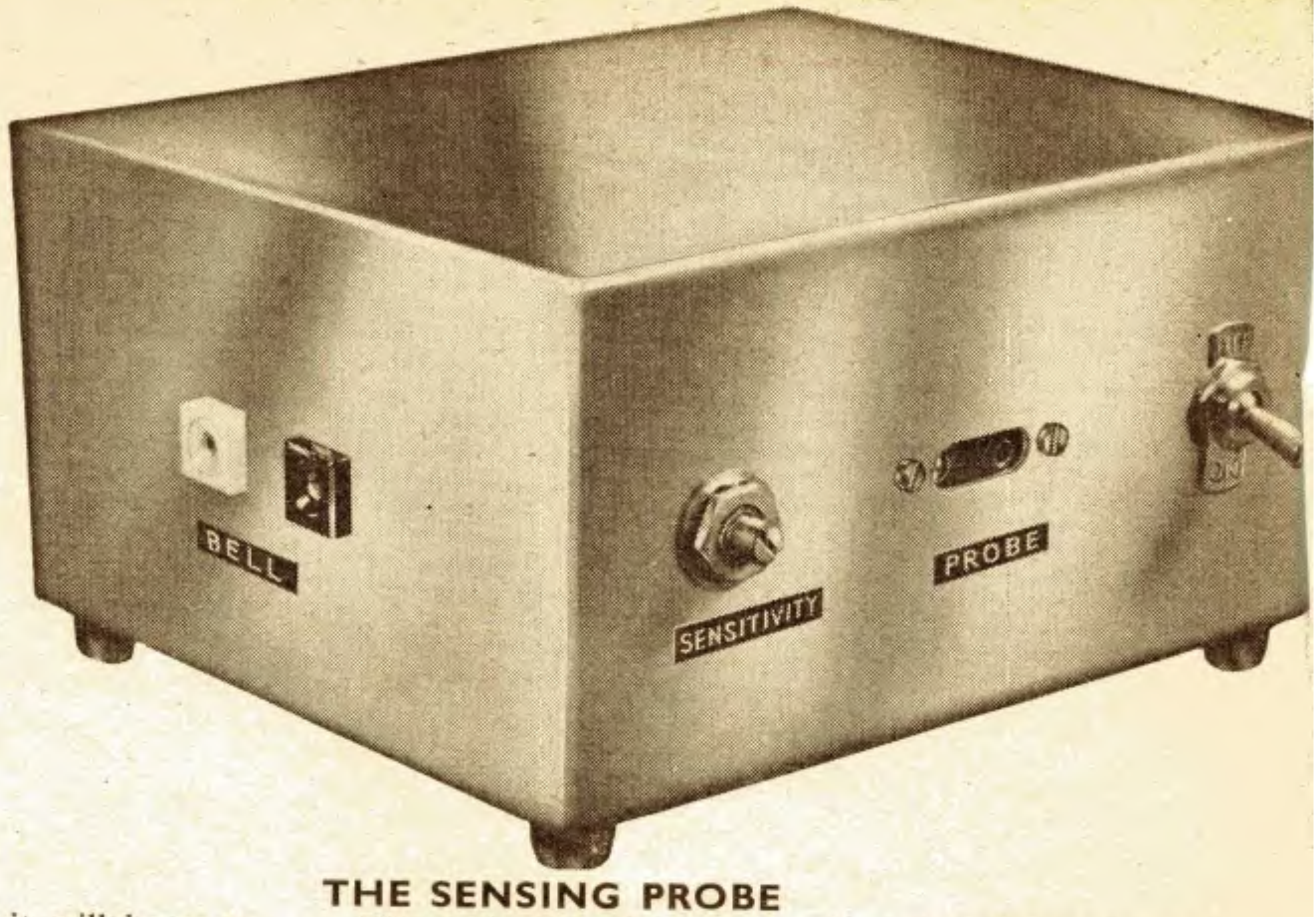
Fig. 8.5b shows the output waveforms when triggered by an input pulse; a reasonable sawtooth will be obtained. Note that the waveform with this circuit is not linearised, being of a partially exponential form.

By making the value of R1 small compared to that of R3, a short flyback time can be obtained, while, by careful choice of the values of R3 and C, and the repetition frequency of the input trigger pulses, quite a good sawtooth waveform is possible. Note that the lower the peak output voltage compared to the supply rail voltage, the more nearly linear will the "rise" part of the sawtooth be.

By replacing the monostable multivibrator circuit of Fig. 8.5a by an astable one, the circuit can be made completely free running, requiring no input pulses to trigger it.

Next month: Design and operation of multivibrator circuits.

PE BLUEPRINT



THIS article describes a battery-operated water level alarm device which may be built on a small piece of laminated plastics and mounted inside a small case together with two flat batteries. Output sockets are provided for connecting to an external indicating device, such as a bell, buzzer or lamp. The circuit diagram and constructional drawings appear on one of the blueprints presented with this issue.

CIRCUIT DESCRIPTION

Referring to Fig. 1 on the blueprint it will be seen that three silicon *npn* type transistors are employed in this alarm circuit. The types specified have been carefully selected for their high gain and very low leakage current characteristics. It should be noted that this circuit will not work reliably, if at all, with normal germanium transistors. The latter have generally high- and temperature dependent leakage currents. This could result in unnecessary high standing current and possibly false alarms on warm days.

The three transistors constitute a triple-cascade emitter follower which repeats (roughly) the input voltage to the input base (TR1) at the output emitter of TR3 in whose circuit the relay RLA is connected. Connections are such that when there is even a quite high resistance path across the two input connections (SK1), such as may be presented by clean water, sufficient amplified current flows in the output emitter circuit to energise the relay and ring the bell.

The 470 kilohm series resistor R1 and the 0·5μF shunt capacitor C1 at the input base, remove sensitivity to stray mains hum which may be picked up. This capacitor must have excellent insulation. The 5 megohm potentiometer VR1 varies the resistance level between the input electrodes.

THE SENSING PROBE

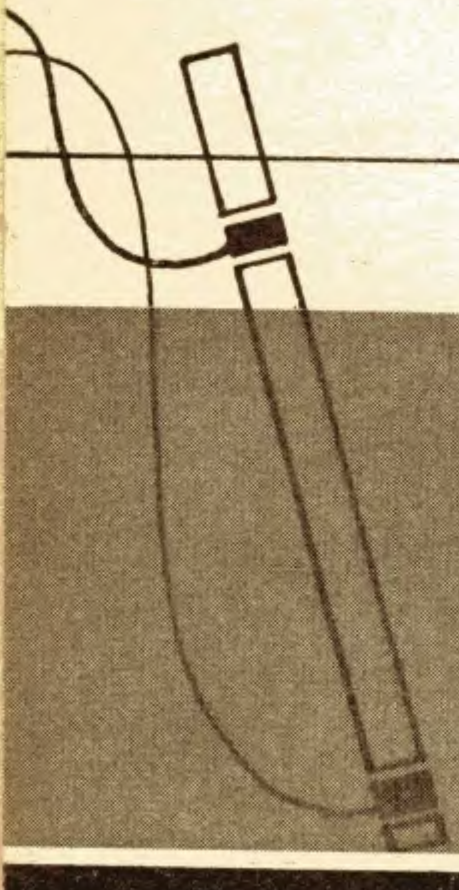
The probe is a relatively simple and easily constructed device. Essentially it consists of two metal electrodes mounted on an insulator rod, as shown in Fig. 3. The lower collar is fixed and is always submerged in the water. The upper collar can be slid to the desired level at which the alarm is required to be sounded.

LOW CURRENT DRAIN

A rod or tube about $\frac{1}{4}$in diameter, made of Paxolin or Bakelite material can be used for the probe. Perspex and certain other thermo-plastic materials are suitable for cold water applications only.

The sensitivity of the probe can be increased by enlarging the area of the metal collars.

The advantage of this circuit is the extremely long battery life it ensues, because the current drain in the non-alarm condition is much less than the self-discharge of the battery. In fact, using the specified transistors, it will normally be immeasurably small if read on the average general purpose meter. Thus the on/off switch S1 could in principle be dispensed with, in which case the electrolytic C2 across the supply should also be omitted. It is unlikely that this would lead to instability, since the circuit employs no voltage gain.



WATER LEVEL alarm

by M. L. Michaelis M.A.

An outstanding feature of this battery-operated alarm unit is its absolute safety. Perhaps a general warning note should be added here that constructors desiring a device to announce to them when their bath has run full should NOT contemplate using a *mains-operated unit.*

CONSTRUCTIONAL DETAILS

The electronic circuit is easily built up on a piece of laminated plastics material. Full size drawings of the top and underside of this panel appear in Fig. 2.

The method of component mounting adopted utilises proprietary terminal pins which are inserted in holes made with a No. 55 drill. These pins are tapered and form a secure anchoring point when lightly tapped home. The longer portion of the pin should protrude through the top (component side) of the panel. Not more than ⅛in of the pin should emerge through the underside of the panel, this is to ensure that no part of the circuit comes into contact with the bottom of the metal case when fitted inside.

If preferred, "home made" terminal pins may be fashioned from short lengths of 18 s.w.g. tinned copper wire. In this case, a No. 56 drill will provide a hole fractionally smaller than the diameter of wire. By gently tapping the end of the wire, it may be forced through the panel.

With all 22 terminal pins in position, proceed to wire up the underside of the panel. Use 22 s.w.g. or smaller wire for this purpose. Next place the transistors in position and bring their leads through to the underside of the panel via the appropriate holes. Solder the transistor leads to the correctly numbered terminals. The remaining components should now be installed and wired up to the upperside end of the terminals. Relay RLA is secured to the panel by means of two 8 B.A. screws supplied with this component.

THE METAL CASE

The metal case consists of a standard (universal) chassis with top panel This can be obtained in prepared sections requiring only to be bolted together from Home Radio (Mitcham) Ltd. Alternatively, a case may be made up from sheet aluminium. Dimensions can be obtained from the full size diagrams Fig. 4 and Fig. 5. Two of the sides should be drilled to accommodate the sockets and controls.

The component panel is secured to the bottom of the case with a pair of 6B.A. bolts and nuts. A ¼in long spacer should be placed over each bolt between the metal case and the plastics panel. The sockets, potentiometer, and on/off switch are mounted and wired up according to Fig. 4. Then the two flat batteries can be installed and connected up.

INSTALLATION NOTES

The 9V supply from the internal battery BY1 is made available at sockets SK2 and 3 immediately the relay is energised. A standard electric bell can be connected up to SK2 and 3. If a visual warning is preferred, an 8V or 12V lamp could be used.

Ordinary mains flex is suitable for connecting the probe to the alarm unit. The latter may be located some distance from the water container it is intended to monitor. ★

DOORPHONE

continued from page 917

CABINETS

The cabinet of the amplifier unit is made of plywood and has a laminated plastic (such as "Formica" or "Wareite") front panel. The construction is shown in Fig. 6, and the drilling details of the front panel in Fig. 7. The baseboard is shown in Fig. 8. It will be found that the amplifier has to be positioned inside the cabinet at a slight angle in order to be clear of the loudspeaker, battery and switch S1. The end of the amplifier which carries the largest transformer (T3) should be at the rear of the cabinet. The amplifier may be screwed down to the baseboard of the cabinet if small soldering-tags are soldered to the end terminals of the groupboard. Four rubber or p.v.c. feet should be fitted to the underside of the baseboard.

The door unit is constructed quite simply from plywood and is shown in Figs. 9 and 10. The wiring of the door unit is given in Fig. 5 on the blueprint and is quite straightforward. It should be noted though that the connection from S2 to the loudspeaker LS2 should be made to the wire which is connected to the positive line of the amplifier, and not to the wire connected to S1a. When the unit is completed, and S1 is at the "off" position, the wire from S2 can be connected to each side of LS2 in turn. Connecting it to one side will be found to result in a more pronounced howl when S2 is operated than connecting it to the other side of LS2.

LOCATION

Since the door unit will be positioned in the open, its location should be chosen with care to avoid the direct incidence of rain. Obviously, the more sheltered the position finally chosen, the less chance there will be of damage to the unit by the weather. The door unit should be painted to keep out damp and it would also be a good idea to seal all the joints when the unit is finally assembled. The grill on the front between the loudspeaker and the panel should be of fine mesh; perforated zinc was used in the prototype. However, there is now on the market a plastic substitute for perforated zinc which would be a better type of material to use. To keep out the damp, a thin sheet of polythene can be fixed to the grille behind the panel; the sound level will be reduced somewhat, but the weather-proofing will be better.

If the door concerned has a porch, this is all to the good, and the door unit can be fitted in a sheltered position.

OTHER USES

This intercom system is capable of giving an output of quite good quality and would certainly be adequate for communication between two offices. It would also be found useful for wiring between the bedroom of a sick person or invalid and another room to prevent needless journeys upstairs. Yet another use would be as a baby alarm, in which case the switches S1 and S2 would not be required, their place being taken by a simple on/off switch for the battery.

The prototype was also found handy for use when installing a television aerial in an area of weak signal, giving communication between the aerial rigger and someone watching the receiver, so that the aerial could easily be positioned for optimum results. ★

ELECTRONORAMA

HIGHLIGHTS FROM THE CONTEMPORARY SCENE

Lunar Reporter ▶

SCIENTISTS at San Diego (California) have designed a 10ft ball-like vehicle that could roll over the surface of the moon, report back to earth, take television pictures of the moon and execute commands via radio from earth. Called a "Roamer", it is powered by the sun. The disc-like solar antenna attracts power from the sun. A small 22in model of the "Roamer" is seen here being tested by two General Dynamics engineers.

U.H.F. Radiotelephone

PYE Telecommunications have announced that they have developed a u.h.f. radiotelephone system operating on the 450 to 470 Mc/s band. It comprises two self-contained pocket cases requiring no interconnecting wires.

The transmitter and receiver are crystal controlled and use unobtrusive aerials. Power is derived from small rechargeable batteries.

