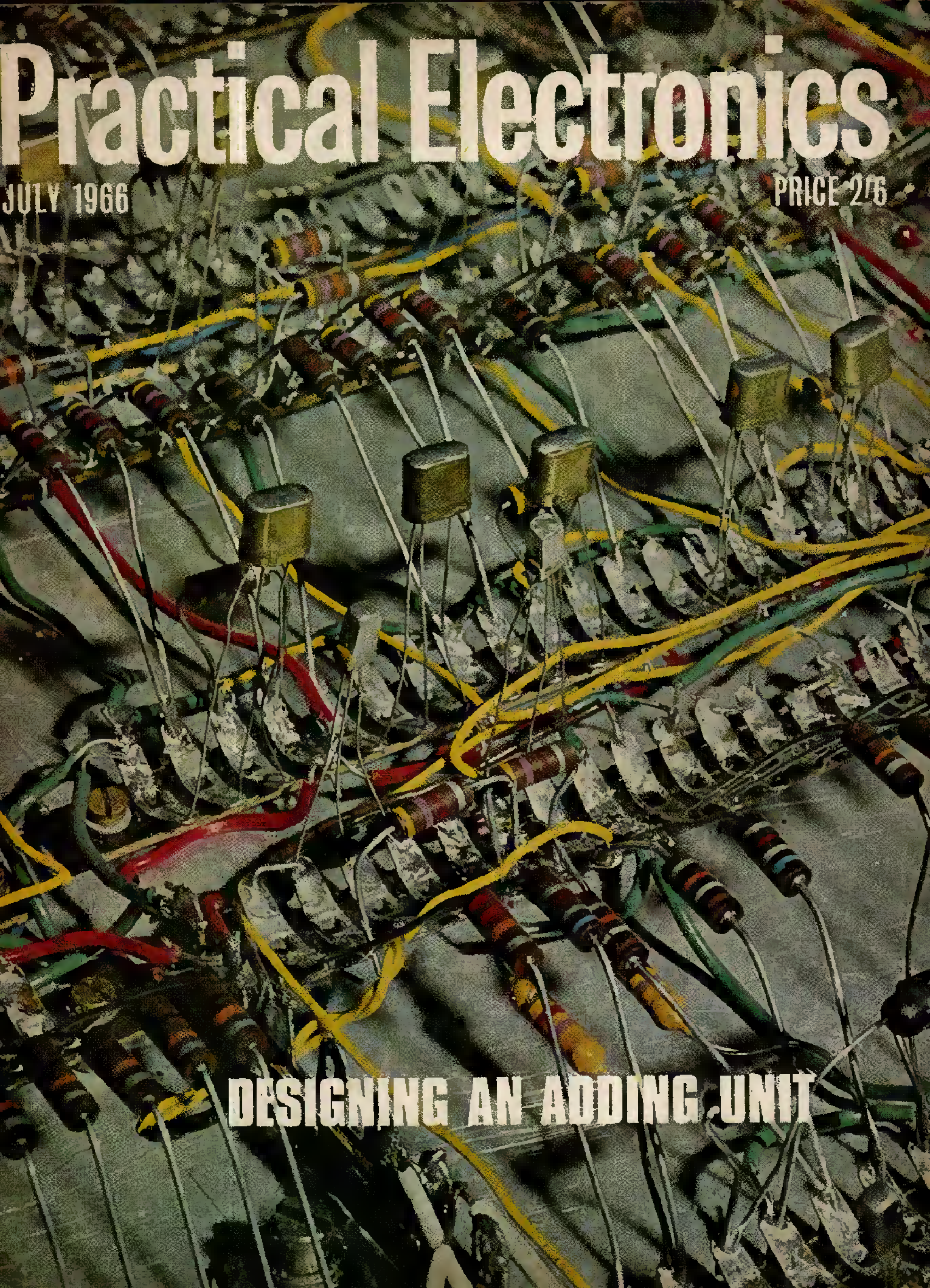
Practical Electronics

JULY 1966

PRICE 2/6



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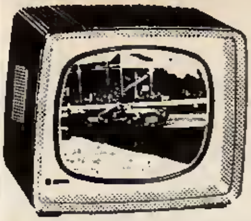

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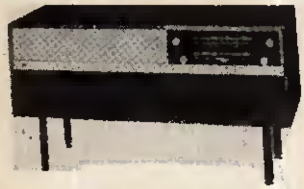

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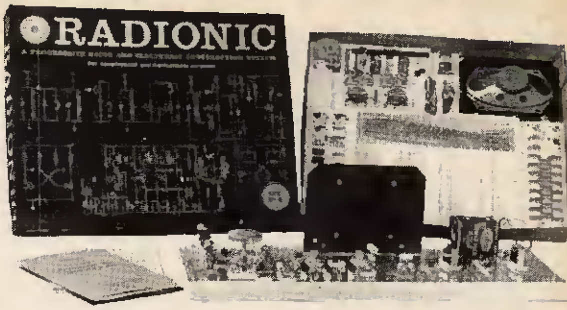

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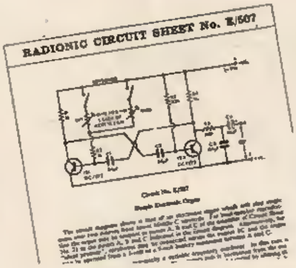
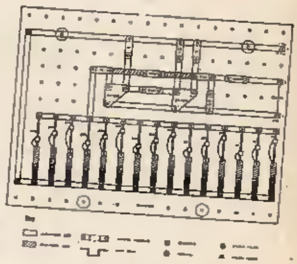


Theoretical Circuit



Practical Layout

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Post 2/6. Set of batteries 7/5 extra.

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TRANSISTORISED UHF MINIATURE MODEL
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Add 2/6 Post and Packing on each.

GORLER UT 340 FM/VHF TUNING HEART

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LASKY'S PRICE 15/11 Post 2/-. ECC85 valve 9/- extra

CONSTRUCTORS BARGAINS

The "Sixteen" Multirange METER KIT

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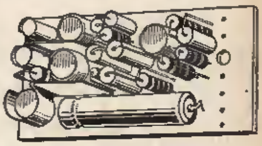
RANGE SPECIFICATION: D.C. volts: 0-2.5-25-50-250-500 at 20,000Ω/V. A.C. volts: 0-25-50-250-500 at 1,000Ω/V. D.C.current: 0-50µA, 0-2.5-50-250mA. Resistance: 0-2,000Ω, 0-200kΩ, 0-20 MΩ. Basic movement: 40µA f.s.d. moving coil. With universal shunt full scale deflection current is 50µA. Black plastic case—3¾ × 5¾ × 1¾in. Controls: 12 position range switch; separate slide switch for A.C. volts—D.C. ohms; ohms zero adjustment pot, meter, meter zero. Power requirements: One 15v. and one 1.5v. batts. Complete with all parts and full construction details. H.P. Terms available.

LASKY'S PRICE **£5.19.6.** P. & P. 5/-

Data and circuit available separately, 2/6; refunded if all parts bought. Pair of batteries 2/- extra.

NEW—LASKY'S MINIATURE TRANSISTOR AMPLIFIER MODULES



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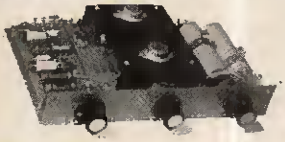
SS20/7 £9/19/6

The now well proven model as illustrated comprising pre-amplifier measuring 4·7" × 2·3" and main amplifier measuring 4·5" × 4" both mounted on base plate and supplied complete with bass, treble and volume on/off controls.



SS20/8 11 GNS.

A de luxe version complete in itself and ready to mount into your cabinet. Supplied with three controls mounted on the front of the stove enamelled chassis and has moulded plastic and spun aluminium control knobs fitted as standard. A tag strip mounted on the back of the chassis in addition to facilitating the L/S and H.T. connections provides separate inputs for crystal, ceramic cartridge, magnetic pick-up, radio and tape recorder. The max. dimensions of the whole unit are 6⅛" × 9½" × 2".

SS20/9 19 GNS.

A beautiful table model version with its own power supply and in keeping with the modern trend to build hi-fi systems from self contained separate and compact units. Ready to operate and to connect to tape, gram and radio via coax. sockets at the back of the cabinet. The amplifier and power supply are housed in an attractive pressed steel case finished in a subdued grey stoved enamel and embellished with a gilt brushed aluminium front panel engraved and displaying the four controls. Treble, bass, volume on/off and three position input selector. Cabinet measurements 12" × 6·5" × 2·1".

TECHNICAL SPECIFICATION

All three models employ similar circuits, have the same electrical specification and are fully transistorised. Six silicon planar transistors and two germanium power. Two diodes. All have benefits of negligible noise and distortion, high efficiency, low power consumption, compact design and no warm up time when switching on. The amplifiers are D.C. coupled throughout (no distortion) and there is a transformerless coupled output having a very low output impedance. Power input, 20 watts peak into 3 ohm speaker. Input impedance, selected to suit input. Output impedance, 0·25 ohms. Bass boost, 12dB at 100c/s max. Treble boost, 12dB at 16Kc/s max. Distortion 0·1% typical. Frequency response, 16c/s to 20Kc/s. Noise, 80dB down on max. output. Power requirements, SS20/7 and SS20/8 only. 20mA quiescent. 3 amps peak. 30 volts.

TAPE EQUIPMENT

TAPE PRE-AMP SSTR/7

All silicon transistor. Zero hum. High gain and equalised at 7½" per sec. to give flat response output. Simple mod. described in accompanying instructions allows equalisation at all speeds. Suitable for all medium impedance heads. Dimensions 40 × 50 × 15mm. ASSEMBLED **29/6.**

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MINICLASSIC SS3/9 AND SS3/10

Two high fidelity amplifiers providing adequate power for normal domestic listening or portable equipment. The SS3/9 is the more powerful and provides a maximum of 6 watts into a 3 ohm speaker. The SS3/9 provides 4 watts into 3 ohms and has the advantage of working from a 12 volt rail. Specification: Frequency response, 16c/s to 30Kc/s. Input Sensitivity 1 volt. Both will operate directly from crystal pickup and make complete tape amplifier with SSTR/7. 6 transistor 2 diode. HT + SS3/9 18 volt. SS3/10 12 volt. Dimensions 50 × 105 × 22mm. **69/-** ASSEMBLED, both models.

Record pre-amp Sr/8 couples SSH/9 to ribbon and dynamic mic. High gain all silicon transistor. **29/6.**

TAPE OSCILLATOR SSO13

Complete unit incorporating push pull silicon transistor oscillator giving adequate erase power and recording bias. The only unit on the market at such an economical price. Ferrite pot core oscillator. Frequency 50–60Kc/s. Unit also provides high voltage D.C. rail for the record amplifier. A high efficiency oscillator operating from 12 volt supply at approx. 250mA. Dimensions 90 × 54 × 35mm. COMPLETE **69/6.**

RECORD AMPLIFIER SSH9/3

Fully transistorised. High voltage H.T. rail derived from oscillator. Provides substantially constant current record signal. 1 volt input sensitivity. Input impedance 5k. Power requirements 1mA 75V. derived from SSO13 and 1mA 12V. This is a gain stabilised low distortion circuit. Dimensions 45 × 40 × 20mm. ASSEMBLED **45/-.**

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KZ9·1	KZ6·2
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GOLD PLATED,	KPS 25 9/11
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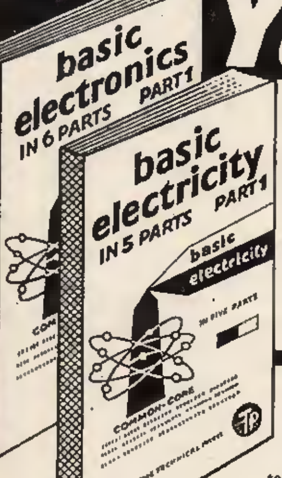

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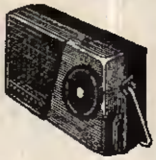

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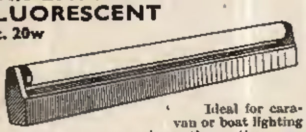

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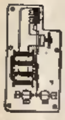

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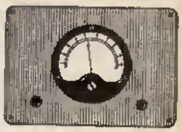

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VOL. 2 No. 7
JULY 1966

Practical Electronics

THE MICROBUG MENACE

THE Postmaster General's declaration that the use of any kind of eavesdropping or "bugging" equipment is illegal in the U.K. is most welcome.

For some time we have noted with apprehension a steady growth of the market in electronic eavesdropping or "bugging" devices—mainly of foreign origin. The undue publicity these electronic gadgets have received through bizarre television series and films must be partly to blame for the cultivation of an unhealthy interest in secret listening among certain sections of the general public. It is to be hoped that the outlawing of these devices will discourage our own manufacturers and retailers from pandering to such (now) illicit demands.