High quality two-way communication is achieved over distances up to about five miles, depending on the layout and density of obstructions. PRACTICAL ELECTRONICS tried out this radio telephone in a double decker bus; no significant deterioration in quality was noticed in spite of the metallic screening of the bus body.

STORAGE SYSTEM

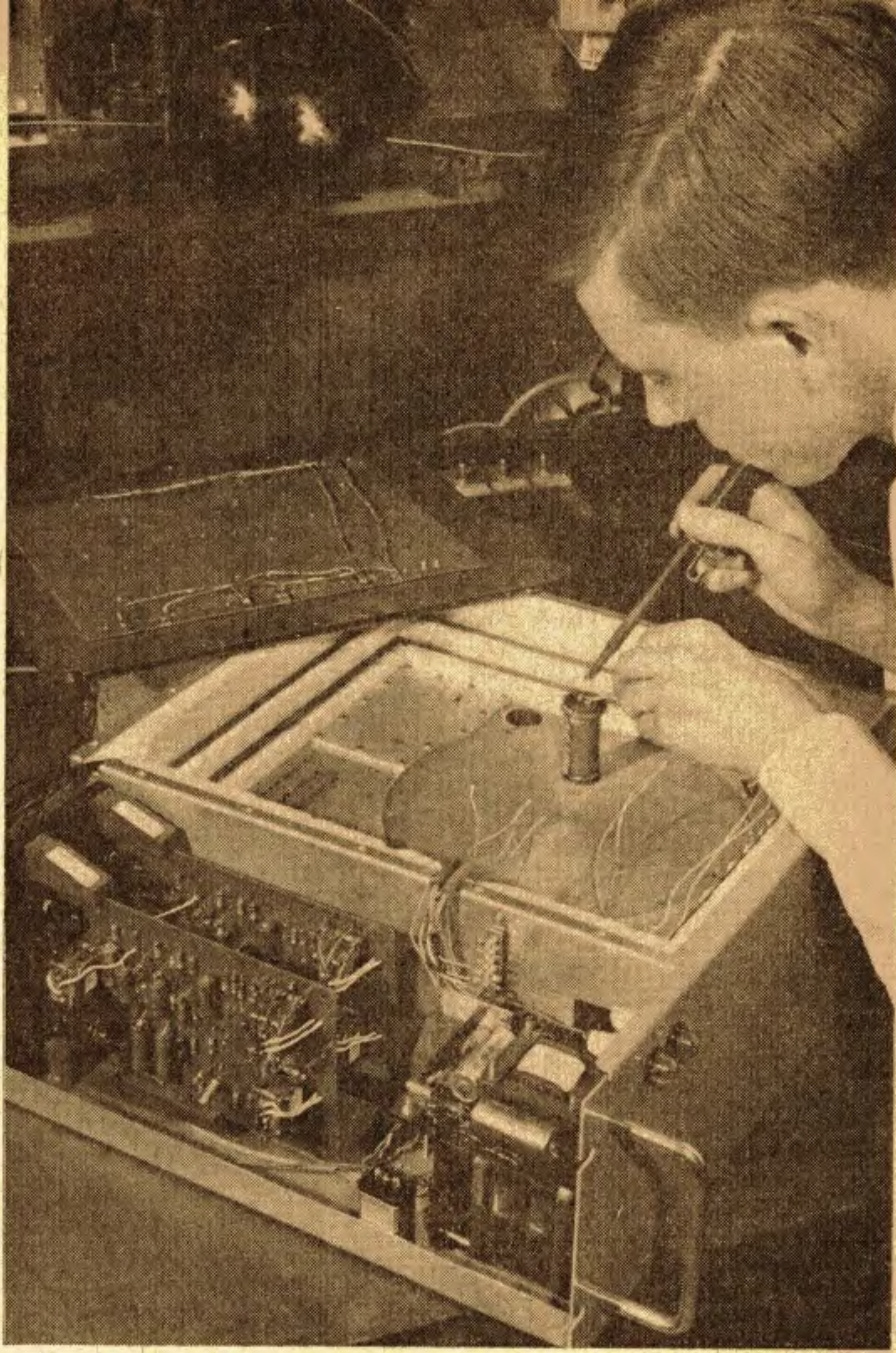
Television Field Delay ▶

AN ELECTRONIC store that, so far as is known, is the first of its kind, is being built at the BBC Research Department, Tadworth, Surrey.

It is capable of delaying a television video signal by 20 milliseconds—the time taken to scan a complete 405 or 625 line field. The equipment will be used in experimental projects including work on standards conversion and film recording.

The broad bandwidth required and the comparatively long delay is obtained by using quartz ultrasonic delay lines. Eight 2·5 millisecond lines have been supplied by The M.E.L. Equipment Company Ltd., and are being used in cascade by the BBC to obtain the total delay of 20 milliseconds.

A BBC engineer is connecting a "booster" heater for one of the delay line ovens (photograph on the right). The boosters operate automatically when the equipment is first switched on, reducing heating-up time.



Bank's Third Computer Centre

HAVE YOU been given a new bank account number? If your account is with the Westminster Bank, you will see from our photographs at the foot of these pages that there is a reason.

On the left is the I.B.M. model 7010 computer system; on the right is one of the five "clearing" systems, now being used at the new Computer Centre off Fenchurch Street, London. These systems are only part of the huge complex of electronic data processing equipment being used by the Bank.

The 7010 system uses a central processing unit, which can store up to 80,000 characters on magnetic tape and perform arithmetic calculations. It will process a day's transactions for an average size branch in less than three minutes. The "clearing" system encodes and records the special magnetic ink numerals on the cheques. Under computer control it directs the cheques into selected pockets. Approximately 1,000 cheques can be dealt with in a minute.

CLEARING SYSTEM

BEGINNERS start here... 13

An Instructional Series for the Newcomer to Electronics

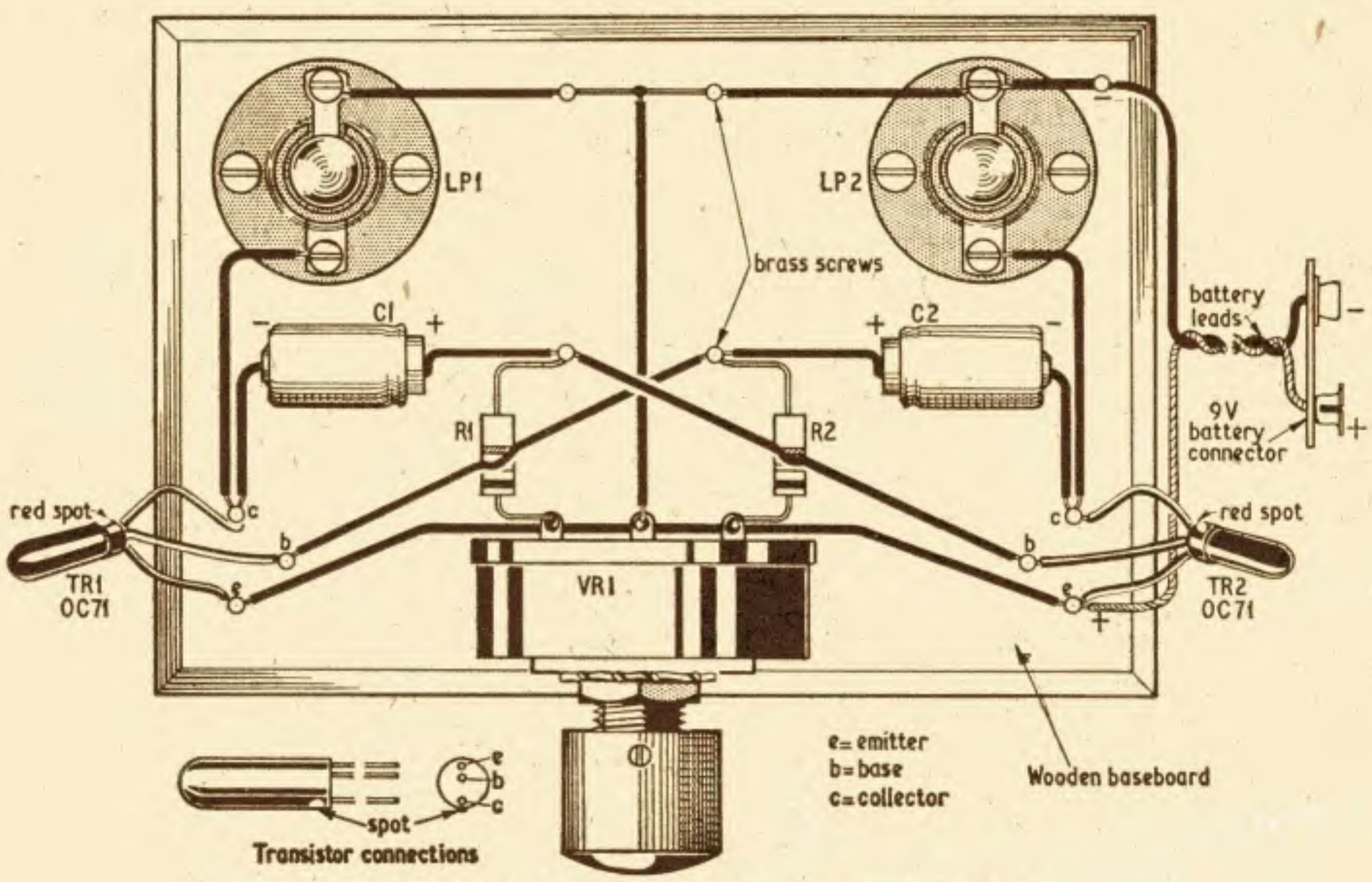


Fig. 13.1 Wiring diagram for the multivibrator

AFTER our discussion of tools and soldering, we put to the test our ability in *practical* electronics, because this month's article is devoted to a constructional project. This project is a *multivibrator*—but don't let the name worry you. Apart from providing a useful exercise in building up equipment, the completed unit will produce a.c. for you from a battery supply. The kind of a.c. obtained is in the form of square waves. This multivibrator will be a valuable aid to the understanding of a.c. theory when we commence looking at this subject next month.

So now to work!

A PROJECT TO BUILD

Two transistors, TR1 and TR2 (see the circuit diagram, Fig. 13.2) are used to switch each other off and on. It is not necessary to understand transistor action at the moment; we will come onto that later. It is sufficient to say that a signal pulse applied to one of the three transistor connections (the *base*) switches on a much larger current in another (the *collector*). This current is then used to operate some device (here simply a lamp). As the transistor is switched on, the initial pulse is applied through the capacitor C1 to the base of the second transistor TR2. The effect here is to switch off TR2. The capacitors C1, C2 gradually change their charge, and eventually the switching is reversed and the other lamp lights up. This goes on indefinitely—notice with no moving parts.

The timing of the switchover is determined by the size of the capacitors, the amount of charge on them, and the size of the resistors R1, R2 through which this charge leaks away. In fact electronic switching can go on not only at the rate of one or two operations per second, as here, but at a few *million* if necessary, by choosing the right values of the components. This circuit is known as a *multivibrator*.

By adjusting the setting of the potentiometer VR1, the value of the resistance affecting each half of the circuit (notice its balanced or symetrical layout) can be altered, causing unbalance between the two halves and a change in the switching time, so that one bulb will be on for a different period of time compared to the other.

In fact, as one bulb comes on for a longer time, the other does so for a correspondingly shorter time. This is called altering the *mark to space ratio* of the generated a.c. waveform.

You can look upon this circuit as one which simply switches the lamps on and off, or as a generator converting the 9 volt d.c. battery supply into a form of alternating current.

CONSTRUCTION DETAILS

We have kept in mind two principles when designing this circuit, the first of a number of construction projects for beginners.

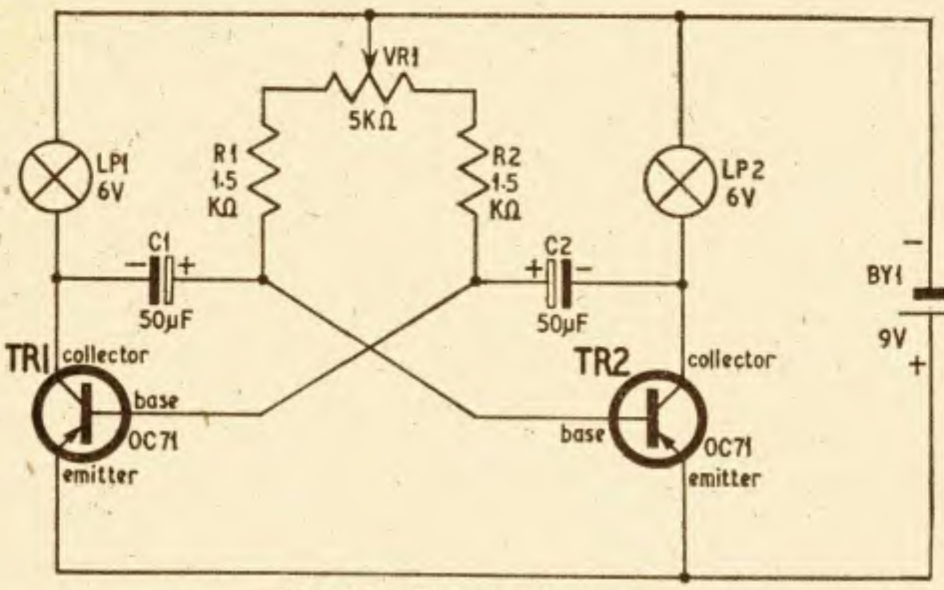


Fig 13.2. Circuit diagram

Firstly, the use of simple materials for the supporting mechanical structure, namely a wooden base and brass woodscrews as anchor points or terminals. As we mentioned in a previous article, dealing with tools, the standard methods of electronic construction involve perhaps a metal chassis, or a bonded plastics "printed circuit" base; but our methods give excellent results and ease of construction, without these complications.

Secondly, the physical layouts can be arranged to follow fairly well the schematic "plans" that are used to record details of circuits. For instance, the multivibrator always has the characteristic "criss-cross" balanced pattern of connections between the two halves. In the end, a quick glance at a circuit reveals that it contains a multivibrator, and so on. It would be poor practice to draw circuits so different that the "shape" is lost, rather like the effect of sticking stamps on envelopes upside down! (see the *Building Blocks* articles).

Thus with our method of construction, the practical layout roughly follows the theoretical pattern, and links up theory and practice for you.

Drive home the brass screws in the positions indicated, then apply the soldering iron and some cored solder to the head of each in turn and ensure that the top of each screw is well tinned.

A simple L-shaped bracket is needed to hold VR1. This bracket and the two batten-type lampholders should be screwed in position. Next connect up the two capacitors and two resistors. The negative ends of the capacitors go to the collectors of the transistors. It is advisable to fit plastics sleeving over the capacitor leads, leaving about ¼in of wire exposed for making the soldered connections. The remaining leads should be connected up. Note that the lampholders have screw terminals.

It now remains to fit the two transistors. Carefully examine the leads on these components. It will be seen that one lead is spaced apart from the other two; this is the collector lead, and usually additional identification is provided by a red spot painted on the body of the transistor adjacent to the collector lead. The middle lead is the base, and the remaining lead the emitter. Do not shorten these leads. Fit a piece of plastics sleeving over each, leaving about ¼in of bare wire. If you have a selection of different coloured sleeving available, it is a good plan to adopt a standard practice, e.g. use red sleeving for the collector, blue for base, and yellow for emitter.

COMPONENTS . . .

Resistors
R1 1·5kΩ, R2 1·5kΩ } colour coding: brown, green, red
½W carbon composition type

Potentiometer
VR1 5kΩ wire wound or carbon linear track

Capacitors
C1 50μF electrolytic, 12V
C2 50μF electrolytic, 12V

Transistors
TR1 OC71, TR2 OC71 } germanium pnp type

Lamps
LP1 Lamp 6V 0·06A
LP2 Lamp 6V 0·06A

Battery
BY1 9 volt battery (Ever Ready PP3 or equivalent)

Miscellaneous Items
Wooden baseboard, approximately 4in × 3in × ½in. Brass wood screws. Two batten type m.e.s. lampholders. Plastic covered tinned copper-wire (can be obtained in various colours, on small reels).

TAKE CARE HERE!

Care must be taken when soldering the transistors in position. The aim must be to complete the operation as speedily as possible and to avoid unduly heating the transistor. The heat from the iron can be shunted away from the component by placing a reasonably large metal object in contact with the bare lead, just above the point where the soldered joint is to be made. A pair of long nosed pliers or a screwdriver blade will serve as a thermal shunt. It is essential that the heat shunt remains in full contact with the bare wire throughout the soldering operation and for a few seconds after the iron has been removed.

Connect a pair of leads to the battery connector, and connect these leads to the positive and negative terminals on the board. Check carefully the polarity of these connections.

Low consumption 6V lamps are used with a current rating of 60mA, but lamps rated at 100mA (0·1A) will work equally well.

Make a final check through the wiring to see that no mistakes have arisen. If everything is in order, connect up the battery. Make sure the correct polarity is observed (+ to +; − to −). The multivibrator should start working straight away, each lamp flashing on and off alternatively.

GENERAL PURPOSE SCALER

By R. W. SAWYER, B.S

THIS month's article describes the mechanical construction, wiring up and testing of the scaler.

METALWORK

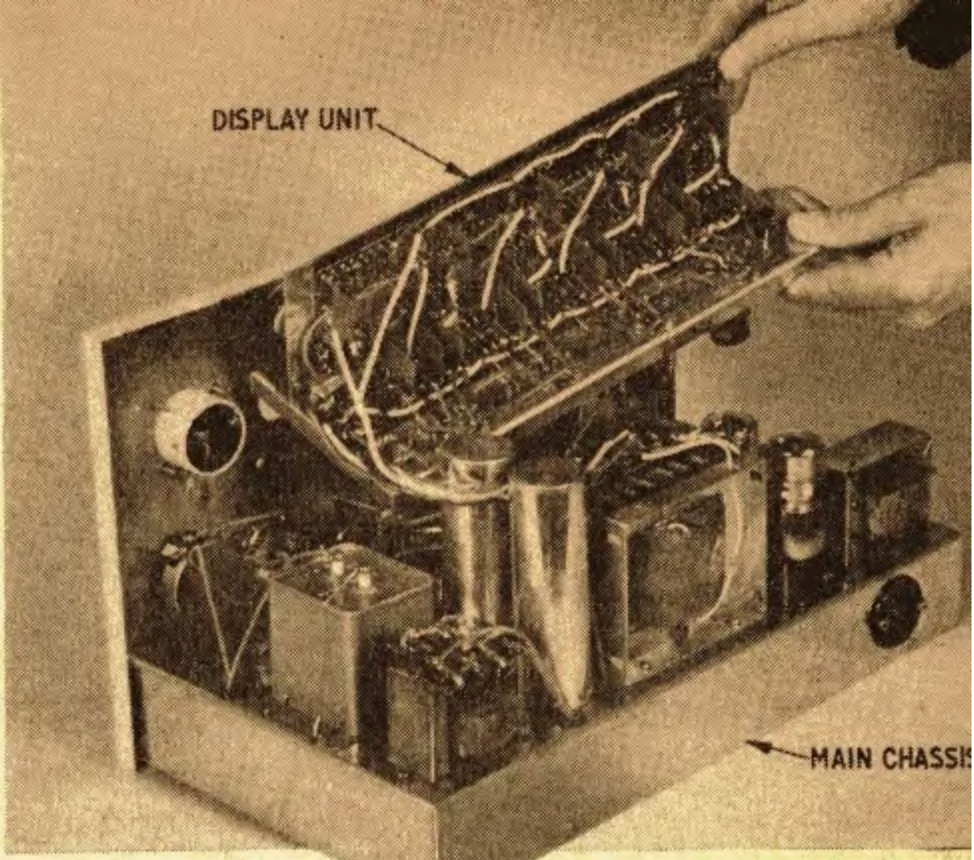
The case, front panel, main chassis and display unit chassis (two parts) are all made of $\frac{1}{16}$in aluminium sheet. Drilling details are given in Figs. 8, 15 and 16, but should the constructor feel that this work is outside his scope it may be left to a specialist firm who will supply the material ready shaped, quickly and at little extra cost. Some of the larger holes may be punched out at the same time if required. The panel and case may be painted or finished as desired.

MAIN CHASSIS

Assembly work starts with the main chassis which is prepared accordingly to the information given in Fig. 8. Grommets should be fitted to holes "G". The larger components should then be bolted in position as indicated in Fig. 8. Use four extra long bolts in the correct places (T2 front pair; C37 rear pair) for the later attachment of tag boards below the chassis. If components other than those specified are used, it may of course be necessary to modify the drilling arrangements.

For the input and l.s. amplifier tag board and the two power supply assemblies, the turret tag and perforated laminated plastics sheet method of construction is employed. A Radiospares standard perforated sheet measures $7\frac{7}{8}$in by $10\frac{1}{8}$in and one sheet can be cut with a fine saw to make the three boards. The standard turret tags are inserted through the perforations and rivetted in place with the special tool which is supplied with them.

The h.t. and e.h.t. tag boards are wired up according to Figs. 9 and 10 respectively, and then they are fixed



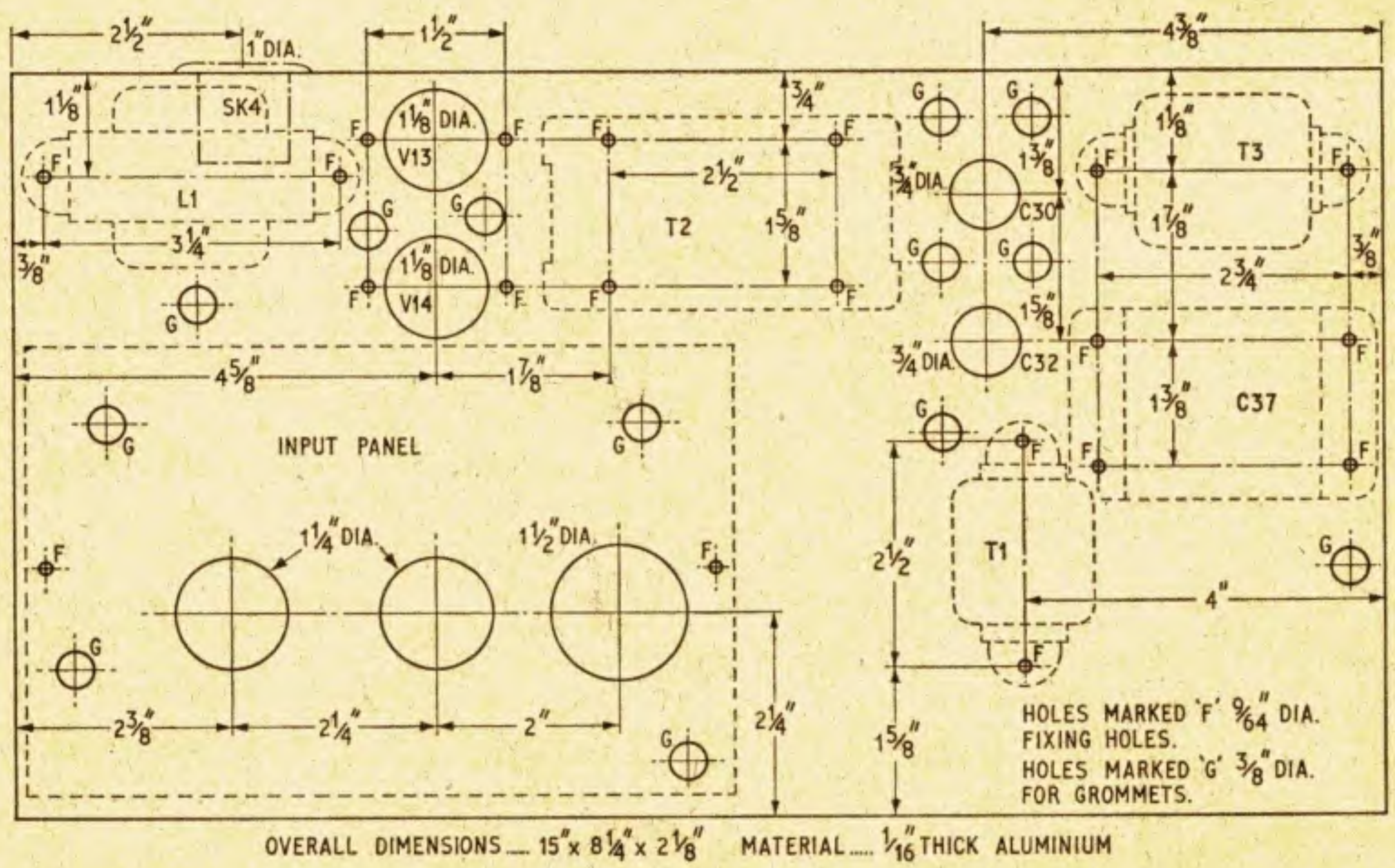


***Fig. 8.** Main chassis drilling details. The location of all components situated on the top of the chasssis is indicated. The three large holes in the bottom left-hand quarter provide clearance for the three valves mounted on the input panel*

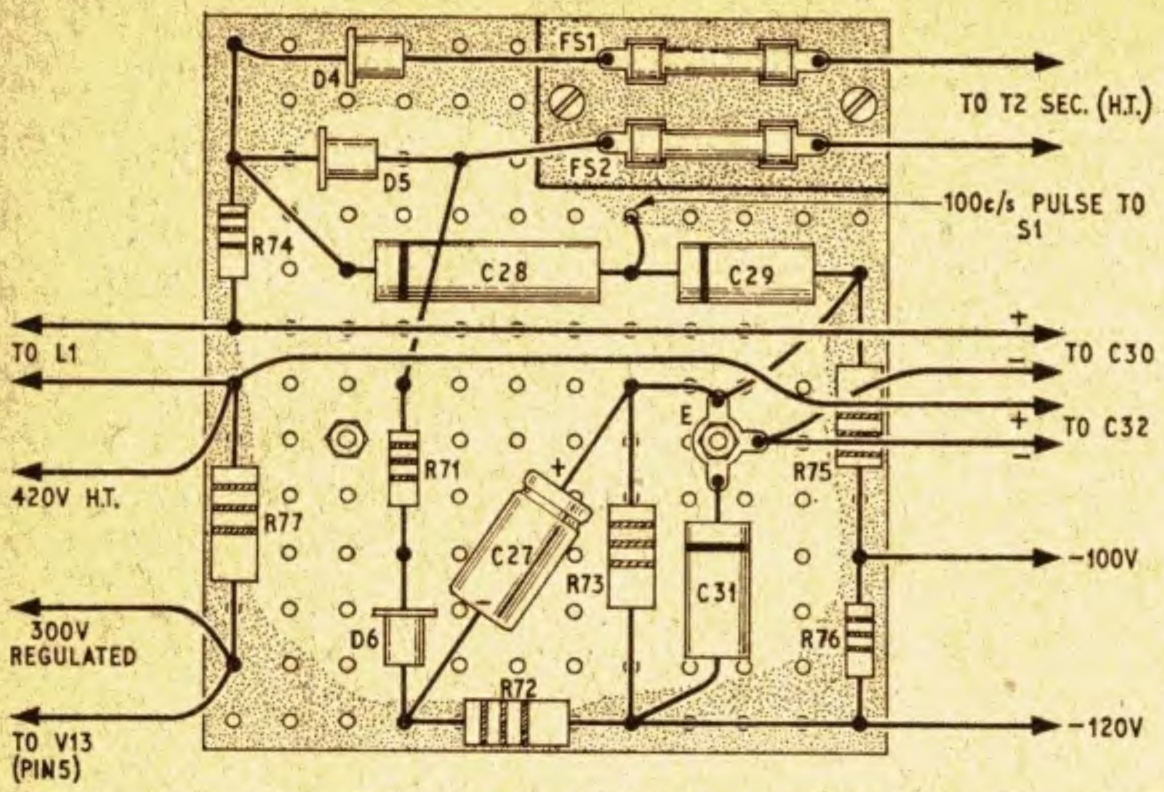


Fig. 9. Main h.t. unit tag board. This is mounted on the underside of the main chassis