It is probably true that the novelty of these miniature devices may fascinate some of the technically minded and induce them to conduct genuine experiments, without any real intent to eavesdrop on private conversations. To satisfy one's technical curiosity is one thing, but there is a real danger that the temptation to continue listening may prove irresistible for some. What might well have begun as an innocent prank or experiment could thus easily develop into a much more sinister and serious affair.

In welcoming the official clarification of the position concerning "bugging" devices we appreciate that fully effective enforcement of the ban on their use is largely beyond the capabilities of the authorities. It is a frightening thought—but nevertheless a realistic appreciation of the times—that no one will ever be entirely safe from this menace. And yet there is no reason to accept passively the use of microbugs and their like. Electronics enthusiasts, amateur as well as professional, have an opportunity to apply their particular expertise in a worthwhile cause. Electronics which admittedly made the radio microbug possible also provides antidotes, including means for detection. Such a "de-bugging" instrument, which can be built by any capable amateur, is featured in our pages this month.

The anonymous snoopers will be discouraged and their pockets hit every time one of their hidden playthings is tracked down and destroyed. As with other kinds of pests, even if we cannot entirely eradicate the electronic variety, we can hold them severely in check.

THIS MONTH

CONSTRUCTIONAL PROJECTS

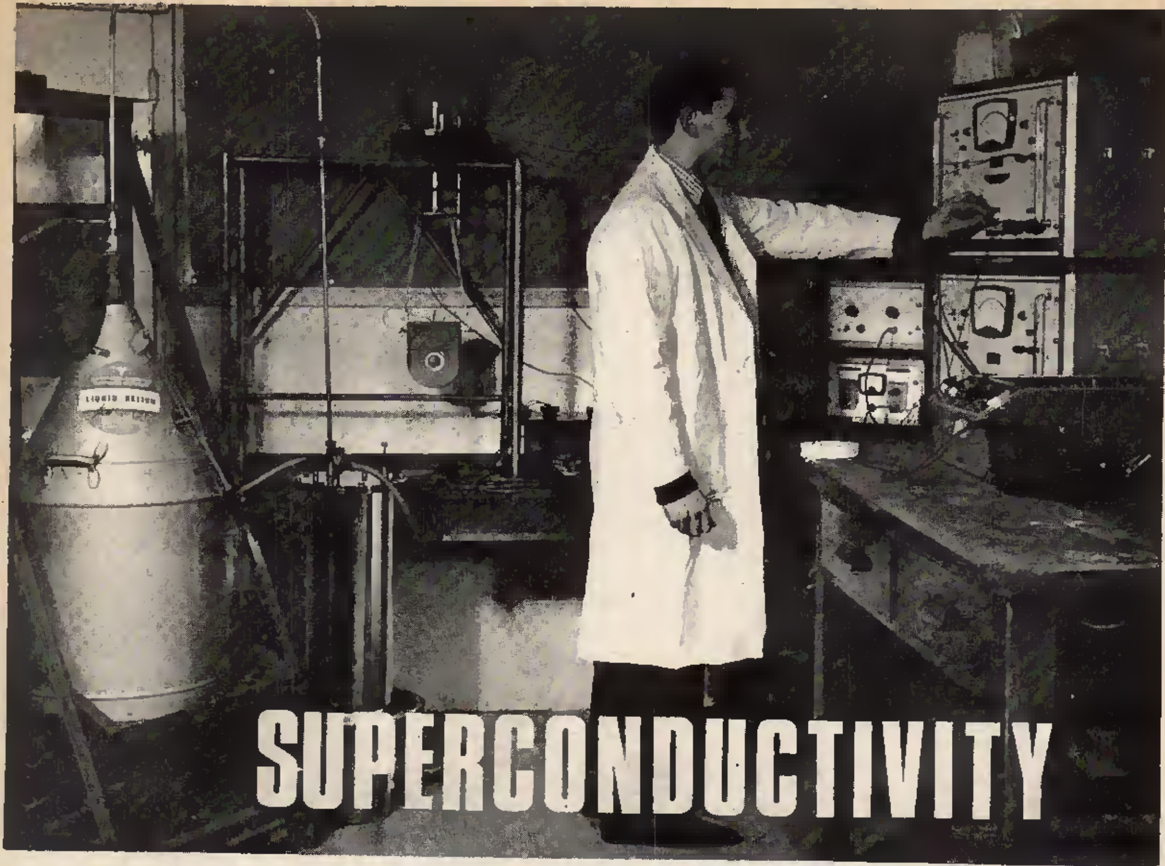
SPECIAL SERIES

GENERAL FEATURES

NEWS AND COMMENT

Our August issue will be published on Thursday, July 14

All correspondence intended for the Editor should be addressed to: The Editor, PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Editorial and Advertisement Offices: PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Phone: Temple Bar 4363. Telegrams: Newnes Rand London. Subscription Rates including postage for one year, to any part of the world, 36s.



By J. H. B. Gould

MUCH work has been done in the field of superconductivity since the initiation, by the then Department of Scientific and Industrial Research, of a national research programme into the applications of superconductivity in Britain. What, you may ask, is superconductivity and how is it likely to affect our lives in the coming decade?

When a piece of metal is cooled down below ambient room temperature, its electrical resistance falls as the electron scattering caused by thermal agitation grows less. There comes a point, however, when the resistance ceases to fall, for at very low temperatures the electrons are scattered mainly by imperfections in the structure of the crystals forming the metal.

But when H. Kamerlingh-Onnes cooled a sample of mercury into still lower regions of temperature he found that the electrical resistance again fell, but this time suddenly, to zero, at a temperature of minus 268·95°C. This discovery marked the beginning of experiments into the phenomenon known as superconductivity.

Although Onnes' discovery was made as long ago as 1911, little practical use was found for the phenomenon until quite recently. Nevertheless, these last few years have seen a radical change in the position, and the effect that for so long had seemed little more than a scientific curiosity has developed into what promises to be a major tool of science and engineering. Its possible applications range from power generating equipment with ratings of hundreds of megawatts to microscopically small components for digital computers.

PROPERTIES OF SUPERCONDUCTORS

The temperature at which the change from finite conductivity takes place depends mainly on the strength of the magnetic field in which the conductor is placed. The presence of a magnetic field will force down the "transition temperature" or even prevent transition entirely (the "critical field"). Yet even in the complete absence of a field, superconductivity demands incredibly low temperatures, temperatures at which all the gases except helium have solidified.

Two types of superconductor have been discovered: "soft" (also known as "ideal" or "type I") and "hard" (otherwise known as "non-ideal", "type II" or "London").

Soft superconductivity was the first to be detected. Soft superconductors such as tin, lead, mercury and aluminium only remain in the superconducting state in magnetic flux densities of less than a few hundred gauss.

Magnetic fields are unable to penetrate beyond the extreme outer layers of a type I superconductor; indeed, it was thought for some years that all magnetic lines of force were excluded entirely from a sample when it entered the superconducting state. However, we now know that flux will penetrate to a depth dependent on the temperature of the sample and its purity. Another peculiarity of soft superconductors is the fact that any electric current entering a superconductor passes through the outer skin of the sample, down to a depth of the order of one hundred-thousandth of a millimetre.

At the present time, many laboratories are conducting investigations into a range of materials that remain in the superconducting state in very powerful magnetic fields. These are members of the class of "hard" superconductors. Hard superconducting materials are of two types: alloys such as niobium-zirconium and intermetallic compounds like Nb_3Sn. This last material has the highest transition temperature found so far: minus 255°C. In hard superconductors, the current is not confined to the outer skin of the conductor, but is distributed fairly evenly throughout the whole cross-sectional area.

There are other factors besides temperature and magnetic field that affect the behaviour of a superconductor. One of these is the value of the current passing through it. Any electric current creates a magnetic field, and according to Silsbee's hypothesis, the critical current for a superconductor, that is the current which causes a sample to revert to its normal state, is simply the current required to produce the critical field at the surface of the sample. Other factors that modify the behaviour of a superconductor are mechanical pressure, carrier concentration and ionising radiation. However, it is the three factors of temperature, magnetic field strength and electric current that bear most directly on the applications of superconducting materials.

SUPERCONDUCTING ELECTROMAGNETS

To create a magnetic field in an ordinary electromagnet, energy must be "pumped" into the windings; when the field collapses, this energy is returned. No energy at all is needed to maintain the field, just an electric current. Unfortunately, ordinary electromagnet windings have a finite resistance and energy must be supplied to overcome this resistance. On the other hand, if the windings had zero resistance, as would be the case if they were superconducting, we could have what amounts to a "permanent electromagnet"; for once the field current had been induced to flow it would continue for ever, as would the field it creates. No heat would be generated in the windings, so that a very powerful magnet could be made as small as desired without any danger of it melting.

Thus the discovery of superconductivity brought to mind the possibilities of extremely powerful electromagnets weighing pounds or ounces instead of tons. Complicated and expensive water cooling systems, needed on conventional power magnets to carry away the energy wasted as heat, would no longer be needed. But it took the further discovery in the United States of hard "high field" superconducting materials before this dream could become anything more than a dream. Bubble chambers, energy storage, ion drives for spacecraft, electron microscopes, radiation shields and power transformers could enter the realm of possibility. Despite formidable problems, it is likely that the superconducting magnet will prove useful in generating electricity, in bubble chambers, energy storage, ion drives, and radiation shields.

The one major disappointment has been the poor behaviour of super-conducting materials when subjected to an alternating field, when the material no longer operates in a completely "lossless" manner. In fact, the losses in a.c. fields have proved to be so high that the power needed to keep the temperature down to the "liquid-helium" level, more than outweighs the power that would be lost in ordinary conductors working at room temperature.

Where direct fields alone are concerned, however, the picture is more promising. Experimental work has been in progress in the U.S.A. on a superconducting excitation magnet system for a 600 megawatt turbo-generator, and an experiment toward the same end carried out in the U.S.S.R. Academy of Sciences is shown diagrammatically in Fig. 1. This simple device is a d.c. generator with what amounts to a "permanent electro-magnet" supplying the field. An armature borrowed from a small motor runs between pole pieces in a soft-iron loop which is broken to admit a superconducting coil. The coil is contained in a double Dewar—a laboratory vessel consisting of a vacuum flask holding liquid helium inside another vacuum flask containing liquid nitrogen.

The superconducting coil (of Nb_3Sn wire) is short-circuited and a direct current induced into it. The voltage that has been obtained at the terminals of this machine is 200 times greater than would have been possible using a permanent magnet. In a full-size turbo-generator, the flux density created by such a magnet system would do away entirely with the need for iron in the magnetic circuit. Not only would this save a great deal of weight and expense, but the considerable loss of energy due to this iron would be absent.