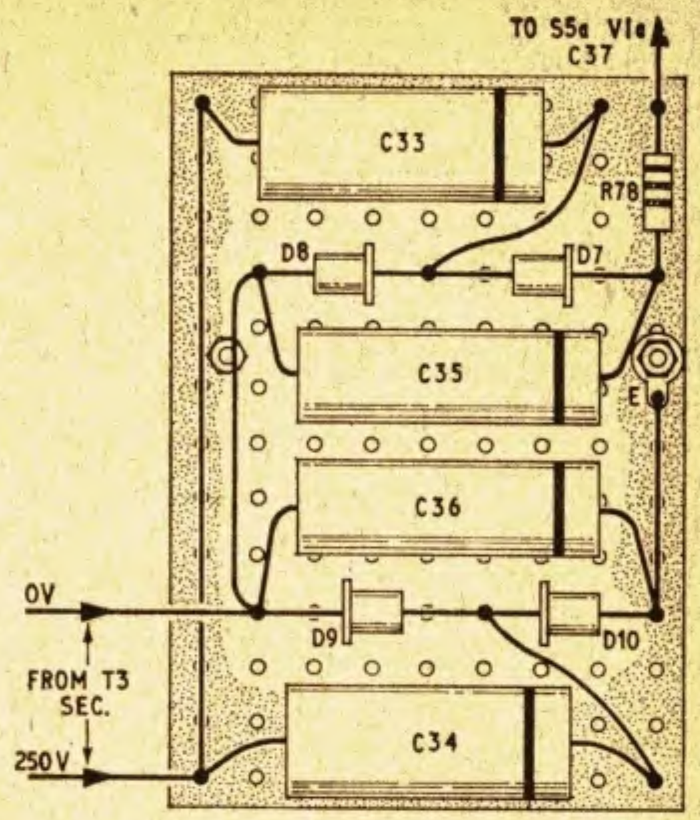


Fig. 10. E.H.T. unit tag board. This is mounted on the underside of the main chassis

on the long screws which were left projecting below the chassis. Spacing, and therefore insulation, from the chassis is ensured by the nuts already on the fixing bolts and by the grommets in the chassis. Wiring up to the other power supply components is then carried out. The screen of the mains transformer T2 should be connected to earth and the other transformer leads which are not required should be taped over.

The mains input socket SK1 should be wired up to the mains switch S4, and a pair of leads brought back and passed through a grommet-lined hole in the chassis and so up to the primary tags on T2.

Leads from the h.t. power supply are brought up through grommets in the chassis and terminated for convenience on a small tag strip mounted on the top flange of the frame of the mains transformer T2. The specified transformer has convenient holes for mounting this strip. An insulating strip of laminated plastics is placed directly below the tag strip while a metal strip with two suitable clearance holes for the mounting screws goes below the transformer frame. This ensures rigid attachment and good earthing. The mounting screws carry earth tags.

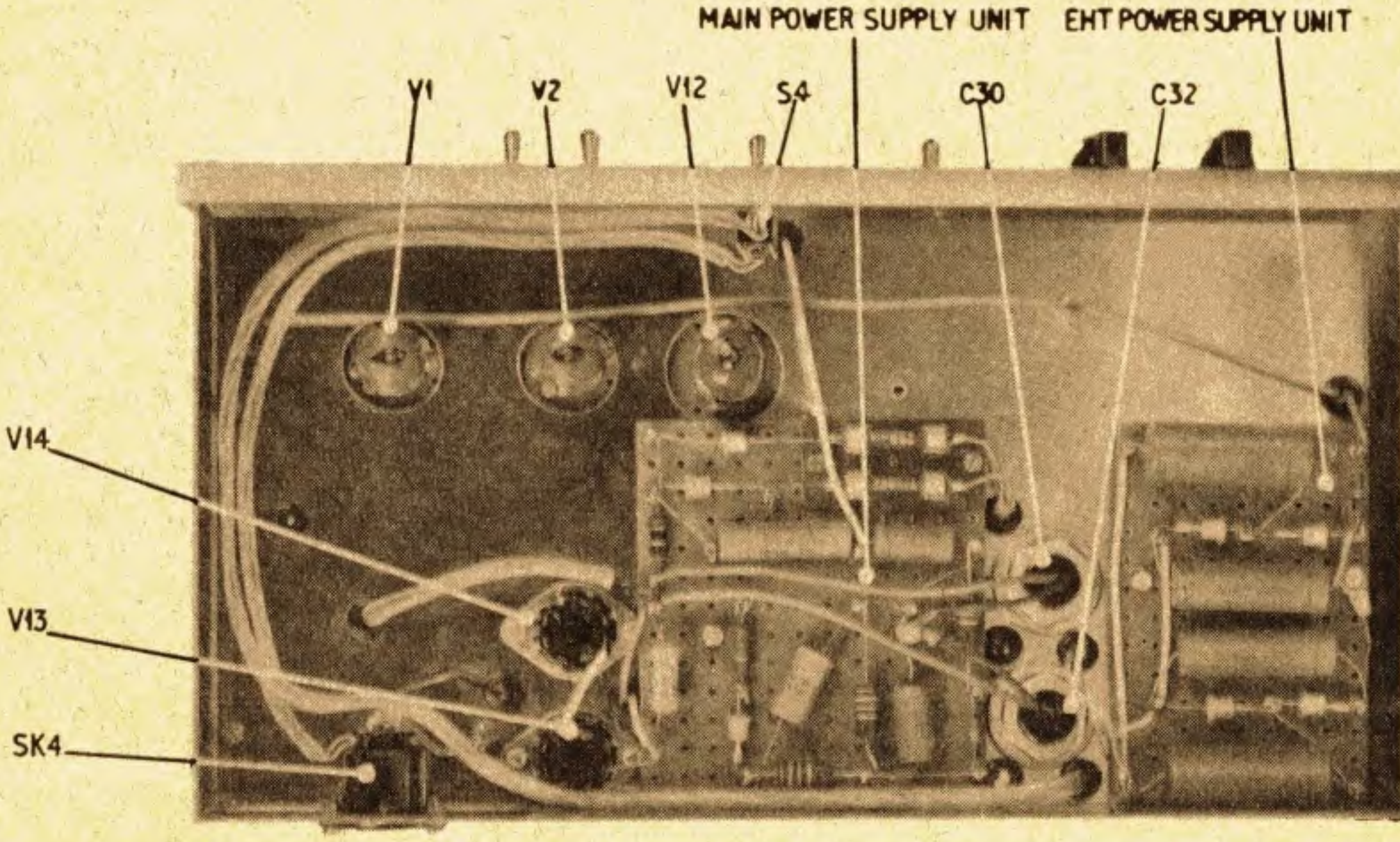


Fig. 11. Underside view of the main chassis showing the two power supply tag boards in position

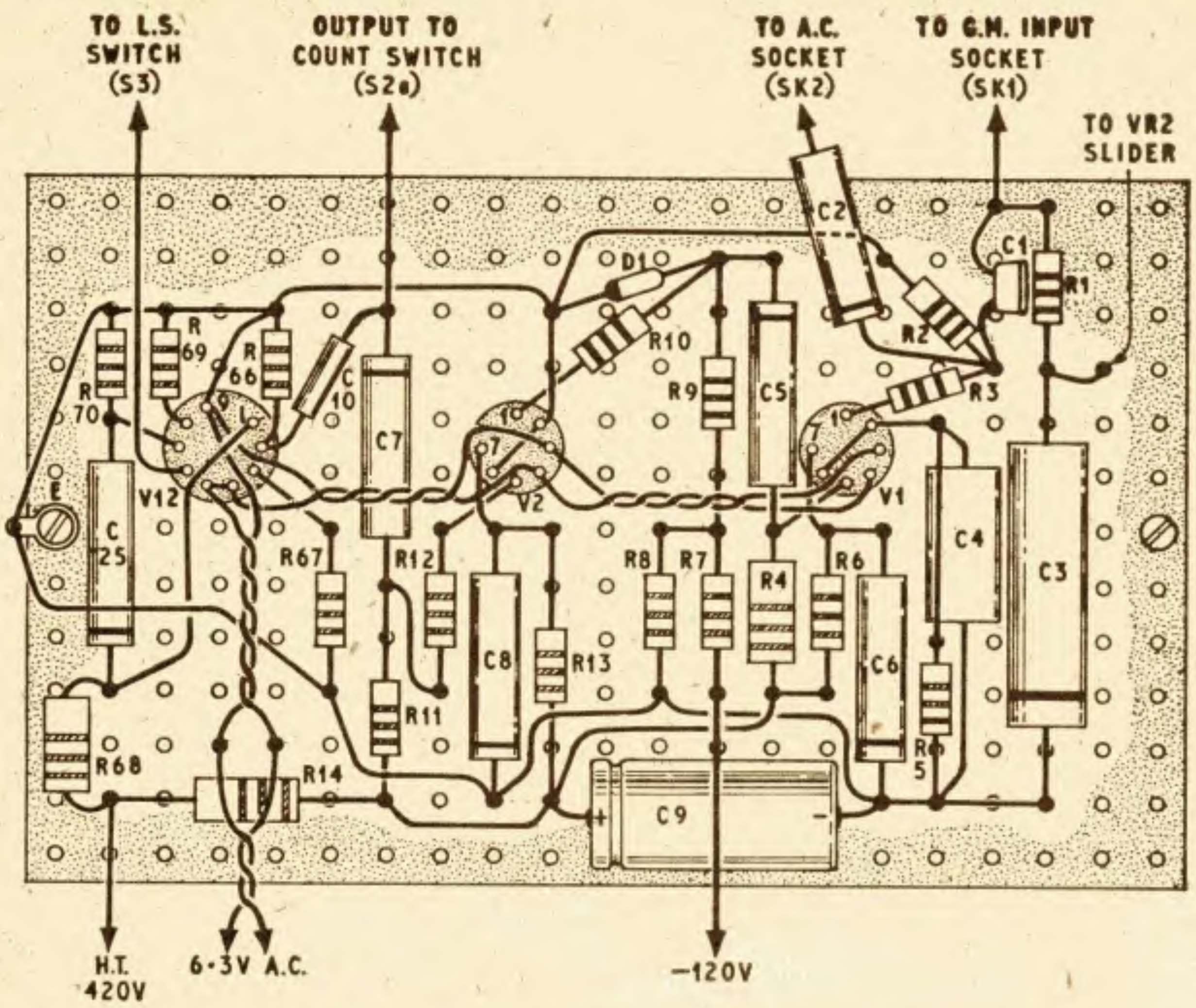


Fig. 12. Input and loudspeaker amplifier tag board showing layout of components and wiring

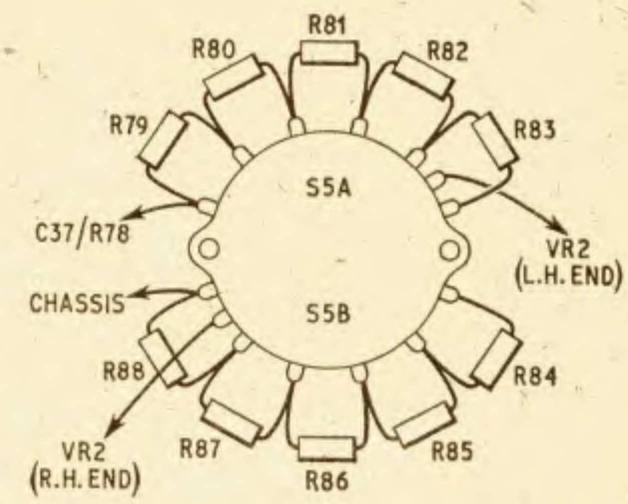


Fig. 13. Wiring details of the e.h.t. "coarse" control S5 and the associated resistors

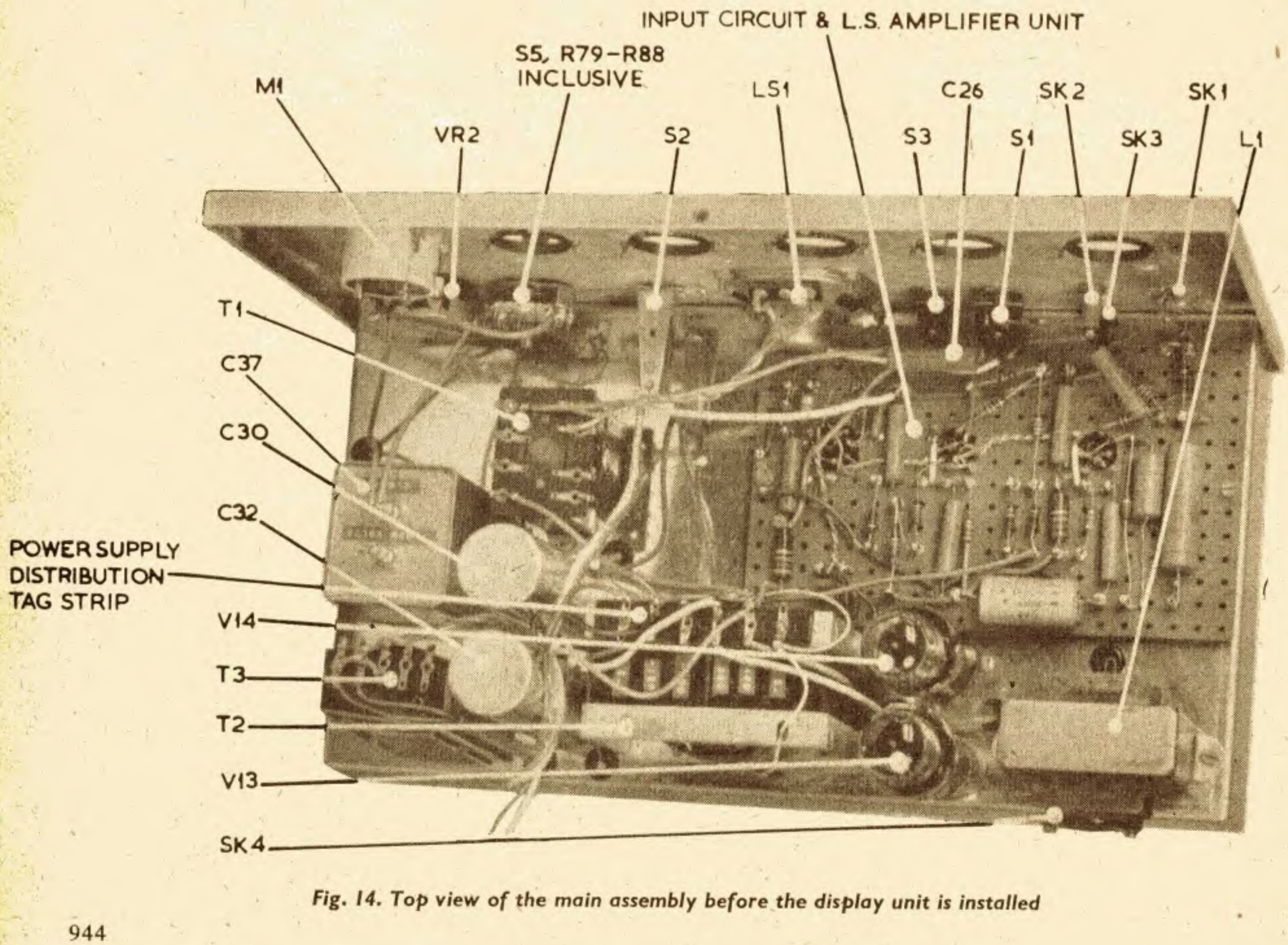


Fig. 14. Top view of the main assembly before the display unit is installed

The e.h.t. supply terminates on the 1μF high voltage capacitor C37. *Due attention must be paid to the high potential present at this terminal when the scaler is operative.*

VOLTAGE CHECKS

An inspection for correct wiring should now be carried out and then the mains voltage applied. The outputs may be checked with a suitable multimeter. All measurements are made with respect to earth.

The e.h.t. is first tested and should show just over 1,000V positive. The mains are then disconnected and the capacitor C37 discharged by shorting with an insulated screwdriver. As a further precaution the input to the e.h.t. mains transformer T3 is disconnected until required later in the construction.

With the voltage regulator valves V13, V14 in place and the mains reconnected, the voltages on the tag strip should be: main h.t. 420V positive, regulated supply 300V positive, and two negative supplies of 120V and 100V respectively. The a.c. heater supply of nearly 7V r.m.s. off load may also be checked on two unsecured wires coming from the transformer T2.

INPUT TAG BOARD

The input and l.s. amplifier tag board is constructed from one half of the perforated sheet and bears the circuitry and valves for the input, pulse-shaper and audio stages. The construction and mounting follow the technique employed for the power supply tag boards and should present no difficulty. Details are given in Fig. 12. This board is attached to the top surface of the chassis by two bolts and spaced by an extra nut on each screw between the board and chassis. The three valves protrude downwards through the holes provided in the main chassis.

The 420V h.t. and the 120V negative supplies are connected from the tag strip above on the mains transformer—the 6·3V heater supply comes directly from the main transformer T2. The 100c/s pulse line is brought up through the grommet below the front right corner of the tag board and temporarily connected through the 0·001 μF capacitor C2 to the input.

The permanent connection is made from one end of the output transformer T1 primary to h.t. and a temporary connection is made between the other end and the second anode of the audio output valve V12 (pin 6). The loudspeaker is then temporarily connected to the secondary of the output transformer.

Power is supplied to the chassis and as soon as the valves have warmed up a loud staccato 100c/s note should be heard from the loudspeaker. If an oscilloscope is available a check of the output at the junction of R11 and R12 in the anode of V2 should show a train of sharp negative pulses at a frequency of 100c/s and about 160V amplitude.

DISPLAY UNIT

The display unit is the heart of the instrument, and will repay careful construction. It is built on two pieces of sheet aluminium which are joined together in the last stage of construction in an L form. Dimensions and drilling details are given in Fig. 16. Each sheet carries two sub-miniature group panels each with 18 pairs of tags, and a piece of panel containing eight pairs of tags. The panels are insulated by miniature backing plates, two on each section.

Note that the correct positioning of the fixing screws for the Dekatron valveholders shown in the small detailed drawing in Fig. 17. This ensures correct orientation of the tubes so that "zero" appears at top centre.

All components, particularly the Dekatron valveholder tags, should be carefully cleaned before assembly. The valveholders are then fixed in position and the small components mounted on the group panels according to Fig. 17. The wiring is carried out with No. 22 or No. 24 s.w.g. tinned copper wire. It is essential for this work to use a small instrument type soldering iron and a suitable sized resin cored solder.

It will be noticed that the anode load resistors of the Dekatrons R20, R31 etc. are wired direct to the valveholder tags. This is a manufacturers' recommendation in order to reduce stray capacitance effects.

The supply lines, preferably colour coded, are brought out to a small 4-way tag strip at one end of the unit. A consistent colour scheme using red 420V; yellow regulated 300V; blue −120V; black −100V; green earth, or bias line, and white for input pulse, prevents errors in construction and assists in checking the assembly later.

TESTING THE DISPLAY UNIT

Thus constructed the display unit is complete in itself and for test purposes may be placed apart (as shown in the photograph at the head of the first part of this article). The Dekatrons and trigger tubes are placed in their sockets and the unit propped up in a convenient position. Leads about 9in long are joined to the display unit tag board and connected to the appropriate tags mounted on the main transformer T2 to give 420V, 300V, −100V, and earth supplies

The Dekatrons should now strike, a single stationary glow appearing on each in a random position. A momentary connection of the reset line to the −120 volt supply should instantly bring all the glows to the top position in the Dekatrons.

A connection from the output of V2 on the input panel, via the 0·01μF capacitor C7, to C11 at the input of the display unit should start the unit counting at 100c/s. The preset potentiometer VR1 may need adjustment; it should be set to give satisfactory steady operation of the Dekatrons, this requires a bias of approximately 35 volts.

If the apparatus fails to work at this stage the fault must be found before proceeding further. The supply voltages should be measured and all component values, connections, and soldered joints checked.

If the first Dekatron does not count, the 100c/s output from C7 on the input panel may be applied in turn to the anodes of the trigger tubes, when the later Dekatrons should operate.

Incorrect bias to the triggers of the trigger tubes will either result in failure to operate, in which case there will be one glow only in the tube, or, in continuous oscillation resulting in rapid counting by the following Dekatrons. The trigger voltage measured at the junction of the 120 kilohm resistor RC, using a 1,000 ohm per volt meter was found to be 160V to earth. This voltage can be increased or decreased by placing a megohm resistor in parallel with one of the resistors. This should not be necessary when using the high-stability, close-tolerance components specified.

Once the display unit is working it should be disconnected by unsoldering the leads to the tag strip and placed on one side to save it from mechanical damage during the further construction of the scaler.

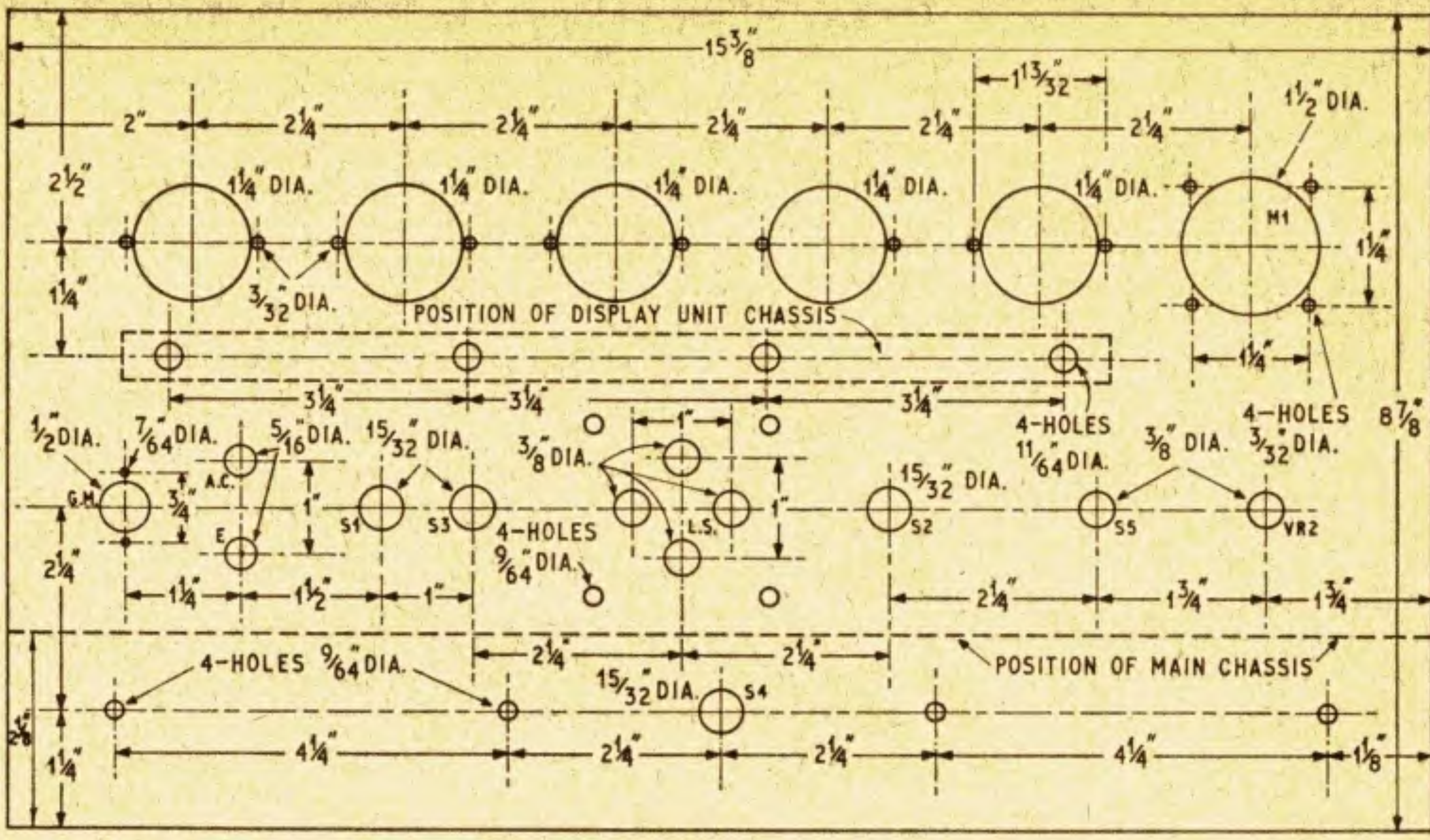


Fig. 15. Front panel drilling details

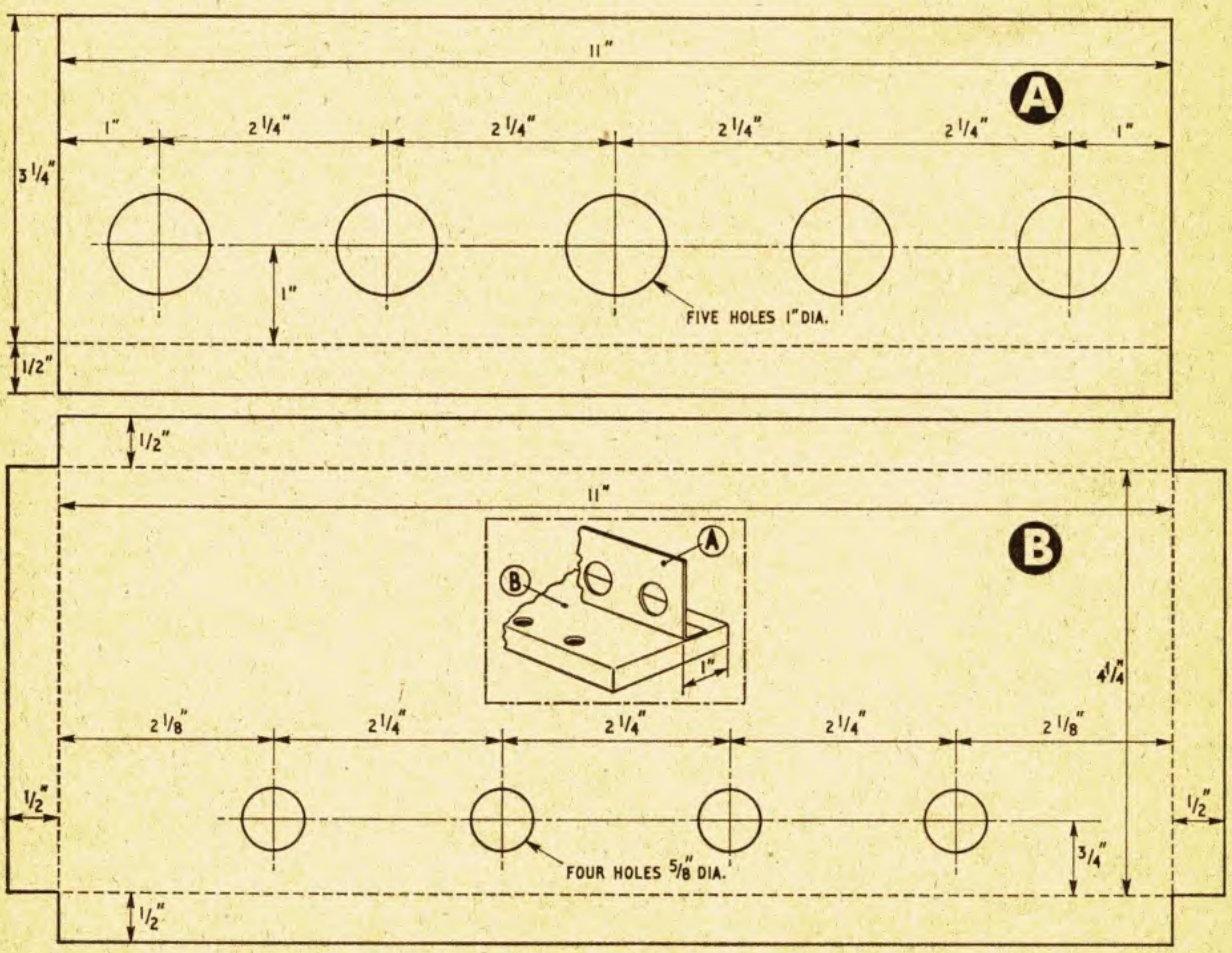
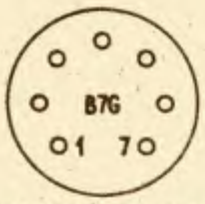
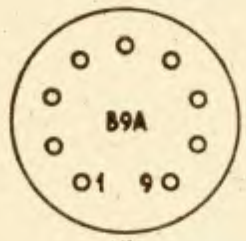