SUPERCONDUCTING BEARINGS

When a conductor is moved in a magnetic field, an electric current is induced in the conductor. If a block of copper is brought near to a magnet, the eddy currents induced in the copper will repel the magnet, but

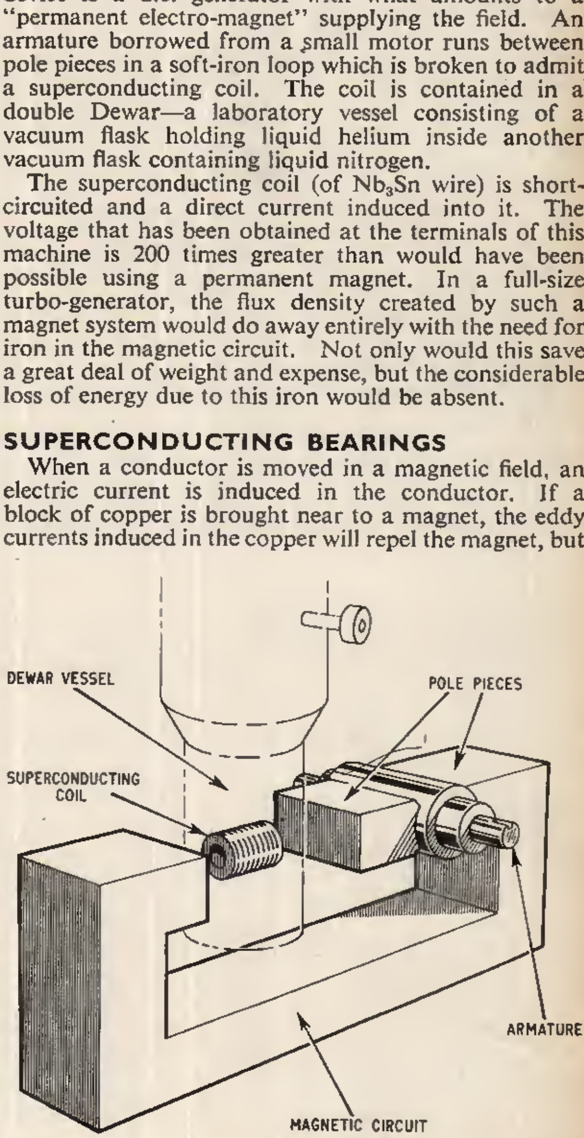


Fig. 1. Experimental d.c. generator using a superconducting field winding

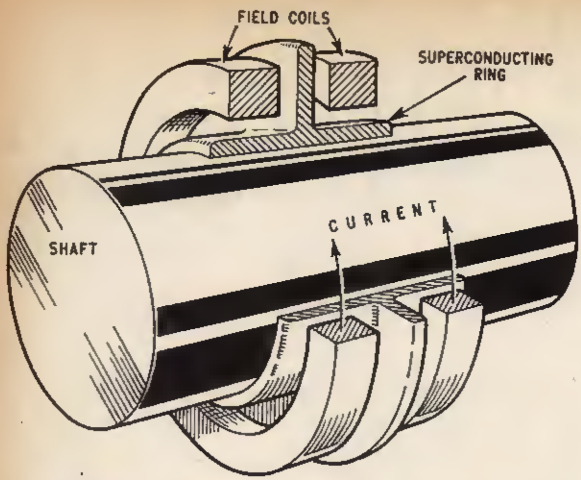


Fig. 2. Cutaway view of an experimental form of superconducting bearing

the force is so small that it is difficult to detect under normal conditions. If the copper is replaced by a superconductor, however, there is no resistance to damp out the eddy currents and a heavy block of metal can be made to hang in space supported only by the field of a magnet beneath it. If, in turn, we make this superconducting block part of the journal at the end of a shaft, we obtain a bearing that has no friction losses whatever, as the shaft is entirely supported by "field interaction". In Fig. 2, the field generated by the two coils supports the T-section ring of superconductor which is rigidly fixed to the shaft.

SUPERCONDUCTOR MOTORS

"Superconducting" motors and generators can be built on similar principles as conventional machines, but with the windings made of superconducting material that is cooled to liquid helium temperatures. On the other hand, more radical designs become possible using superconductors.

Fig. 3 shows one such design in diagrammatic form. A superconducting rotor in the shape of a polygon runs inside a system of stator conductors. Currents flowing through certain of the stator bars create forces on the rotor which act perpendicular to the surface of the rotor adjacent to the bars concerned. As the forces are "off-centre" with respect to the shaft, the rotor will turn in the direction shown, i.e. counter-clockwise. In turning, the rotor switches the currents into the next series of bars so that the energised bars are always in the same relative positions to the rotor. Such a machine has been studied in the laboratories of the General Electric Company of America.

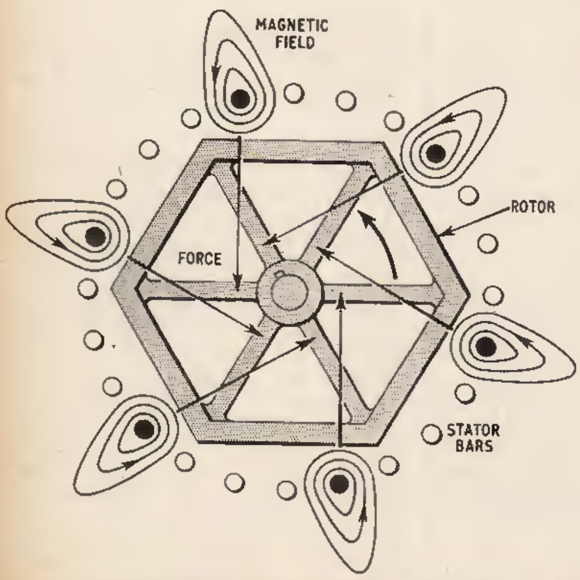


Fig. 3. Superconductor synchronous motor with polygonal rotor

THIN-FILM CRYOTRON

The term *super*conductor is no exaggeration; in a superconducting circuit a piece of silver would act as a relatively high resistance. Thus, the effect on a circuit, when an element in the superconducting state reverts to its normal finite conductivity, is like turning off a switch. This "switch" can be turned off by temperature, current, a magnetic field or even by mechanical pressure or radioactivity. It is, however, electric current that controls the behaviour of a thin-film cryotron.

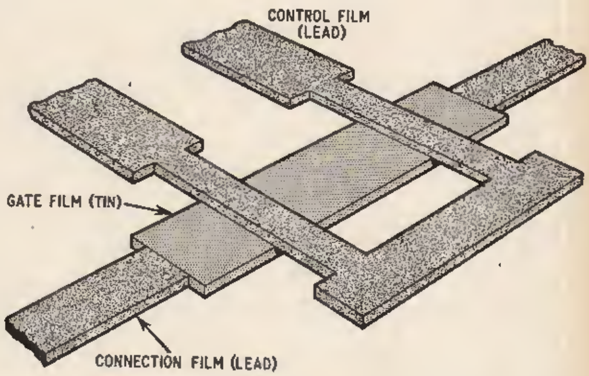


Fig. 4. Diagram illustrating the principle of the crossed-film cryotron (greatly enlarged)

Basically, the cryotron is an extremely simple device, for it involves nothing more than the intersection of two metal strips, electrically insulated from each other (Fig. 4). One strip is known as the "gate", the other as the "control". The gate is made of a material that permits it to be switched from the superconducting to the normal state by the introduction of a current into the control. It is, in effect, a relay.

The cryotron can be used to switch the automatic circuitry of a factory or power station, and it can form part of the logic scheme of a digital computer. However, its use in logic circuits is limited by its relatively slow speed of operation (relative, that is, to the present-day speeds of computers). As far as computers are concerned, the cryotron is more likely to find its place in the memory system, a role in which it shows considerable promise. If the strips of superconductor are arranged into loops, any currents introduced into these loops will persist until some outside action (such as a

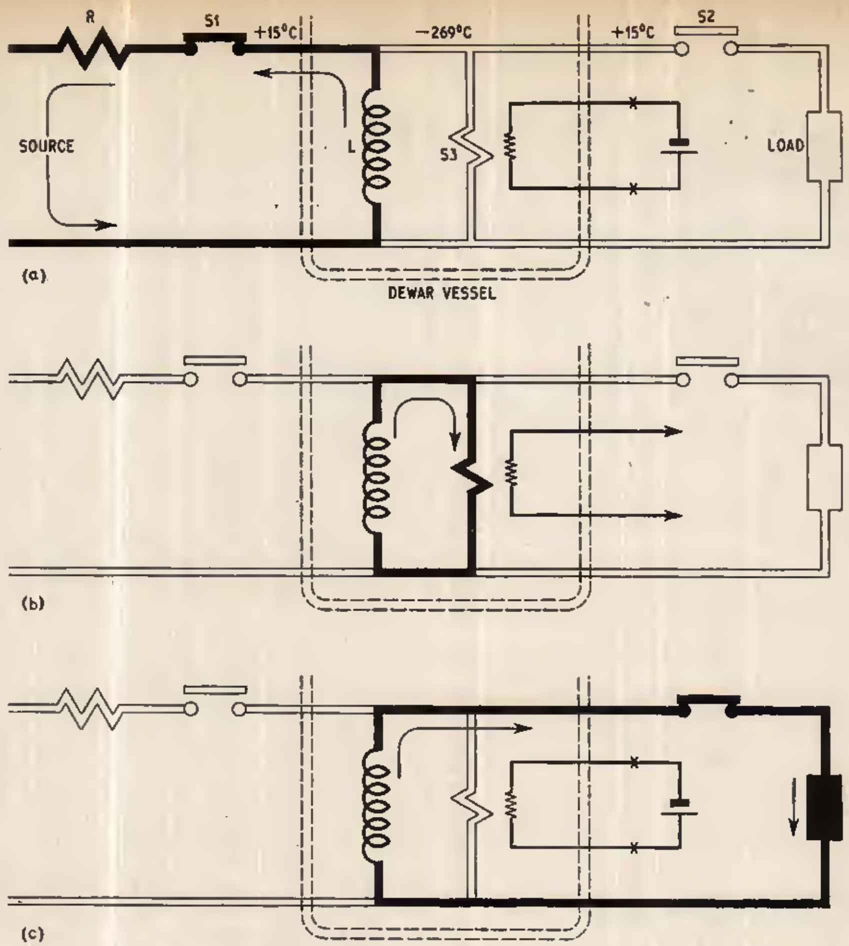


Fig. 5. Basic scheme of superconducting energy store. (a) The source of supply gradually builds up, the current flowing through inductor L at a rate controlled by charging resistance R until the required value is attained. (b) Switch S3 closes to short-circuit the inductor; switch S1 opens to disconnect the supply. (c) To discharge the inductor, switch S2 closes and switch S3 opens, diverting the current into the load. S3 is a superconducting switch turned off by the field of a small electromagnet

current in the "control") determines that they do otherwise.

ENERGY STORAGE

Storing large amounts of electrical energy is a costly and sometimes inefficient business. One factor common to all storage systems is the great size and cost of the stores (accumulators, capacitor banks, the reservoirs of a pumped-storage scheme etc.) in relation to the amounts of energy that they can hold. As was mentioned earlier, a magnetic field can store energy; but unlike an accumulator or pumped-storage scheme this energy can be released in one intense burst. Its only real competitor at the present time is capacitor storage; this can be very powerful indeed. While a bank of capacitors must be considerably larger than the inductor of a magnetic store of equivalent power rating, the losses in the latter are extremely high. These energy losses, caused by the resistance of the inductor windings, are so great that magnetic energy storage on a large scale is only practical where the energy can be pumped rapidly into the store and then released immediately.

Both of these requirements are achieved if the inductor is wound with a superconducting material. With no resistance losses, the field can be "trickle-charged" from a low power source of electricity; the inductor will hold its charge until such time as it is required. Fig. 5 shows one way in which a superconducting energy store could operate in practice.

Many problems have still to be solved before the superconducting energy store is able to compete successfully with existing storage methods, but its great potential seems to lie in situations where large amounts of energy (more than 100 kilojoules) are needed for release over periods of a few thousandths of a second. It could, for example, be used to supply the energy for metal-forming processes of the "exploding-wire" type, or for pumping high power lasers.

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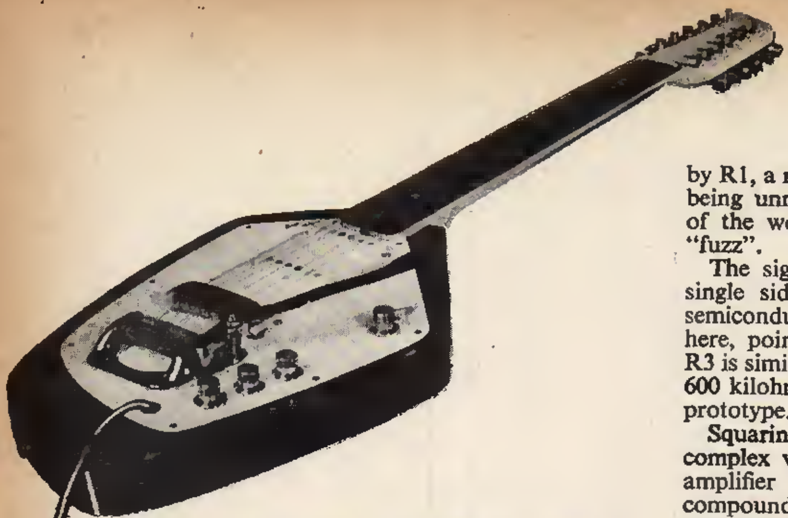


APART from the usual tone controls, there are at least three different electronic effects that are currently in vogue amongst both individual guitar players and pop groups. They are:

(a) *Echo or Reverberation*—effected by a tape delay or a mechanical delay. This is made evident as a periodic recurrence of a single sound.

(b) *Vibrato*—sometimes mistakenly called tremolo—is produced by mixing a fixed low frequency oscillation with the guitar signal.

(c) *Fuzz Box*—a harsh yet not unpleasant sound effected by wave shaping circuits. Here the impact of this contrived distortion is most evident on low frequencies.

There are plenty of published designs for echo units and vibrato units yet there has been little available on Fuzz Box circuitry, although considerable interest has been aroused in the subject.

Commercial units are available but the price of these inclined the author to design and build his own.

TECHNICAL DESCRIPTION

The fuzz box is based on a three stage shaping circuit, shown in Fig. 1. The first stage TR1 is a simple pre-amplifier of medium gain the input being applied via an 0·47μF capacitor C1. The value of this capacitor can however be decreased to 0·1μF if fuzz bass is not to be used. Base bias current is supplied by R1, a more sophisticated means of bias stabilisation being unnecessary as any thermally induced changes of the working point can only introduce additional "fuzz".

The signal developed across R2 is applied to the single sided peak clipper diode D1. Any type of semiconductor diode could reasonably be applied here, point contact or junction types. The value of R3 is similarly non-critical, a choice of resistor between 600 kilohm and 1 megohm proving satisfactory in the prototype.

Squaring of the component tones of the guitar complex wave input is completed by the overdriven amplifier TR2, the output of this being fed to the compound-connected output amplifier composed of TR3 and TR4, which together further amplify and improve the squaring by reducing the rise and fall times.

This output is then differentiated by the CR network, made up of C3 and the output potentiometer VR1. The resultant spiked positive and negative pulses make up the rasping "fuzzed" sound which can be fed to an amplifier or other effects units by way of SK2.

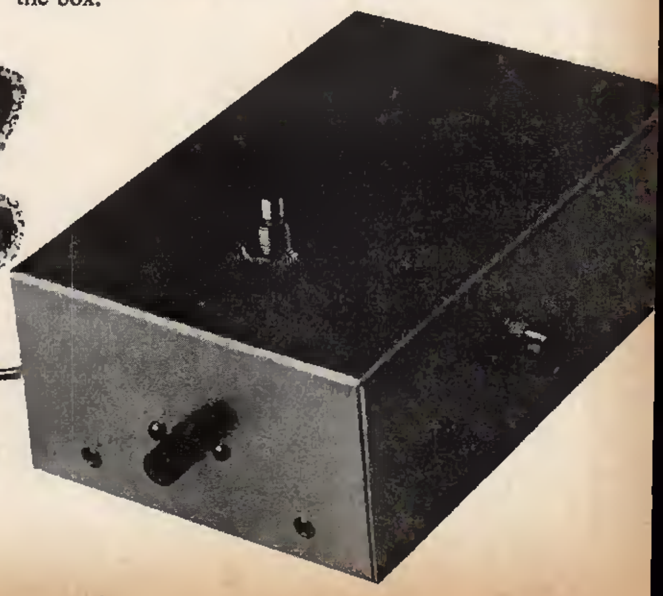
A requirement of this kind of unit is its ability to be switched in and out of circuit without the instrumentalist using his hands. This was achieved by using a single-pole changeover switch S1 operated as a foot switch. This serves the dual purpose of by-passing the effects box when the switch is not depressed and energising the circuit, thereby breaking the by-pass when foot pressure is applied. As can be seen this provides a considerable saving in current.

The setting of the output preset potentiometer VR1 will be determined by the power output of the main amplifier and an optimum level can be found by individual experiment.

CONSTRUCTION

Since the unit housing would be subjected to continuous foot pressure, it was decided to use an 18 s.w.g. aluminium chassis, with the changeover switch being mounted at one end. This allowed for easy control of switching as the foot is allowed to pivot on the box.

FUZZ BOX



by M. SCIBOR-RYLSKI

Fig. 1 (right). Circuit diagram of the fuzz box with footswitch

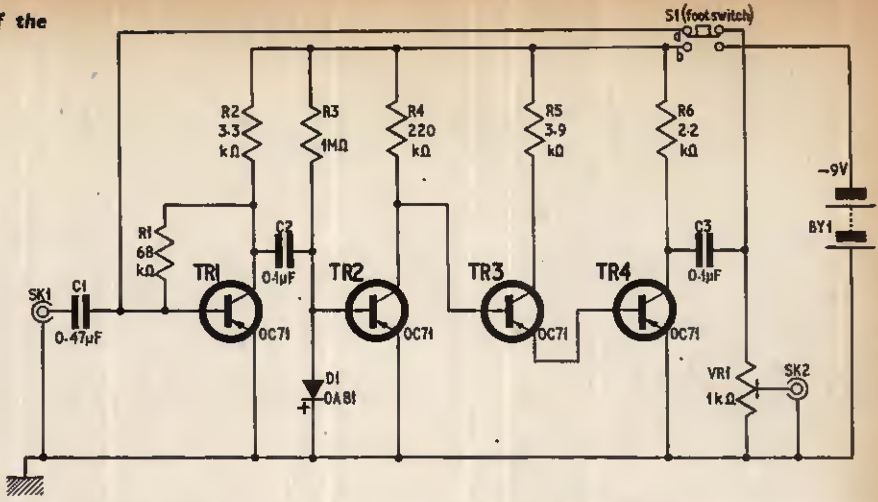
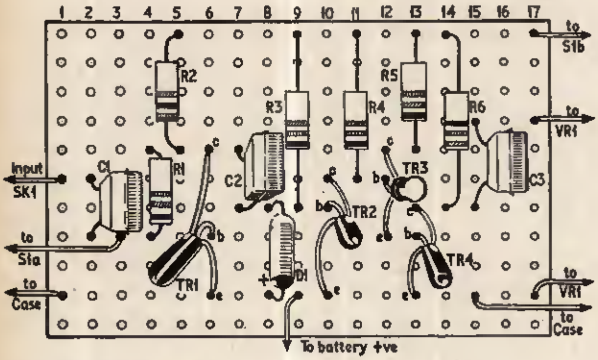


Fig. 2a (below). Layout of components on the laminated wiring board



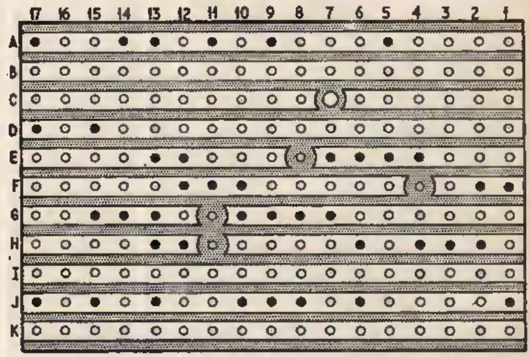


Fig. 2b. Underside of the component board showing holes which are used (black) and copper strip breaks

COMPONENTS . . .

Resistors
- R1 68kΩ
- R2 3·3kΩ
- R3 1MΩ
- R4 220kΩ
- R5 3·9kΩ
- R6 2·2kΩ
- All ± 10%, ½W carbon

Capacitors
- C1 0·47μF polyester 160V
- C2 0·1μF polyester 150V
- C3 0·1μF polyester 150V

Transistors
- TR1—TR4 OC71 or NKT214 (4 off)

Diode
- D1 OA81 Mullard

Potentiometer
- VR1—1kΩ preset, linear

Switch
- S1 Single pole changeover switch—S.M.357 Bulgin

Battery
- BY1 9V battery. Ever Ready PP3 or Vidor VT2

Sockets
- SK1–2 coaxial, surface mounting (2 off)

Miscellaneous
- Chassis: 18 s.w.g. aluminium, 6in × 4in × 2¼in
- Veroboard: 2½in × 1½in. P.V.C. covered wire
- Terry clip. Solder tags

Assembly of components is made on a piece of Veroboard and can be readily followed from the wiring diagram, Fig. 2. Stand-off insulators can be used for board mounting but in the prototype a section of barrier terminal strip (block) served equally well.

It will be noted that the positive line is taken to chassis by solder tags at the input and output sockets.

OUTPUT FILTER

A π network filter may be found necessary in some amplifiers which have relatively large coupling capacitors (see Fig. 4). Its inclusion is dependent on the fuzz quality required. Its exclusion gives a somewhat heightened string intermodulation which, in the author's opinion, epitomises the "wildness" of fuzz.

It is kinder to the loudspeaker however to use this filter if much high volume chord work is intended or if the speaker enclosure is found to resonate on account of too fierce a fuzz. The filter serves to reduce the harmonic content which is considerable due to the effectiveness of the squaring circuit.

The filter is inserted between the output capacitor and the output level control. The potentiometer VR2 is adjusted for the desired effect.

EFFECTS SWITCHING

There are three possible methods of installing and using the unit:

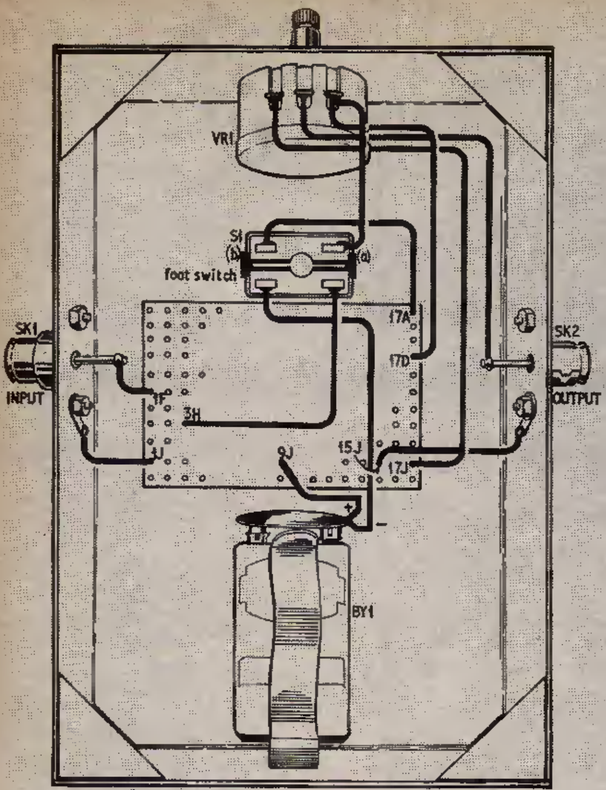


Fig. 3. Wiring details of the unit. The full details of the centre component board are shown in Fig 2

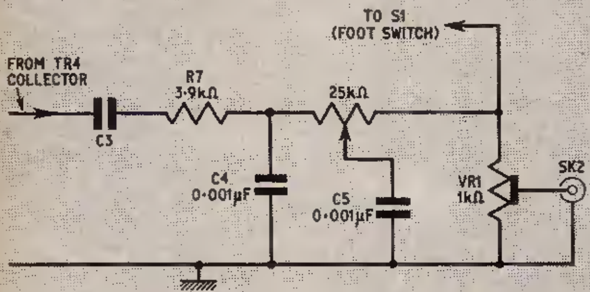


Fig. 4. Pi-filter connected to the output of TR4

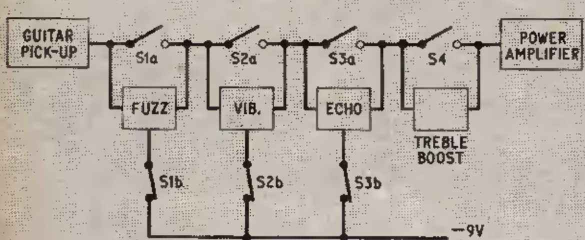


Fig. 5. Suggested method of coupling four effects units to the guitar amplifier input

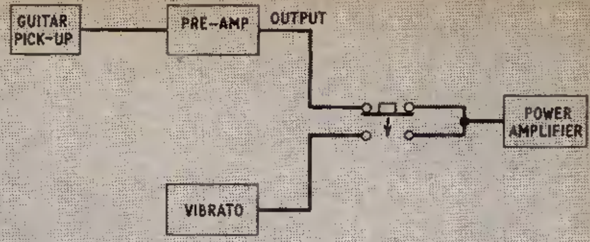


Fig. 6a. Footswitch used to introduce vibrato

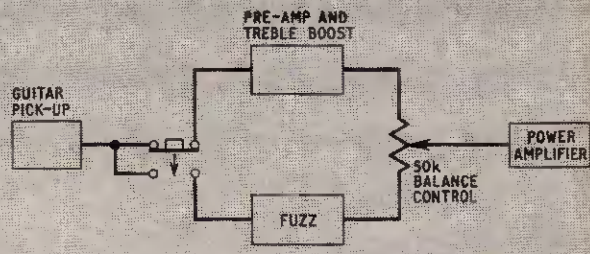


Fig. 6b. Footswitch used to introduce fuzz

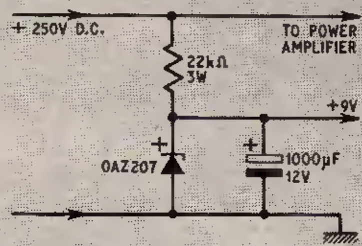


Fig. 7. Method of obtaining a positive low voltage supply from the power amplifier h.t.