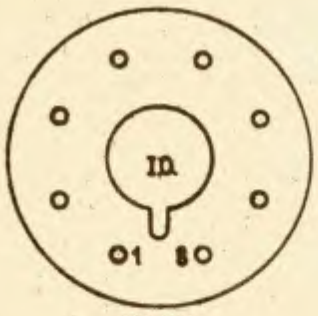
Fig. 16. Display unit chassis drilling details. The position of the Dekatron valveholder securing screws on panel "A" is indicated in Fig. 17



V1,V2,V4, V6, V8, V10

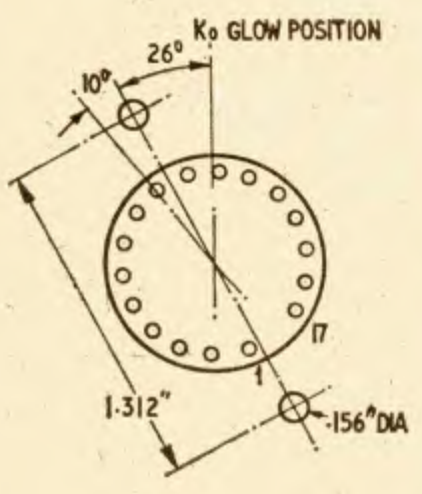


V12

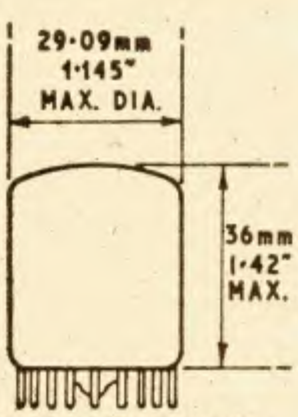


V13 V14

VALVE BASES VIEWED FROM CHASSIS UNDERSIDE



DEKATRON VALVEHOLDER FIXING ARRANGEMENT VIEWED FROM REAR OF PANEL



OVERALL DIMENSIONS OF DEKATRONS V3, V5, V7, V9, V11

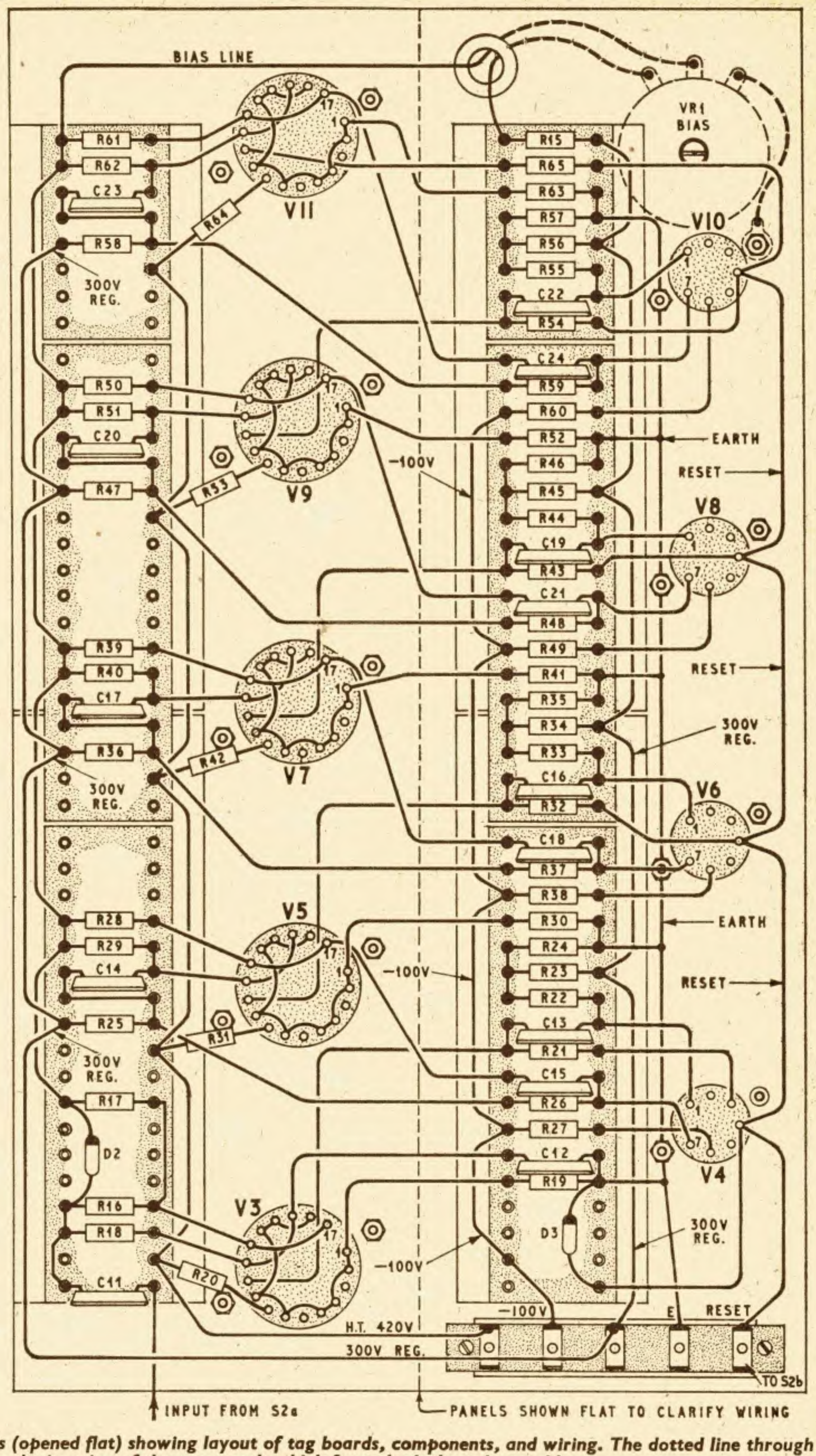


Fig. 17. Display unit chassis (opened flat) showing layout of tag boards, components, and wiring. The dotted line through centre of diagram indicates the junction of the two panels which form the L-shaped assembly

FRONT PANEL

Drilling details for the front panel are given in Fig. 15. The controls and other components are indicated in their respective positions. Labels to indicate the functions of the various controls may be made with Dymotape or one of the other proprietary materials which are readily obtainable. Resistors R79 to R88 conclusive are mounted directly on the switch S5 in the manner shown in Fig. 13.

The switch S2 is the only item requiring further comment. It is neat and convenient to use one switch for count, hold and reset. The constructor could of course use two switches, one a biased type for the reset. There is one type of "surplus" switch which is very suitable, the others have too stiff an action. The specified switch is in current production and when adjusted works well.

The switch has no central stop and in going from "count" to "hold" the dolly may go too far and momentarily close the lower contacts. The lowest leaf which carries the reset voltage must therefore be bent well down so that it only just makes contact when the switch is raised to "reset". The stiffness of the movement can be adjusted with advantage by altering the curve of the springs against which the dolly acts. This is easily done with a small pair of taper nosed pliers.

Reference to the circuit diagram of the display unit (Fig. 3) will make clear the wiring of S2. The rotor of S2b is connected to the −120V supply, see Fig. 6 and Fig. 9.

The lead for the variable e.h.t. for the Geiger Muller tube is taken down from the live terminal of C37 through a grommet in the main chassis. It passes along the underside of the chassis and up through the grommet under the input tag board where it is terminated on the terminal bearing R1 and C1.

The front panel is now bolted to the front edge of the chassis and the wiring up of the components completed. Reference to the appropriate circuit diagrams will clarify any wiring not given in detail in the assembly diagrams.

The display unit leads are then reconnected to the power supply tag strip and two leads (for input and reset) connected from S2 to the display unit. The display unit is thus on flying leads and may be tested using the 100c/s timing pulse by depressing switches S1 and S2. When satisfactory working is obtained, the apparatus is switched off and the display unit placed in position behind the front panel where it is fixed by four self-tapping screws.

Finally, the e.h.t. supply is connected by resoldering the main supply lead to the miniature mains transformer T3. Operation of the coarse and fine voltage controls should indicate on the meter a supply smoothly variable up to nearly 1,000V.

GEIGER MULLER TUBE OPERATION

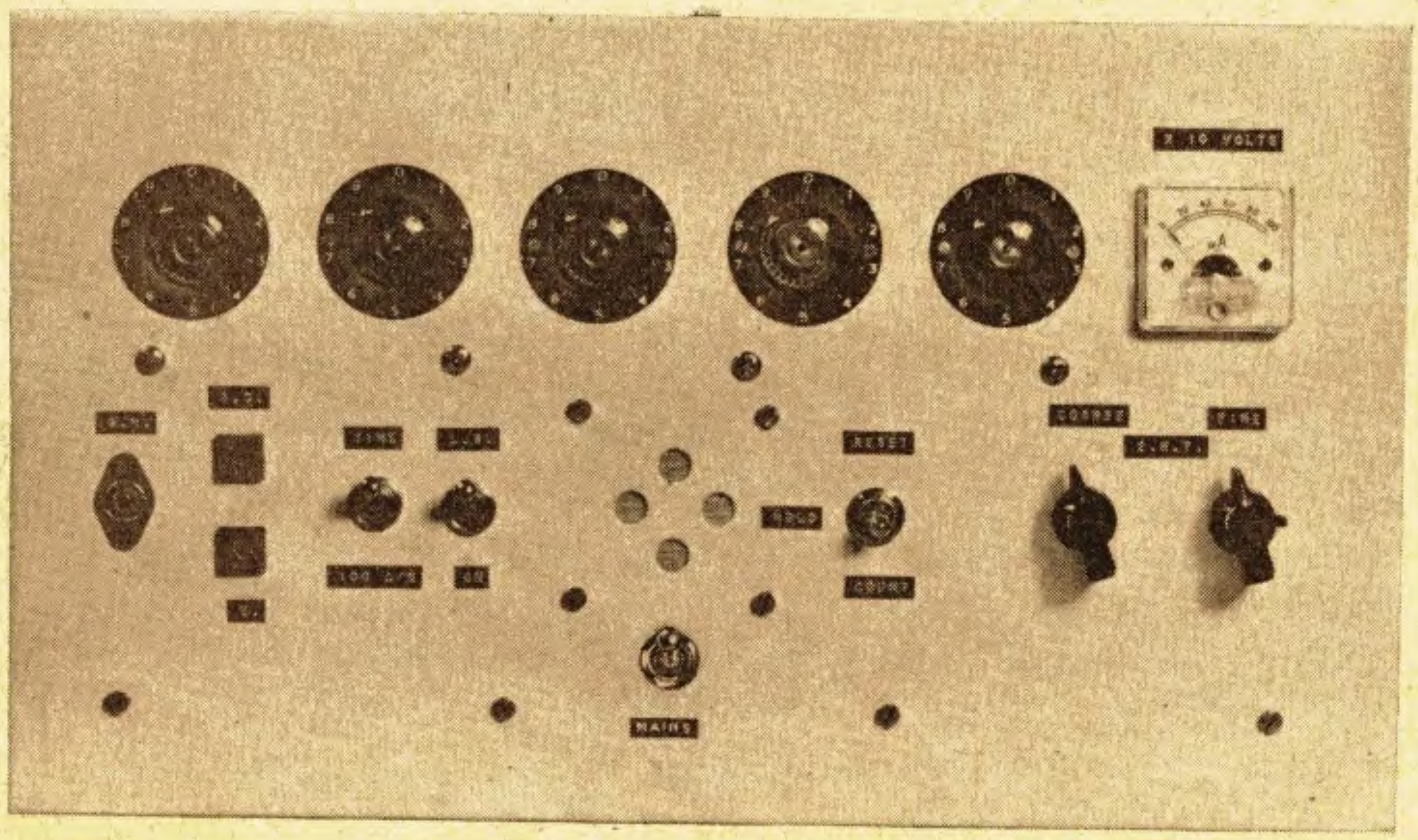
Every Geiger Muller tube has its correct working voltage which must be found by experiment. At *too low* a voltage the tube will fail to ionise sufficiently when radiation enters it and so it will produce no pulses; at *too high* a voltage the tube may conduct almost continuously and will be damaged.