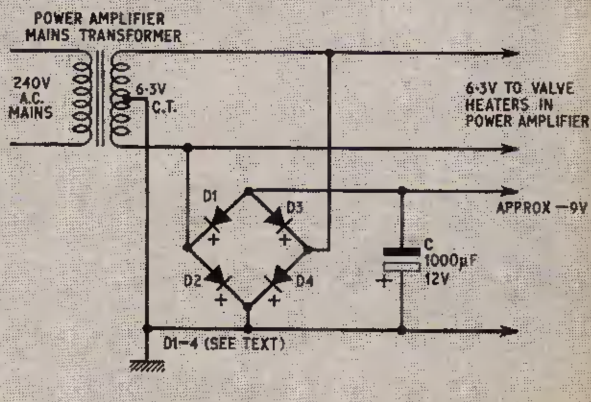


Fig. 8. Rectifying the heater supplies to obtain –9V output

(a) The unit can be installed in the amplifier itself, either with a separate footswitch control or with manual control to form a "fuzz channel".

(b) As a complete footswitch unit as described earlier incorporating all the electronics. The guitar lead plugs into the footswitch unit itself and the output from the unit is connected to the amplifier.

(c) As part of an "effects box" which is external to the amplifier. The remote control of this unit is difficult to achieve without either induced hum or "switchover click". However if good coaxial cable and a shielded microswitch are used then sufficient control is gained by just shorting out fuzz input to fuzz output via the footswitch. This system is really more suited to the type of unit described earlier.

If built into an effects box, one can have a number of facilities such as echo, fuzz, vibrato, treble boost and so on. All that has to be done is to link the required units to switches on a control panel; a suggested set-up is shown in Fig. 5. Alternatively a footswitch unit with one switch for each effect can be used.

It is possible to simplify the arrangement by making one footswitch perform two functions. This can be particularly useful in groups. For example, the rhythm section would use vibrato/pre-amplifier switching and the lead section fuzz/treble boost switching. Examples of footswitching for these are shown in Fig. 6.

POWER SUPPLIES

There are a number of different ways of providing power to the subsidiary effects circuits: battery supplies, separate mains driven power unit, or tapping the h.t. from the power amplifier. Polarities and connections of the supply are very important, particularly when using *pnp* transistors with a valve power amplifier. The fuzz box uses *pnp* transistors.

Taking the first method (battery supplies) this should present no problems, but remember that *pnp* transistors require a negative supply and *npn* transistors a positive supply. Never exceed the recommended voltage for each effects unit.

The second method (mains driven power unit) can be made up from one of the circuits which have been or will be published in these pages.

The third method calls for a certain amount of ingenuity and care. First of all make sure that the power amplifier supplies have enough reserve to enable up to about 10mA to be drawn from the h.t., which will usually be in the region of about 250V positive.

This h.t. is not likely to be stabilised so it is advisable to employ a Zener diode, for example OAZ207 or OAZ272 for 9V, to help maintain a steady d.c. supply voltage. One method of doing this is shown in Fig. 7; the extra components can be mounted on a small tag board inside the amplifier cabinet. This is only suitable for *npn* transistors.

Alternatively the 6·3V heating winding on the amplifier mains transformer can be used if suitably rectified and smoothed. This is illustrated in Fig. 8. It is important here to make sure that one side of the heater winding is not connected to chassis; it is best to connect the centre tap of the 6·3V winding to chassis, which will also be common to the "positive" line of the 9V d.c. output.

This method is suitable for *pnp* circuits and is probably the simplest. The polarity of the output can be reversed for *npn* transistors provided the *negative* line is connected to chassis instead of the positive. Almost any low voltage rectifier diodes of low current rating can be used, for example OA200 or OA90. ★

STABILISED POWER SUPPLY

BY P. RUSH, B.A. (Cantab)

An unstabilised power supply is usually not suitable for driving a power amplifier since the current taken by such an amplifier varies greatly with the signal input. (Here we are assuming a class B output, as is common with transistor amplifiers.) Because of the current variation the voltage supplied from an unstabilised unit will vary with signal amplitude, resulting in distortion.

STABILISATION

The stabilisation of the supply keeps the voltage to the amplifier almost constant no matter what current is drawn, that is it gives the supply a very low internal resistance which is comparable to, or better than, that of a battery.

Fig. 1 shows the poor regulation of an unstabilised supply (initial internal resistance about 45 ohms). The stabilisation applied in this unit reduces the internal resistance to only 1·8 ohms (0·9V drop in supply voltage at 500mA).

The basic method of stabilisation is the use of a Zener diode. This is a special silicon diode biased in reverse. The voltage across it is always fixed by this diode at a characteristic value, provided the supply voltage is greater. To limit the current through the

SPECIFICATION

Input: 200–250V a.c.

Output 1: 13V d.c. 0–500mA
(internal resistance 1·8 ohms)

Output 2: 9V d.c. 0–50mA

The power unit described here has outputs chosen so that the unit is suitable for supplying a transistor radio tuner or pre-amplifier (9V supply) and a transistor power amplifier delivering up to 4 watts (13V supply). The ripple content is negligible and is inaudible in the output of an amplifier powered by the unit.

It is suitable not only for powering existing equipment but for providing stable experimental supplies. Details are given for modifications.

Zener diode a series resistor, such as R1 and R2 in this unit (see Fig. 2) is needed. The internal resistance measured across the diode is equal to the dynamic resistance of the device. This method of regulation is used for the 9V supply.

An extension of the basic method is used for the 13V supply. The transistor base voltage is fixed by D2 and so the emitter voltage is only about 0·2V less than the characteristic voltage of D2 no matter what the current. The transistor has the effect of reducing the internal resistance of the circuit even more, here, for the 13V supply, to 1·8 ohms.

Such stabilised supplies are not dependent to any great extent on input voltage. This unit has been operated on both 210V and 240V mains with only a minimal difference in output voltage.

SUPPRESSION OF RIPPLE

Because the output voltage depends to a slight extent on input voltage, ripple is automatically suppressed. The capacitors C2, C3 and C4 incorporated here reduce any remaining ripple to an almost undetectable level. The values of these capacitors might possibly be reduced without a significant increase in ripple, but they are readily obtainable at the values quoted at low prices and are recommended.

COMPONENTS . . .

Resistors
R1 1·2k 10% ½ watt carbon
R2 470Ω 10% ½ watt carbon

Capacitors
C1 2000μF elect. 50V
C2, C3, C4 5000μF elect. 15V
C5 2500μF elect. 12V

Diodes and Transistor
D1 BYZ 13
D2 OAZ 213 (12 volts nominal, ¼ watt)
D3 ZS 9·1 or OAZ 292 (9·1 volts nominal, 7 watt)
TR1 XC 142 (Ediswan)

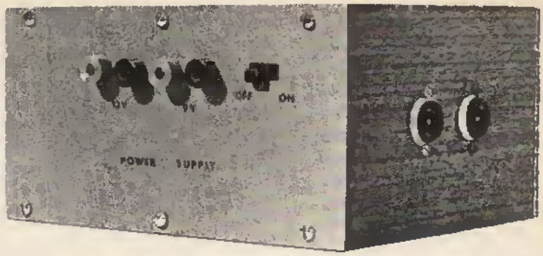
(All available from Henry's Radio and other stockists)

Transformer
T1 Primary 240V a.c. mains, Secondary 24V 1A, type 23 or equivalent (see text) (Samson's Electronics Ltd., 9 Chapel Street, London, N.W.1.)

Fuse
FS1 1A cartridge fuse and holder

Switch
S1 Double pole on/off (mains rating), slide or toggle switch

Miscellaneous
Two B7G valveholders and plugs. Four wander plugs and sockets. P.V.C. covered wire, mains cable and anchoring clip. Mica washer, 4B.A. nylon screws, and silicon grease for transistor insulation. Aluminium sheet 16 s.w.g. for chassis 5½in × 4½in × 2½in. Plywood for box 6¾in × 5in × 3½in.



CONSTRUCTION OF THE UNIT

The prototype was built on a chassis of heavy gauge aluminium. The layout used can be seen from Fig. 3, but this can be varied according to personal choice. It is essential, however, that the transistor is given an adequate heat sink, which is insulated from the chassis, since it must dissipate several watts when the unit is supplying a high current. In the prototype the chassis is used as the heat sink with particular care paid to insulation. A mica washer is used to insulate; silicon grease was applied to the surfaces first. Nylon or similar non-conducting screws are essential for fixing. The diode D1 should also be given a heat sink; here it is insulated from the chassis with plastic bushes. Heat sinks are not necessary for D2 and D3 with the values of components as given, but if run near to their maximum power ratings (¼ and 7 watts respectively) then a heat sink is advisable.

The original unit used a Zener diode type VA9-B which is rated at 2¼ watts although it tended to get warm on test. It was decided to replace this with a Brush Crystal Zener type ZS 9·1 which is rated at 7 watts and should suit the application just as well.

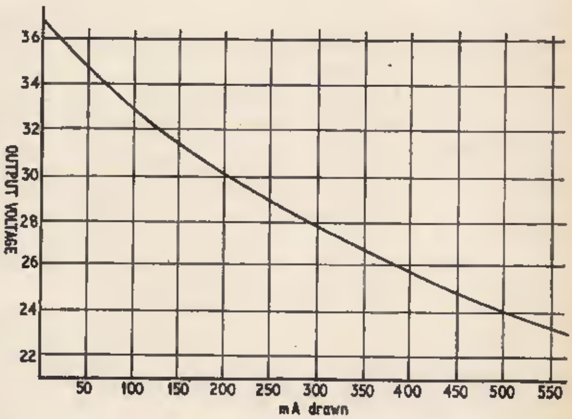


Fig. 1. Graph of the load characteristic—output voltage against load current for a typical low voltage unstabilised d.c. power supply circuit

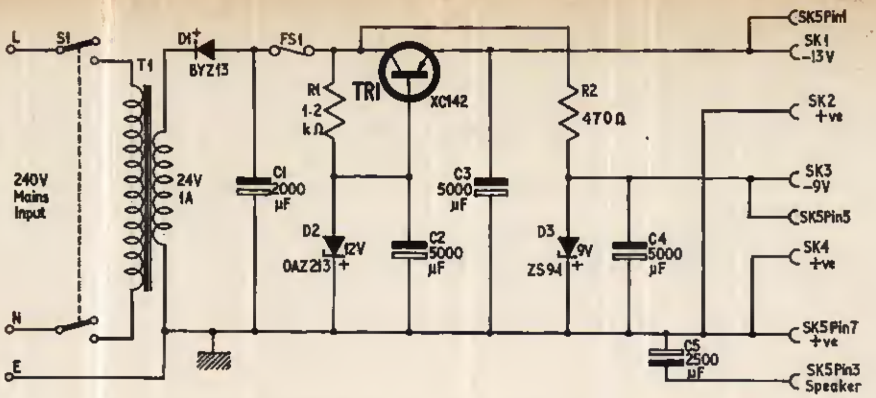


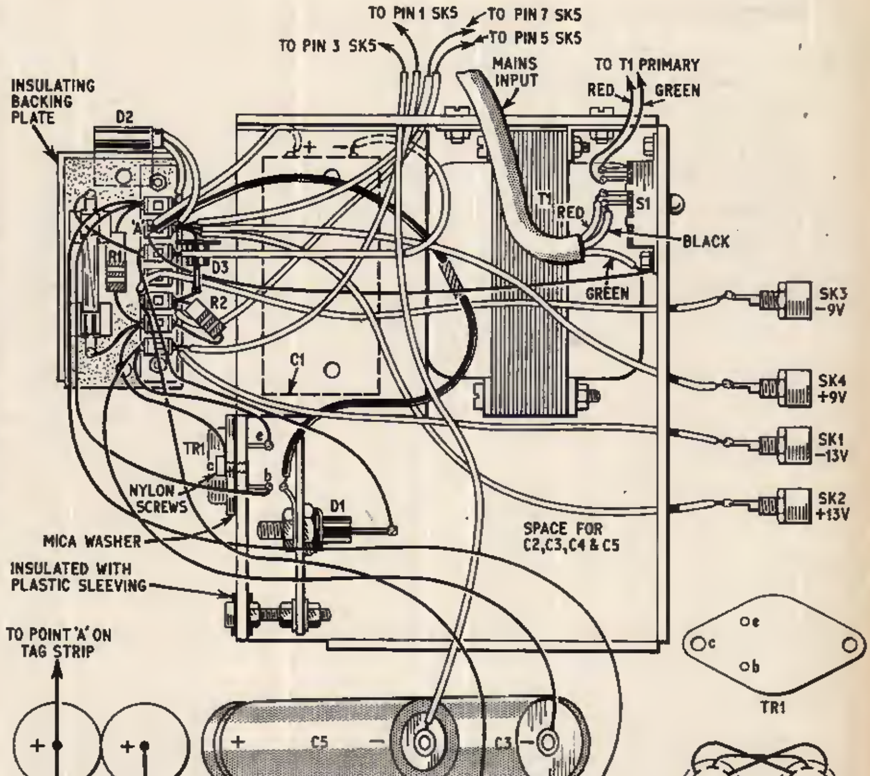
Fig. 2. Circuit diagram of the stabilised power unit

The transformer is described in the components list. If an alternative component is used make sure that the secondary has a minimum resistance of 1½ ohms; if not make up to this value with a fixed series resistor. With this value the diode D1 will not be destroyed by the surge current when the unit is switched on.