The e.h.t. controls should therefore be turned to minimum before the tube is connected to SK1. The scaler should be set to "count" and the loudspeaker may be on if desired. A source of radiation—a luminous watch will serve—is placed near the Geiger Muller tube. The e.h.t. voltage is then gradually increased until counting starts. A further small increase in voltage will increase the count rate but a condition is quickly reached where the count rate is virtually independent of voltage change. Now every radiation entering the tube is producing a pulse. This is the "Geiger threshold" and the voltage should be noted.

If a graph is made of count rate against voltage it can be seen that a *plateau* has been reached where an increase of approximately 200 volts makes little difference to the count rate. But beyond this comes a point after which the count increases rapidly. *This is the end of the plateau and brings danger to the tube.*

The correct working voltage is taken as 100V higher than the Geiger threshold voltage or halfway along the plateau, whichever is lower.

The third and concluding part of this article will be devoted to practical uses of the scaler. A few simple experiments will be described; these will demonstrate the capabilities of the scaler especially as a teaching aid in the physics laboratory.



DETACHED PARTICLES
By John Valence

SILENT DETERRENT

You can't get away from it, can you? Picking up a copy of *Amateur Gardening* from a colleague's desk the other day, I thought I would find a temporary diversion among the dahlias and chrysanthemums. But the first thing to meet my eye was an account of supersonic vermin scares. It seems that one large seed firm have rid their storehouse of birds, mice and rats by criss-crossing the building with ultrasonic beams. To provide the maximum irritation to these pests, the ultrasonic signals are continuously varied in frequency and duration. According to this report, the birds in residence quickly took off; the rats soon followed, but the mice stuck it out for a few weeks. The reason they took so long getting the message was because they had buried themselves inside sacks and obviously were receiving a somewhat attenuated signal.

I don't know if it was the painful aural experience that drove these creatures away, or whether perhaps it was the heat induced within their small bodies by cell excitation. Heat effects produced by ultrasonics are used in physiotherapy for the treatment of patients. But it is known that over-excitement of the body cells results in extreme discomfort. Contra-wise, if a beam of ultrasonic waves is directed onto a particular nerve, it can produce an analgesic effect. The effective use of ultrasonics obviously demands a highly specialised knowledge of the subject. Get the frequency wrong and the beam in the wrong place, and I suppose you would have deliriously happy mice and rats lolling about the place.

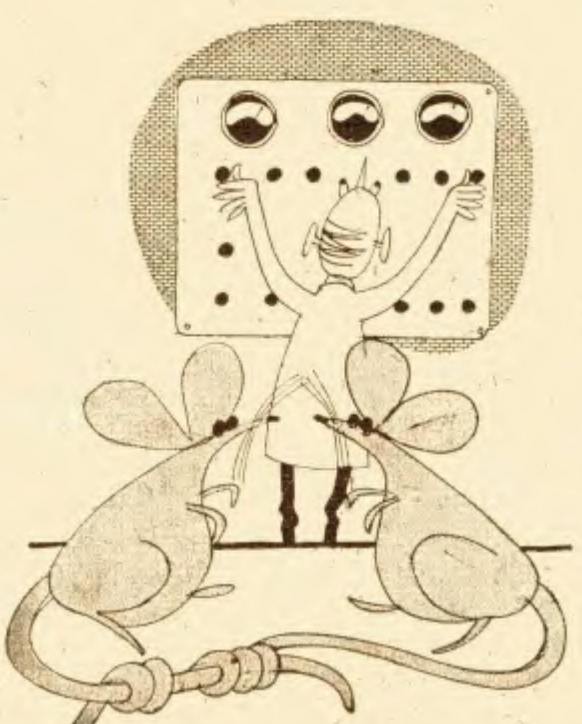
PCM TO THE RESCUE

Long suffering commuters take heart. If you are reckoning on being around in the year 2000, your daily torment on road or rail may by then be over. The solution to the ever increasing problem of getting people to work in the morning and returning them to their suburban semi's is in fact delightfully simple. They simply won't have to go. Instead of bodies, the brains and skills of these individuals will be transported to their place of employment. And it will all be done by telecommunications, involving data links and private television channels.

This is no wild dream of a science fiction writer. It is the opinion of an eminent British scientist, Alec Harley Reeves. This month the Franklin Institute of America will be honouring Mr. Reeves by presenting him with the coveted Stuart Ballantine Medal. This medal, named after a noted U.S. scientist, is awarded for "outstanding achievements in the fields of communication". Mr. Reeves receives this award for his invention of Pulse Code Modulation (PCM) way back in 1937.

Like so many inventions, PCM was before its time. For its practical application, it required a more advanced technology than then existed. The coming of semiconductors plus the today's enormous demand for telecommunication links has focused attention once again on this invention.

Pulse code modulation is a digital system. Speech signals are scanned electronically and all significant information is transmitted in a series of pulses. One of the great advantages of PCM is that a large number of separate channels can be sent over one pair of lines. It can also be used for picture transmission, as was dramatically demonstrated a little while ago with the pictures from Mars.



"I haven't the heart to tell him that we can't hear it either"

ON THE BEAM

Now back to Mr. Reeve's vision of the future. He feels that PCM's tremendous potential capacity for sending and receiving speech or visual data over cables or better still, over laser beams, can be most usefully harnessed to alleviate some of the problems that already beset us, and which will multiply in a terrifying way as time goes by.

Apart from keeping us off the streets, Mr. Reeves stresses the importance of central information processing centres as an answer to another problem of modern life—how to read and digest all the literature published in one's own particular field of interest. In this connection he makes the interesting observation that moving pictures will be the only way to pass the information fast enough to the caller's brain.

P.S. Full of the pioneering spirit, I have already volunteered to do my daily stint from my own home with the aid of Ye Olde G.P.O. analogue-type telephone as office link. The suggestion was politely but firmly turned down. Just another example of being ahead of one's time, of course.

THAT OTHER CHANNEL

Belated birthday greetings to the Independent Television Authority.

I recall looking in on that first transmission from Croydon 10 years ago. With a hastily rigged up dipole suspended from the house eaves, coupled up to a converter unit perched on the top of the Band I set, the opening transmission on Band III was received surprisingly well.

In the moments before the Rediffusion emblem appeared on the screen, one experienced the excitement of a first night, knowing that we were about to witness something quite new (and perhaps alien) to our way of life. How would this newcomer fit into our home, where hitherto only BBC programmes had entered? And there was much speculation about the commercials of course.

Today there is no doubt about the success of commercial TV; that is if success is measured by numbers of viewers captured and held.

Audio TRENDS . . .

A Commentary on Sound Reproducing Equipment by Clement Brown

A LARGE proportion of new products seen in the last two months—particularly those introduced to the trade during summer and autumn exhibitions—has been of foreign manufacture. This has emphasised yet again how, from the U.K. viewpoint, the radio and electronics market takes on an increasingly international look. The variety now offered, not least in the audio sector, is truly remarkable.

Some of the new items are of special interest to the constructor and experimenter. Many more will appeal to those who seek to obtain the best value for money by assembling audio outfits from units and who demand hardware that is well "packaged"—to use the word in the design and layout sense. Even if the amateur decides in the end to solve his own mechanical design problems, he can at least benefit from a close look at professional methods.

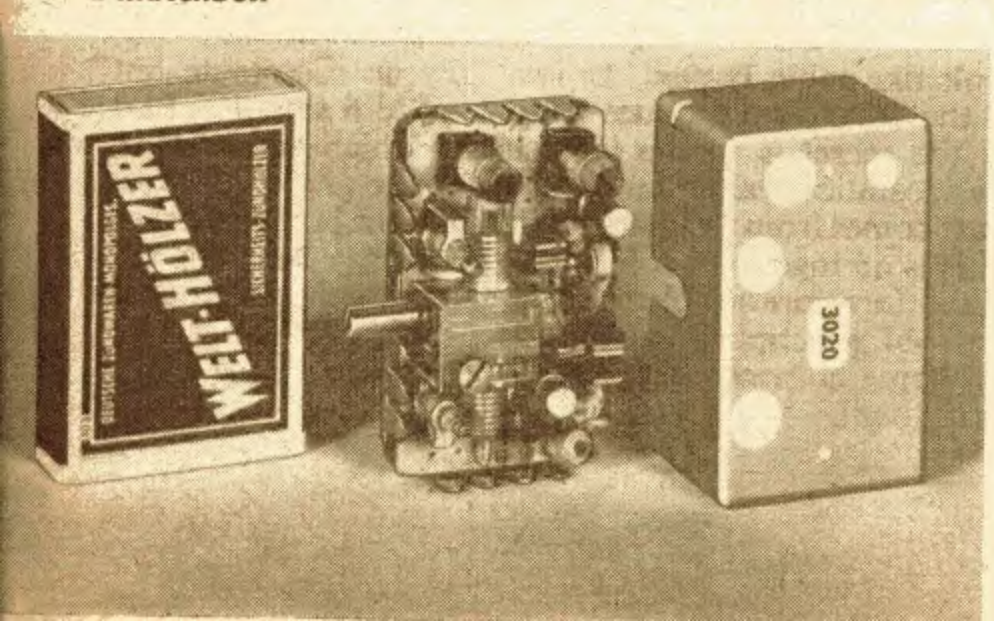
NEW DISC EQUIPMENT

It can be said, with every justification, that Thorens turntables are the "Rolls-Royces" of the disc equipment world, and that the Bentleys of the breed follow respectfully behind. But not every enthusiast can afford the best that Thorens make, and it is therefore especially interesting to note a new model which this firm has added to the competitive £20–£25 range.

Designed for 33 and 45 r.p.m., this transcription model—a nice-looking product—has the type number TD150. Its eight-pound, non-magnetic turntable platter is belt-driven by a synchronous motor, and an accuracy of plus or minus 0·2 per cent is claimed for the speeds. Priced at £20 13s 2d, the turntable is supplied with a separate pick-up mounting board and is ready for building into a cabinet. For a few pounds extra it can be obtained fitted on a plinth. The U.K. distributors are Metro-Sound of London.

Special attention to bearing design, and to methods of decoupling the driving motor so as to minimise rumble, must be well up the list of requirements of any design engineer interested in "transcription" standards.

Transistor f.m. tuner by Telefunken compared in size with a matchbox



Evidently this has been so with Transcriptors Ltd., whose pick-up arms and accessories were noted in the September *Audio Trends*.

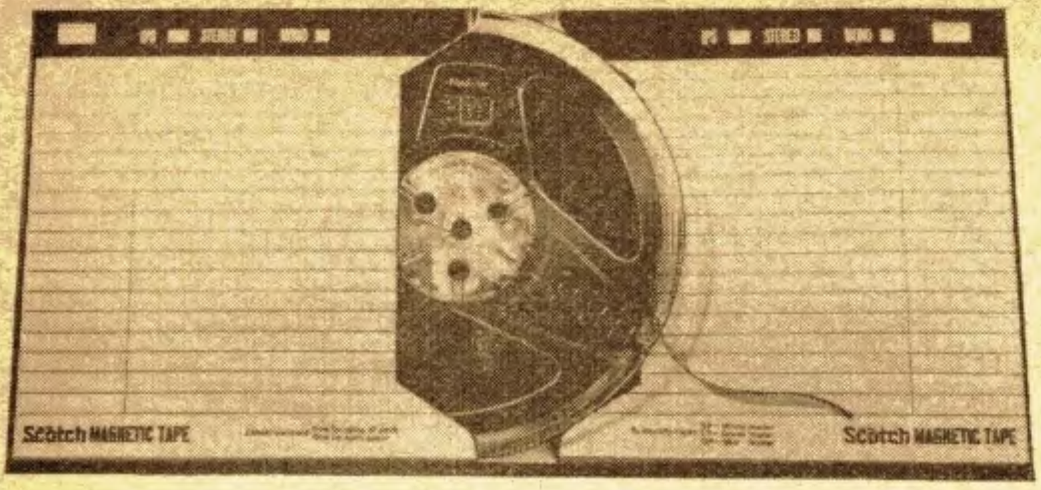
This firm has now provided details of its new turntable, which is due during November at a price of about £28. It incorporates some unusual features. For instance, there is a built-in bubble indicator for levelling; adjustable legs are fitted and the bearings are of p.t.f.e. (a plastics material noted for its "slippery" quality). Again, the drive is transmitted by an adjustable belt and pulley arrangement which gives a speed range of 10–80 r.p.m. Other practical points are a stroboscope and neon indicator.

JAPANESE DESIGN

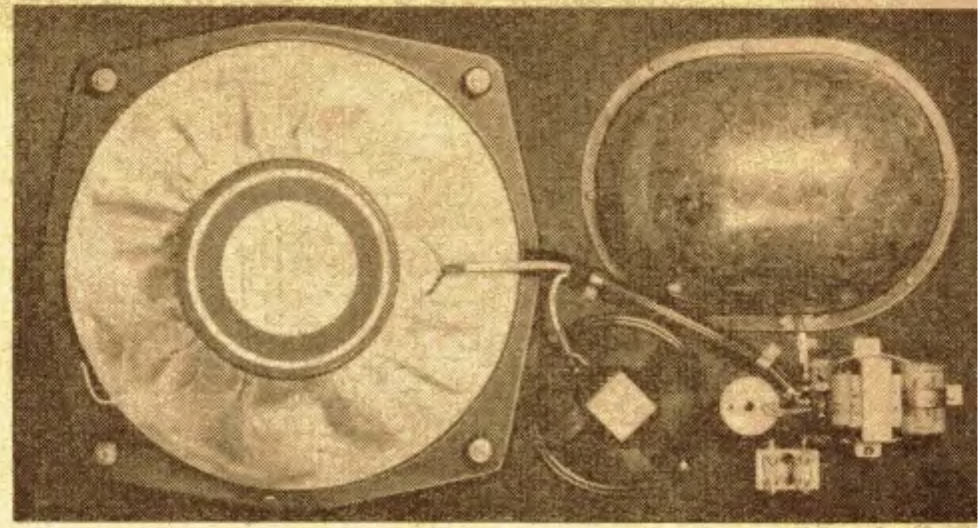
Another new product in this field is the LSM pick-up, of Japanese design. It incorporates such technical refinements as a bias compensator (to correct side-thrust), miniature ball-bearing pivots and separate lateral and vertical balance weights. The well-finished arm, of satin chromed brass, is to be supplied at about £26 complete with a dynamic stereo cartridge. This has a hi fi specification and 1½ gm playing weight. The agents, new to audio enthusiasts, are Living Sound, 11, Essex House, George Street, Croydon, Surrey.