A slide or toggle switch may be used, preferably two-pole for safety. If the former is employed as on the prototype ensure that it is suitably rated for mains operation; some are not. Bare terminals should be covered with insulation tape or sleeving. As a further precaution provide an anchorage point inside the cabinet for the mains cable in order to avoid pull on the switch terminals if the cable is tugged.

The capacitor C5 is used between the loudspeaker of the power amplifier and "earth" in transformerless output amplifiers where one side of the loudspeaker would normally be connected to the centre-tap of a battery. This capacitor can be omitted if the amplifier to be powered is not of this type.

Fig. 3. Layout and wiring of the power unit. The small component board on the left and the capacitors C2, C3, C4 and C5 have been moved for clarity. The connections of TR1 are shown looking at the pin side of the transistor. Notice the insulation for TR1 and the heat sink fixing bolt for D1. Sockets SK5 and SK6 are shown diagrammatically; the tags are numbered in a clockwise direction looking at the undersides. D1 positive (cathode) is connected to the stud which should be electrically insulated from its heat sink



In the prototype the outputs were connected to B7G type valve sockets; a B7G plug and multicore cable connects the unit to the tuner and amplifier. A second socket for further developments and wander-plug sockets to provide supplies for experimental purposes were also included.

ALTERATION OF OUTPUT VOLTAGES AND CURRENT RATINGS

The unit can be easily modified provided certain precautions are taken. To alter an output voltage substitute a Zener diode of appropriate voltage and alter the series resistor so that the current through it is either (a) equal to the maximum current needed plus about 1–2mA (D3 and R2), or (b) equal to the maximum base current needed plus 1–2mA (D2 and R1). The maximum base current can be taken as roughly $1/\beta$ of the maximum current which you wish to draw from the supply. For this transistor $\beta = 62{\cdot}5$. As an example, suppose we require the unit to provide 13V at 500mA.

Fig. 1 shows that at 500mA the transistor collector is at 24V relative to "earth". There is thus:

$$24 - 13 = 11 \text{ volts across R1.}$$

Now the maximum base current is

$$I_b \simeq \frac{500}{62{\cdot}5}\text{ mA}$$
$$\simeq 8\text{ mA}$$

so R1 should carry 1–2mA more than this, say 9mA. Therefore R1 should carry 11/9 kilohms. The nearest preferred value is 1·2 kilohms.

To alter the output current keep the Zener diodes as specified and alter the series resistors as described above, but in all such cases ensure that the wattage ratings of the Zener diodes or the transistor (11W) are not exceeded. ★

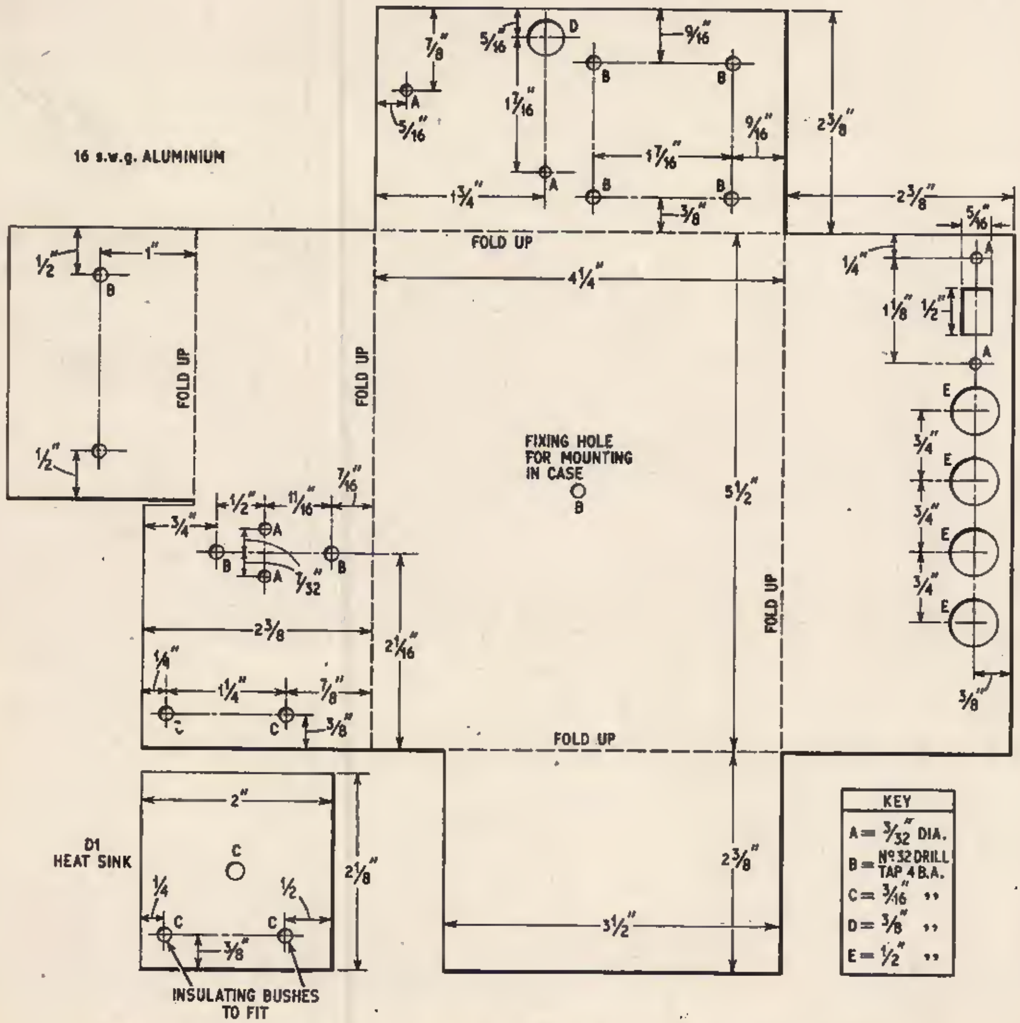


Fig. 4. Drilling details of the chassis made from 16 s.w.g. aluminium. The left-hand flange is folded twice so that part of it is U-shaped. A grommet should be fitted to hole "D" for the wires to SK5 and SK6

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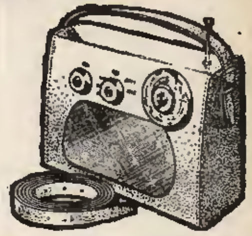

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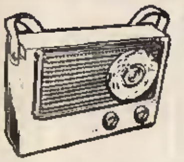

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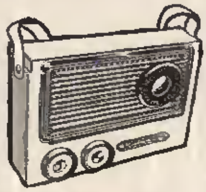

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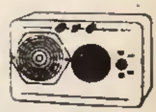

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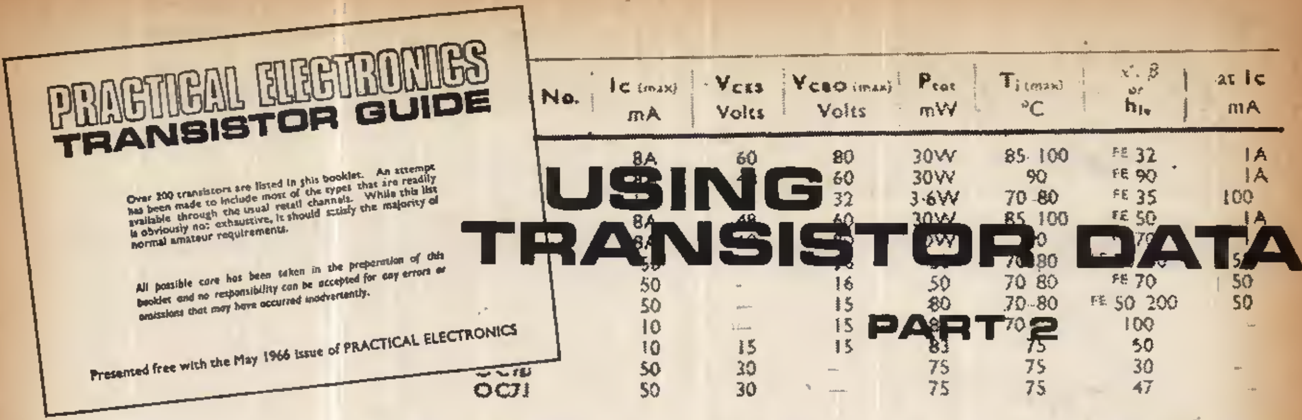


USING TRANSISTOR DATA

PART 2

THE first part of this article (see May issue) dealt with the meanings of the symbols used in the PRACTICAL ELECTRONICS Transistor Guide. In this concluding part, more general matters are explained and a table is also provided in which all types mentioned in the booklet are grouped according to application suitability.

CASES AND ENCAPSULATIONS

The case which contains a transistor is just as important as the glass envelope which maintains the vacuum and houses the electrodes of an electronic valve. The first function of a transistor case is to keep the dirt out. It has been painfully established over the years that the life of a transistor is very largely a function of the amount of foreign matter inside it. This is why transistors are assembled under clinically clean, dust-free conditions and in atmospheres of controlled low humidity—water is a great enemy of transistors.

Early types of transistor such as the OC71 were smeared with silicone grease and then hermetically sealed in a glass envelope. Later, metal cans were used, with the transistor leads taken out via an insulating glass base or "header". These cases are often filled with an inert gas such as helium.

The more recent development of silicon planar transistors has eased the problem of "encapsulation". It is possible to treat the surface of the silicon chemically during manufacture so as to passivate it, i.e. make it less vulnerable to chemical attack. The process is so effective that unencapsulated surface-passivated transistors have been operated immersed in water, a treatment which would cause more or less instant death to other types.

This, of course, was only an exhibition gimmick, but an important side-effect of the planar process is that, with care, silicon planar transistors can be encapsulated in a blob of epoxy resin without ill effects. This dispenses with the usual hermetic sealing and brings down costs drastically. Silicon "epoxy transistors" can now be bought for about the same price as comparable germanium transistors. They can be used in all normal environments (living rooms, computers, etc.) and some types have passed military humidity tests, but designers would at the moment hesitate to put them in apparatus which must work in a really hostile atmosphere, e.g. one laden with chemical vapours.

A second function of the encapsulation is to provide means of conducting heat from the working parts of the transistor. Most of the power consumed in a transistor is turned into heat at the collector-base junction. In high-power transistors, it is quite usual, therefore, to connect the collector directly, with a large-area thermal and electrical contact, to the metal case. This in turn can be clamped firmly to a heat sink of aluminium or copper (not steel, because its thermal conductivity is poor in comparison). In the case of a large power transistor, a good heat sink can increase the power-handling capacity enormously—perhaps a hundredfold.

In certain r.f. transistors, the metal can is used for screening purposes. It is connected internally either to an internal screen or to the collector.

COMPARABLES AND EQUIVALENTS

It is much easier to substitute one transistor for another than one thermionic valve for another. To begin with, all currently produced transistors are triodes. Then again, they are usually wired-in, not plugged in, and so one is not bothered by variations in pin connections.

Thus, in principle, any two transistors with comparable electrical characteristics can be substituted for one another. The problem is to be sure their characteristics are *really* comparable, and this depends on the particular application.

One thing is quite clear: it is *never* possible to substitute a *pnp* transistor for an *npn* transistor without modifying the circuit, since a *pnp* transistor requires a negative collector supply while an *npn* transistor requires a positive collector supply. (The *middle* letter gives the collector polarity with respect to the other electrodes.)

On the other hand, in non-critical applications, quite different transistors may do the same job. For example, a high-voltage transistor, with a collector voltage rating of, say, 50V may be a perfectly good substitute for a low-voltage transistor in a particular circuit. But the low-voltage transistor cannot do duty in the place of the high-voltage one in a high-voltage circuit. This is a case of "one-way" exchangability.

The PRACTICAL ELECTRONICS Transistor Guide lists "comparables", i.e. transistors which can probably be substituted for one another in *many* applications: but not necessarily for *all* applications—the detailed characteristics should be consulted if there is any doubt. In general, there is enough information in the P.E. Booklet to enable substitutes to be picked out, but occasionally one has to consult the transistor makers' complete data. Here are some examples:

Noise

If a transistor is to be substituted in the *first stage* of a high-gain amplifier or receiver, the user must find out from the makers' full data whether it passes muster

A.F. LOW NOISE

AC107	NKT216	NKT226	NKT265	NKT275	2N2926

A.F. AMPLIFIER, LOW-LEVEL GENERAL PURPOSE

AC113	NKT215	OC71	OC201	V10/50A	2N2926
AC155	NKT219	OC73	OC202	XB103	2S002
AC156	NKT223	OC75	OC203	XB104	2S004
AC165	NKT224	OC78D	OC430	XB105	2S005
BCZ11	NKT225	OC81D	V6/4R	ZT23	2S321
BSY95A	NKT264	OC81DM	V6/8R	ZT24	2S322
NKT213	NKT272	OC82D	V10/15A	ZT697	2S323
NKT214	OC70	OC200	V10/30A	2N706A	2S324

A.F. POWER

AD140	NKT402	OC16	OC28	OC206	V30/20P
MGT400	NKT403	OC22	OC29	V15/10P	V30/30NP
MGT600	NKT404	OC23	OC30	V15/20P	ZT2270
NKT263	NKT405	OC24	OC35	V15/30P	2N456A
NKT362	NKT452	OC25	OC36	V30/10P	2N457A
NKT401	NKT453	OC26	OC81M	V30/15NP	2S013

LOW POWER A.F. AND SWITCHING

AC128	ASY83	GET104	NKT222	OC72	OC205
AC154	ASY84	GET105	NKT227	OC76	V10/15J
AC157	ASY85	GET106	NKT228	OC77	V15/201P
AC166	ASY86	GET111	NKT271	OC78	V30/201P
AC167	ASY87	NKT211	NKT273	OC81	
AC168	ASY88	NKT212	NKT274	OC82	
AC177	ASY89	NKT217	NKT304	OC83	
ASY28	GET102	NKT218	NKT713	OC84	
ASY82	GET103	NKT221	NKT773	OC204	

R.F. AMPLIFIERS, OSCILLATORS & HIGH SPEED SWITCHES

ADT140	AFZ12	NKT142	OC140	ZT706A	2N412
AF114	AUY10	NKT162	OC141	2G301	2N428
AF115	BSY53	NKT612	OC169	2G302	2N585
AF116	BSY95A	NKT613	OC170	2G303	2N697
AF117	MAT100	NKT674	OC171	2G306	2N706A
AF118	MAT101	NKT675	V6/2R	2G371	2N1091
AF124	MAT120	NKT676	XA101	2G381	2N1302
AF125	MAT121	NKT677	XA102	2G382	2N1613
AF126	NKT121	OC41	XA111	2G401	2N2926
AF127	NKT124	OC42	XA112	2G402	2S019
AF139	NKT125	OC43	XA151	2G414	
AF186	NKT126	OC44	ZT23	2G415	
AFY19	NKT128	OC45	ZT24	2G416	
AFZ11	NKT141	OC139	ZT697	2N410	

APPLICATION GROUPING

on this score. Makers usually quote a *noise figure* or *noise factor* for the transistor under specific conditions of frequency, collector current, signal-source resistance and so on. These can be compared, but take care to make sure that they are really comparable.

Example: an OC71 is used in the first stage of a tape recorder. Its noise performance is satisfactory but the treble response is poor. Can a high-frequency transistor such as the OC171 be used to remedy this defect? A glance at the makers' data suggests that substitution is possible. The maximum noise figure for the OC71 is 16dB, while that for the OC171 is 8dB, which suggests that the OC171 is much better. But wait a minute! *This* noise figure for the OC171 is obtained at 500kc/s and 10Mc/s, not at a.f. The *a.f.* figure is 30dB maximum which clearly rules it out for this critical application.

Internal Capacitances

In tuned high-frequency amplifiers such as i.f. amplifiers, neutralisation is sometimes necessary to preserve stability.

Can an AF117 be substituted for an OC45 in a neutralised 470kc/s i.f. stage? Reference to the makers' data shows that the internal feedback capacitance of the AF117 is quite different from that of the OC45, while the gain is higher. There is evidently some risk of instability.

GERMANIUM OR SILICON?

There is no difference in principle between silicon and germanium transistors. But there *are* important practical differences. In the early days of silicon transistors, the difference which received most emphasis was that the leakage currents in silicon transistors are much less than in germanium. The effect of temperature is therefore reduced. In addition, silicon devices will withstand higher junction temperatures, and this is of interest in many military aircraft applications where ambient temperatures are high.

In everyday applications these properties are not all that important, though sometimes the lower leakages enable simple biasing circuits to be used (Fig. 1) even at quite high ambient temperatures. This saves components, and may tip the economic balance in favour of silicon even if a silicon device costs more.

A difference between germanium and silicon transistors which has a bearing on circuit design is that the working base-to-emitter voltage for silicon is about 0·5–1 volt, compared with 0·1–0·3 volt for most germanium devices. This has a bearing on the design of bias networks, and it also means that silicon transistors will not work from quite such low voltages as germanium ones.

Planar transistors have the useful property of "beta hold-up" at low collector currents, i.e. the current amplification factor does not fall off much as the collector current is reduced. Current gains of 100 or more at $I_C = 50\mu A$ are not uncommon. This is very useful in low-level audio work, because, in general, transistor noise is reduced at low currents. Noise figures of less than 2dB can be achieved with some transistors. However, though the current gain at low frequencies is preserved at low currents, the radio-frequency performance falls off.

POLARITY: *PNP* AND *NPN*

Most germanium transistors are *pnp*. This is mainly a matter of convenience in manufacture, although a *pnp* transistor would have somewhat better

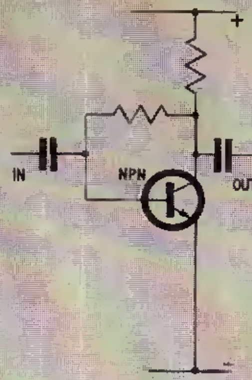


Fig. 1. Simple bias circuit

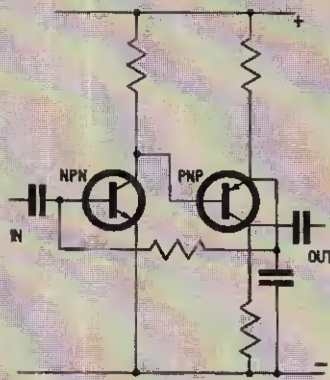


Fig. 2. Mixed polarity amplifier

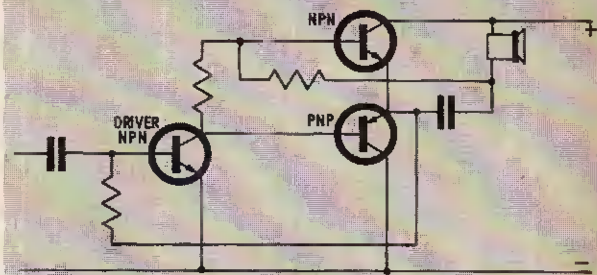


Fig. 3. Complementary output stage

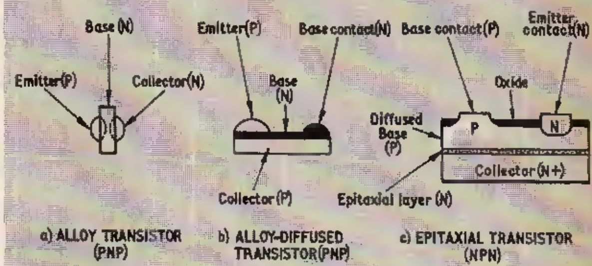


Fig. 4. Transistor structures

h.f. performance than its exact *npn* twin. With silicon planar transistors, the *npn* types are more common at present.

In all-transistor circuits, there is no special advantage in using one type rather than the other. Performance and cost are the important considerations. In mixed valve and transistor circuits, *npn* types have the advantage that the valve h.t. supply can be used very easily to furnish a collector supply.

However, the important thing is to remember that *both* types can be used in the same circuit, often with advantage. The circuit of Fig. 2 is a typical example. It not only provides component economy, but also enables direct coupling between stages to be combined with a small load resistance for TR1—an advantage in wide-band amplifiers. If an a.g.c. current is applied to TR1, *both* transistors are controlled. TR2 may be a germanium type, but silicon is best for TR1 because it must have low temperature drift.

Another use for mixed-polarity circuitry is the "complementary" output stage, which enables push-pull output to be achieved without using a transformer (Fig. 3).

FABRICATION

The earliest junction transistors were all of the alloy type (Fig. 4a). To form a *pnp* structure, blobs of *p* type material are placed on opposite sides of a thin wafer of *n* type material and then the whole lot is "cooked" at a little below melting point. The *p* type impurities pass into the *n* type material, and the whole art of making this type of transistor is to know just when to stop. The best h.f. performance is obtained when the *p* type impurities almost meet in the middle, but not quite. This is not easy to arrange, and in mass production 15Mc/s cut-offs are about the best average that can be reached (OC44, etc.).

Alloy transistors, including r.f. types, usually have good noise figures at audio frequencies.

The difficulty of controlling the width of the base layer led manufacturers to search for alternative methods of fabrication. One ingenious answer was to dissolve away the base wafer simultaneously on opposite sides with the help of two tiny jets of electrolyte and an electric current. (This process is the reverse of electro-plating.) Much better control over base thickness is possible, and the finished "surface barrier" and "micro-alloy" transistors can have better h.f. performances than ordinary alloy types.

In the above transistors, the main wafer is the *base*. In later types, however, it ends up as the *collector*. In the alloy-diffused type of transistor and the post-alloy diffused type (PADT) a thin *n*-type base layer is formed on the surface of *p*-type material by gaseous diffusion. Emitter and base contacts are later alloyed to this layer (Fig. 4b). Familiar types of alloy-diffused transistor are the AF115 series. These transistors are noisy at audio frequencies, but at r.f. their noise can be very low.

In the *grown junction* structure used in the original Texas Instruments silicon transistors, the device is not fabricated from a tiny wafer. Instead, the three layers are formed in a large crystal as it is "grown" from molten silicon, by adding the right kind of impurities at the right time. The crystal is later cut up and leads attached, to form individual transistors. The process is wasteful of silicon, and is not used much nowadays, having been superseded by the planar technique.

The silicon planar epitaxial type of transistor is made by an extension of the diffusion process plus photochemical techniques rather like those used in lithography or printed-circuit production. The base and emitter contacts are "printed" on the surface of a silicon wafer, and this enables their precise shape and size to be controlled very accurately.

An essential part of the process is to form a layer of silicon oxide on the surface of the wafer. This acts as a barrier, just like the "resist" used in photo-lithography and printed circuits. It can be etched away where required to expose the areas of silicon needed for the base and emitter contacts. (Unfortunately, germanium does not lend itself easily to the technique, because germanium oxide evaporates).

In epitaxial transistors the collector is made up of *two* layers: a thick layer of low-resistance material, and a very thin, high-resistance layer. The thick layer acts mainly as a mechanical support for the more active regions. The h.f. performance is vastly improved. A simple epitaxial transistor's structure is shown in Fig. 4c. Many modern types have complex base and emitter areas whose shapes interlock, and the base connection is a closed loop, such as a ring, which encircles the emitter connection. At the present time this is the most popular fabrication process, and it has made most of the others obsolescent.

APPLICATION GROUPING

The information in these two articles can be used to assess transistor operating data such as that in the Practical Electronics Transistor Guide. To provide a quick reference to application suitability, however, transistors included in the guide have been grouped together under various headings on page 492. The groupings are to some extent arbitrary, and some transistors appear under more than one heading because they are general-purpose types.

Since transistor technology is in a constant state of change, a transistor which is today a candidate for one list will tomorrow have to be put in another. Early r.f. alloy transistors are a case in point: no professional designer would nowadays specify the OC45 for a 470kc/s i.f. amplifier, though he might be inclined to use it as a general purpose low level a.f. type. It has been put in the r.f. list here because readers will probably come across it in i.f. stages of transistor portables.

On the other hand, the OC24, which was designed for use as a high frequency power amplifier, has been put in the a.f. power list. Why? Because, with a cut-off frequency of only 2·5Mc/s, it has been superseded for radio frequency applications. But if it ever appears on the surplus market, at a low price, it will be an attractive proposition for a small a.f. power amplifier.

FIND THAT bug

MICROBUG LOCATER

BY D. BOLLEN

THE widespread use of miniature electronic eavesdropping devices could be a cause of anxiety and embarrassment for the private citizen, as well as for those presiding in board-rooms. Unfortunately, the GPO cannot possibly be expected to track down every short-lived, unauthorised transmission, especially when the signal is weak and the range limited. Radio amateurs and radio control enthusiasts have been justly complaining for some time about the fly-by-night activities of pirate walkie-talkie operators and, if the trend continues, it may be gloomily predicted that anarchy of the air will overtake us in the future, when all the normal radio bands will be jammed solid by individual gibberish.