Constructors should look out for the wide—and recently increased—range of components and equipment imported from Japan by Adler and Sons, the London firm. There are speakers, microphones, crossover filters, and a variety of small components to interest the amateur enthusiast. All are sold by radio and hi fi specialists in the usual way, mostly under the trade name Eagle. Prices are moderate.

Uher Model 22 tape unit



"Scotch" tape pack in book form



Saba Electronics System III loudspeakers on a baffle

Elac products, from Western Germany, now include a new and improved moving-magnet stereo cartridge, the STS240D, which is to sell at a little over £15. It supersedes the familiar STS222D. Cartridges from this maker are of high quality and are particularly noted for good channel separation and consistent performance.

FOR THE TAPE ENTHUSIAST

Still on the subject of Continental designs, recent additions to tape equipment should be noted. Braun's TG60 is a very desirable piece of machinery with engineering features which will repay study by the amateur enthusiast. New Uher models include tape units which, lacking output stages and speakers, are intended to be associated permanently with hi fi equipment. They are transistorised, equipped for stereo, and are made in twin-track and four-track versions (models 22 and 24 respectively). Speeds are 7½ and 3¾in/sec and there are separate heads and amplifiers for recording and playback. Prices, still to be announced, will be in the medium range.

A new pack has been introduced for Scotch recording tape. It looks like a bound book with simulated leather finish and gold lettering. There are three sizes, for 5in, 5¾in and 7in spools; each has two pockets and indexing spaces. Adhesive labels are provided. The aim is, of course, to reduce the space required for tape stage as well as to improve decor.

TUNER AMPLIFIERS

Now to the electronics of audio. Tuner-amplifiers are very much in vogue, particularly on the Continent. At least that is what one concludes after surveying the variety of models now reaching us via the U.K. agents for Telefunken, Saba, Korting and other prominent manufacturers. In this type of equipment, equal emphasis is placed on radio and amplifier sections, which are integrated in a wood or metal housing for shelf mounting. In this way hi fi becomes accepted as a normal domestic appliance, as unremarkable as television.

In the German products, technical ingenuity abounds: it is fair to say that they are most impressive on the electronic side and that U.K. experts excel when it comes to the mechanics of disc reproduction. Transistors are used liberally to secure desired performance characteristics and the radio sections, usually mono and stereo f.m. plus one or more a.m. bands, are especially imposing.

Telefunken, for example, offer outputs of up to 15 watts per channel in their Opus tuner-amplifier and other models, and a great deal of work has gone into miniaturising the complex transistor circuits. Elaborate electronic designs, which may involve 30 transistors and nearly as many diodes, lead to a new preoccupation with space-saving techniques.

Another compact unit of this type, supplying 15 watts per channel from class B transformerless stages, is the Korting 26–452 (79 gns). Like most of the more advanced equipment, it has switched automatic frequency control and is equipped for stereo reception. There are such refinements as a moving-coil tuning indicator, and the tuner covers f.m. plus long, medium and short waves.

The Braun Audio 2 is also a must for those wishing to survey the international scene. This very advanced product is a stereo radiogram unit, for use with separate speakers. It includes the Braun PS400 transcription turntable and pick-up and a no-compromise tuner-amplifier. Only 6¼in high, the Audio 2 is a remarkable example of compact design.

THREE-UNIT SPEAKER SYSTEM

One high-quality item for the constructor is the System III baffle speaker introduced by Saba Electronics. This three-unit system, ready to build into an enclosure, is rated at 30 watts and covers the range 40–18,000c/s (3dB limits are quoted). Since the 12in bass unit resonates at 20c/s, there is evidently a prospect of securing still deeper bass, but this of course depends on enclosure design.

The mid-range is reproduced by a 7½ by 4¼in unit and the treble by a 4½in tweeter. As the illustration shows, a crossover filter is fitted to the baffle. Crossover frequencies are 300c/s and 7,000c/s. Saba suggest a sealed enclosure of three cubic feet, loosely filled with wadding. The System III costs £38 17s and the bass unit is available separately at 17 gns.

UNCONVENTIONAL SPEAKERS

Loudspeakers have the final word this month. LWL Distributors Ltd. not only offer conventional speakers of their own but also intend to market some distinctly unconventional American reproducers. These look like table lamps: in fact they do illuminate but at the same time produce an aura of hi fi sound! Part of the secret is in the lampshade, which conceals an electrostatic speaker handling the range above 3,000c/s. Bass comes from a moving-coil unit in the lamp pedestal. This is an ingenious solution to what may be called the audio furniture problem; it also represents a serious if unusual attempt to achieve good reproduction and, assuming it wins acceptance, prices are likely to be fairly high.

NEW PRODUCTS

Harmonic Distortion Meter

Daystrom Ltd., Gloucester, England.

The Heathkit model IM-12U is a harmonic distortion measuring instrument of high accuracy and stability. When used with an audio generator this instrument will accurately measure harmonic distortion at any frequency between 20–20,000c/s.

The IM-12U indicates the residual signal in an amplifier under test, after the fundamental frequency is eliminated, to give an accurate reading of hum, noise and harmonic distortion. Distortion is indicated directly on the meter in ranges of 0–1, 3, 10, 30 and 100 per cent full scale and noise level measurements, down to − 60dBm, are read on a separate decibel scale. The 4½in meter has a 200μA movement with scales of 0–3, 0–10 volts, and −10 to + 2dB.

The input resistance is 300 kilohm and minimum input voltage for distortion measurements is 0·3 volt. The output voltage for monitoring is 2·5 volts at full scale meter reading.

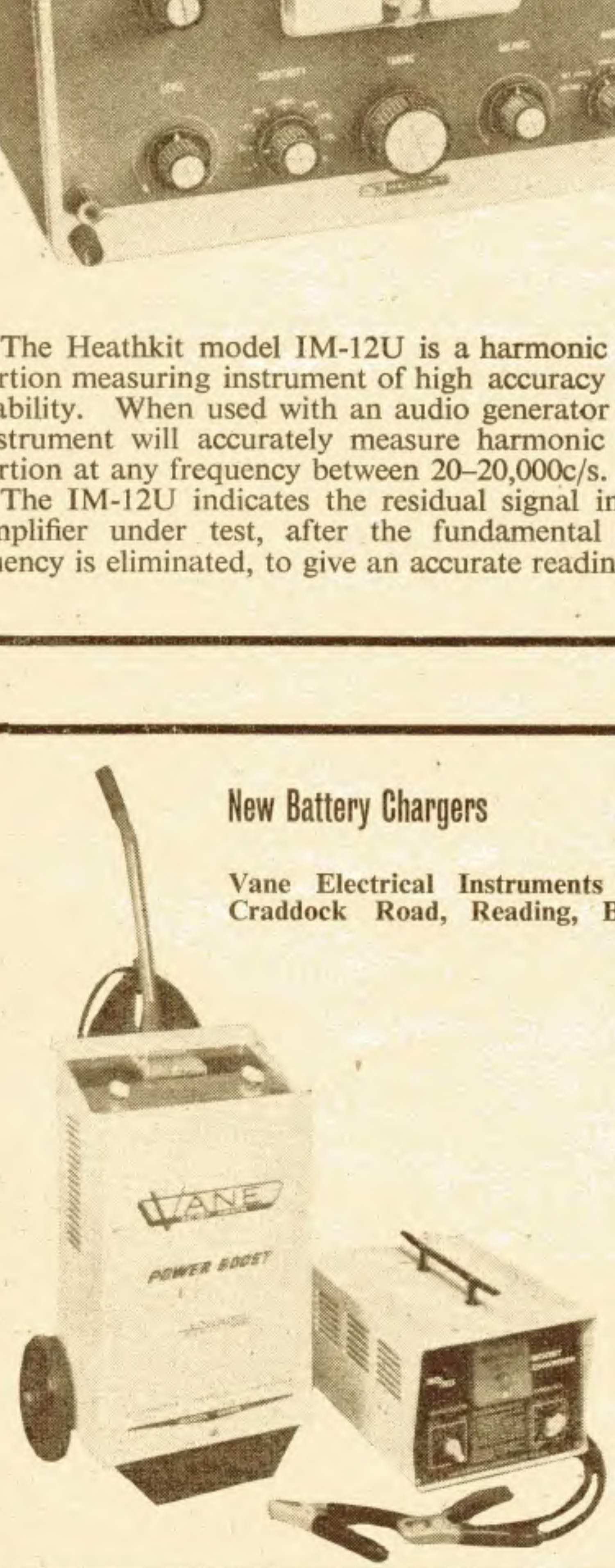
The valve voltmeter (ranges 0–1, 3, 10, 30 volts full scale) section of the IM-12U uses a twin triode amplifier with negative feedback. The output of this amplifier is available at the output terminals so that the waveforms of the voltages measured may be visually monitored with an oscilloscope.

The accuracy of the meter when used as a voltmeter is ± 5 per cent of full scale, and ± 5 per cent of full scale + 0·1 per cent when distortion readings are taken.

The Heathkit IM-12U is available in kit form for £24 15s 0d or £34 assembled.

New Battery Chargers

Vane Electrical Instruments Ltd., Craddock Road, Reading, Berks.



A new range of battery chargers has been introduced to the market by Vane Electrical Instruments. All units in the range use silicon rectifiers at only one third of their rating for maximum safety. Cooling is effected by using modern convection techniques which eliminate the need for fan motors. Ammeters of moving coil type are used to give "at-a-glance" readings of charging current.

All operating instructions are engraved on a panel on each charger. Most models are fitted with an automatic thermal overload switch which prevents damage to the charger or the battery in the event of a reverse connection or a short circuit.

Two models are depicted in our photograph. The model 2600 "Power Boost", housed in the console trolley cabinet, costs £48 and charges at 30 amps on 6 or 12 volts and 15 amps on 24 volts.

The model 2400, 30/30 "Booster" model, has similar features to the "Power Boost", except that the polarity protector is not included but can be obtained as an optional extra. The "Booster" is housed in a portable cabinet and is priced at £36.

Both these chargers make excellent car engine starters.

INGENUITY UNLIMITED!

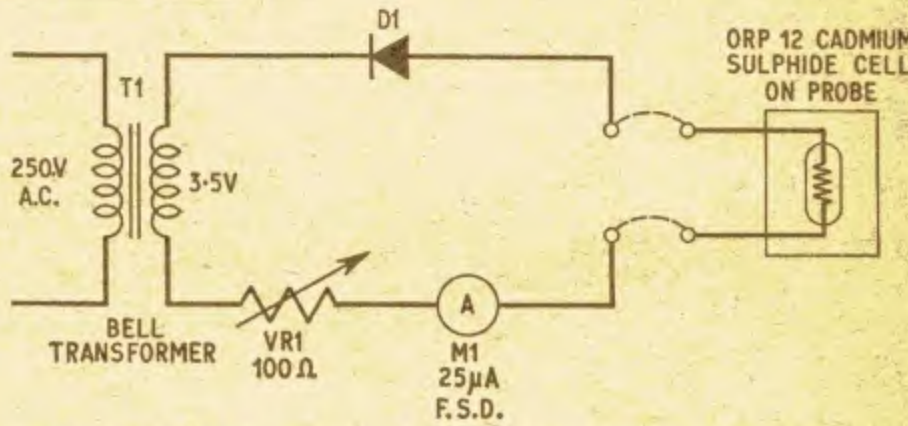
IN THIS feature we hope, from time to time, to be able to publish suggestions submitted by some of our readers on the possible improvement of projects previously described in PRACTICAL ELECTRONICS; short contributions on other subjects may be included. The aim is not to find fault or undermine the abilities or knowledge of our contributors. It may well be that the original article is *par exellence* but it could be improved or adapted to suit individual requirements. The views expressed by readers are not necessarily those of the Editor.

SIMPLE ENLARGER TIMING

One of your readers B. J. Solloway ("Readout" April), asked for a circuit to indicate exposure times for a photographic enlarger. I designed and am now using the following simple circuit with a 2in Wray enlarger.

I removed the click stops from the lens making the aperture infinitely variable. Then using a good negative I made a print which needed 15 seconds exposure; others may need more or less time. Without changing the aperture or other conditions I slid the probe containing the ORP12 cell under a "middle tone" and adjusted the potentiometer until the meter indicated half-scale deflection.

From this initial setting up any negative in the enlarger can be printed by adjusting the aperture until the meter reads half scale; then expose for 15 seconds. After setting VR1 it should be locked in position.



J. Livingstone,
Luton,
Bedfordshire.

SELF DISCHARGING

After the flash gun has been used the capacitors C4 and C5 are left fully or partially charged, and remain so for some considerable time as the only leak is their own resistance and the reverse resistance of diode D5. If the power pack has been switched from full to half power, C5 is left charged and isolated (see July issue).

A permanent leak could be used, but a more efficient method is to use a standard jack with changeover contacts in place of SK2 as shown. Switch S2 is now made a changeover switch.

This circuit automatically discharges C4 and C5 when the jack plug is removed; the oscillator is switched off simultaneously. Switch S1 is no longer necessary, but is convenient when the flash gun is in frequent use, and isolates the accumulator when it is out of use.

R. A. Porter,
Chipstead,
Surrey.

C4 and C5 are 400 + 100 + 16 μF each.