The tiny, transistorised, so called "bug" can be planted virtually anywhere, to relay private conversations 100ft or more, to a nearby house or parked car, and the National Press has already brought this threat to the attention of the public. The potentialities of its use by criminals are almost limitless.

Fortunately though, bugs are self-advertising, and the inverse square law of their radiation pattern favours the intended victim. A transmitter of only a few tens of milliwatts power will produce a strong r.f. field in its immediate vicinity, which is easily detected by a suitable instrument. Equipped with a Bug Locator, the private citizen can do much to discourage the use of such electronic pests. If he finds one he can throw it straight on the fire, or better still, take it to bits to use the components for some more rewarding project. Purchasers of bugs will soon find themselves very much out of pocket if their gadgets are always discovered.

The purpose here is to describe a fairly simple instrument which will detect a suspected "plant" and incidentally can be used also to locate numerous sources of troublesome electrical interference.

DETECTING TECHNIQUE

Although the favoured frequencies for "bugging" are in the 27–28Mc/s h.f. band, and the 85–100Mc/s v.h.f. band, such strict adherence to any particular set of frequencies, on the part of unlicensed operators, cannot be relied upon. Their choice will be largely determined by the receiver they intend to use. It is reasonable to assume that the practical upper limit, imposed by conventional components, will lie at about 200Mc/s. Since, at low frequencies, the ferrite rod will radiate effectively over room to room distances, doing away with the need for a long aerial, the lower limit might lie within the long wave band of a domestic receiver. Therefore, for the purposes of detection, the need is for an uncomplicated receiver covering, say, 100kc/s to 200Mc/s.

Few commercial receivers will cover this wide range, and those that do are bound to be cumbersome, complicated, and expensive. Sensitivity and selectivity are not of primary importance in this present application. If the bug is close to the receiver, acoustic feedback will occur by interaction between the concealed bug microphone and the loudspeaker of the receiver, and there will be no doubt as to the nature of the signal.

A simple alternative, avoiding knob-twiddling and band-changing, would be an untuned wide-band amplifier, capable of picking up any signal within the frequency range suggested above, and relying on the fact that this nearby signal will swamp all others and make tuning unnecessary.

Initially, tests were made with a simple point-contact diode detector and a.f. amplifier, to estimate the degree of sensitivity required, however when placed next to the output lead of a signal generator, results were unpromising. A stage of r.f. amplification ahead of the diode was tried. Even then, with a single transistor, RC coupled for wide band unselective coverage, the gain was disappointingly low. Finally, a two transistor cascode amplifier gave the desired sensitivity.

THE FINAL CIRCUIT

The complete circuit of the finalised microbug locator is given in Fig. 1.

The left-hand half of this diagram consists of the cascode amplifier TR1, TR2, the detector D1, and the coupling stage TR3.

A modulated r.f. signal is picked up and fed to the base of TR1, which operates as a common emitter amplifier, and is partially compensated by selective feedback resulting from C4 and R4, to offset fall of gain with increasing frequency. The collector of TR1 is directly coupled to the emitter of its companion transistor TR2. With base grounded to a.c. by capacitor C3, TR2 functions in the common base mode, with a good gain-frequency characteristic needing no compensation. It will be noticed that C3 is taken to the negative rail, the virtual earth of the *npn* pair. This arrangement gave the best results at critically high frequencies. R1, R2, R3 provide joint base biasing for both of the cascode stage transistors.

The combination R5, C5, D1, supplies a demodulated signal to the base of TR3 via C6, and the audio output is taken from R8. TR3 thus acts as an emitter follower.

A word or two about the types of transistors for the cascode stage. The BFY19 has been selected for TR1 because it has a cut-off frequency of 300Mc/s. In the common base mode, a BFY18 which has an f_T of 200Mc/s is quite acceptable for TR2. These particular transistors will give optimum performance. If, however, alternatives have to be used, those mentioned in the components list will be suitable—but with a slight limitation to the extreme high frequency response.

Almost any small transistor amplifier, whether transformer type, transformerless output, or complementary output, could be coupled to the emitter follower stage to supply the necessary drive for the locator loudspeaker.

The a.f. drive amplifier shown in the right-hand half of Fig. 1 is of a type that is fairly common and may, indeed, be bought complete as a commercial module, constructed from a kit, or it can even be sliced from the circuit panel of a defunct transistor radio!

To increase audio sensitivity in noisy surroundings, provision is made for low impedance headphone operation by means of jack socket JK1 mounted in the handle of the instrument.

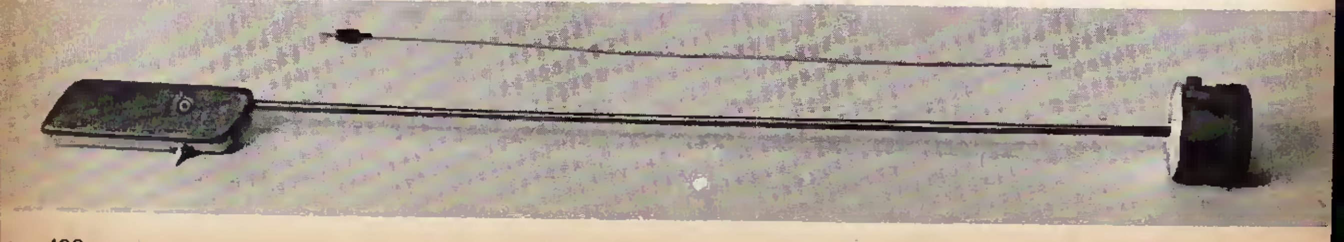
MECHANICAL DESIGN

Microbugs may be hidden in inaccessible places, behind high pelmet boards, inside ventilator gratings, behind or under furniture, to instance just a few hideouts. To reach high places, or under obstacles, the locator was constructed as a hand-held boom, with amplifiers, aerial, and loudspeaker at the business end, and battery, switch, and headphone socket in the wooden handle.

Another reason for this particular layout was that the wiring inside the boom tube would act as a counterpoise for the short whip aerial. To minimise strain on the wrist, weight must be kept low since considerable leverage results from a boom nearly a yard in length. To this end a lightweight, glued rather than screwed, compact method of construction was chosen.

General layout details of the microbug locator are given in Fig. 2. Individual construction may differ slightly from the prototype, dictated by the sort of components available. It so happened that the writer's 2in loudspeaker fitted neatly inside the lid of a Kodak *Microdol-X* developer tin. Other tins of approximately the same dimensions should not be difficult to find.

Perhaps it should be stressed that both tin and tube were selected, not for screening purposes, but rather for mechanical rigidity, and it is possible that a much lighter form of construction would result from the use of alloy tubing for the boom, and a slim loudspeaker of the kind favoured by makers of miniature radios.



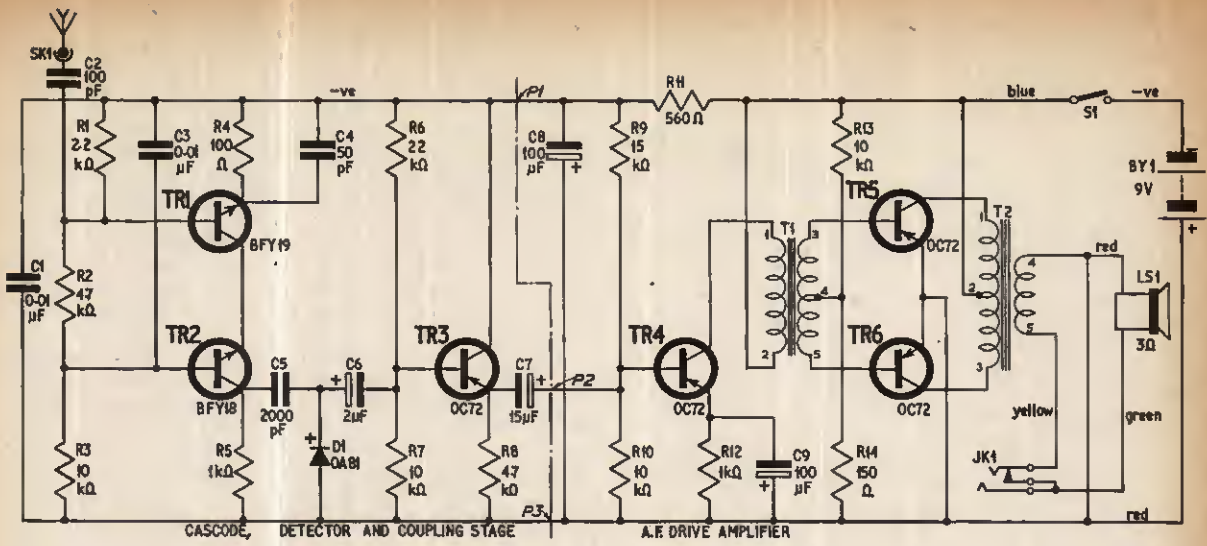


Fig. 1. Circuit diagram of the microbug locator

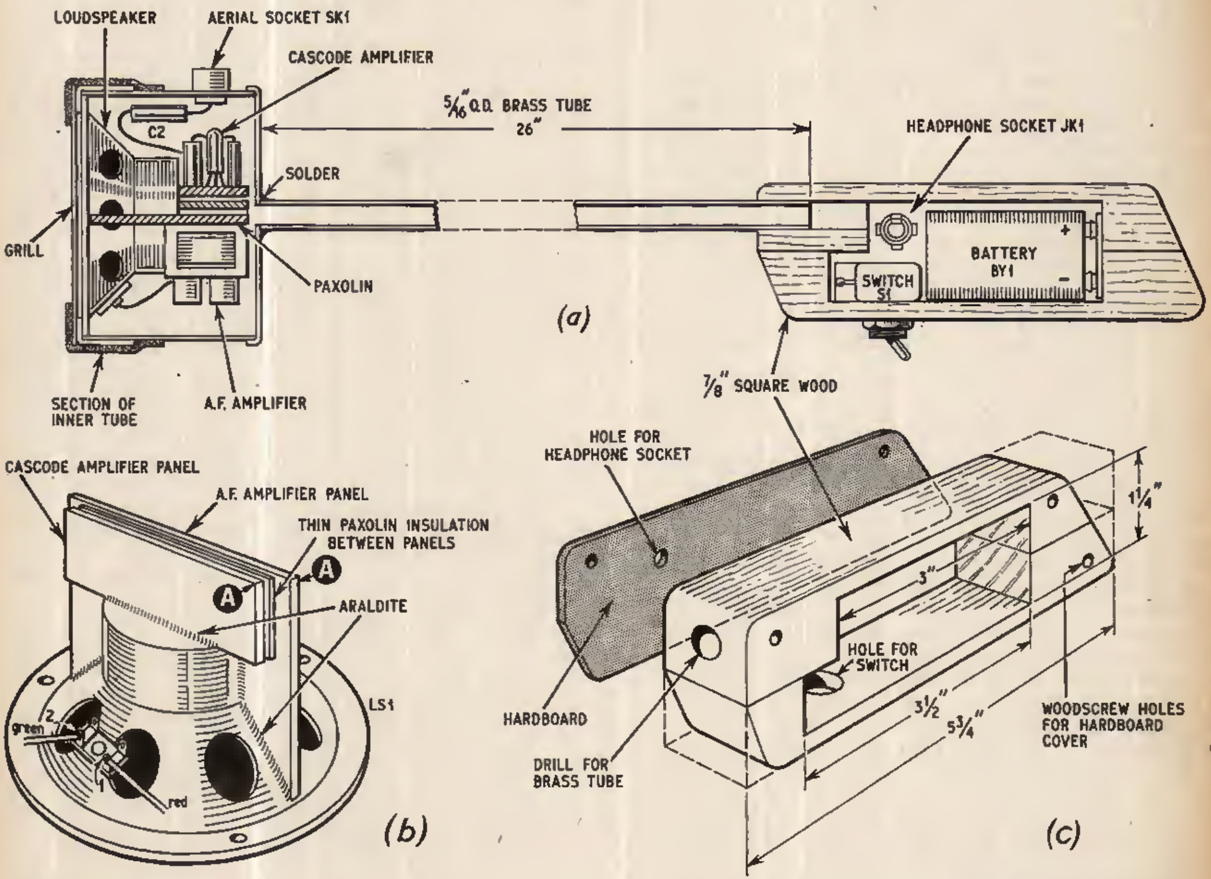


Fig. 2. General constructional details of the microbug locator.
(a) General assembly of the complete instrument
(b) The loudspeaker unit, showing how the two electronic sub assembly panels are mounted
(c) Details of the wooden handle

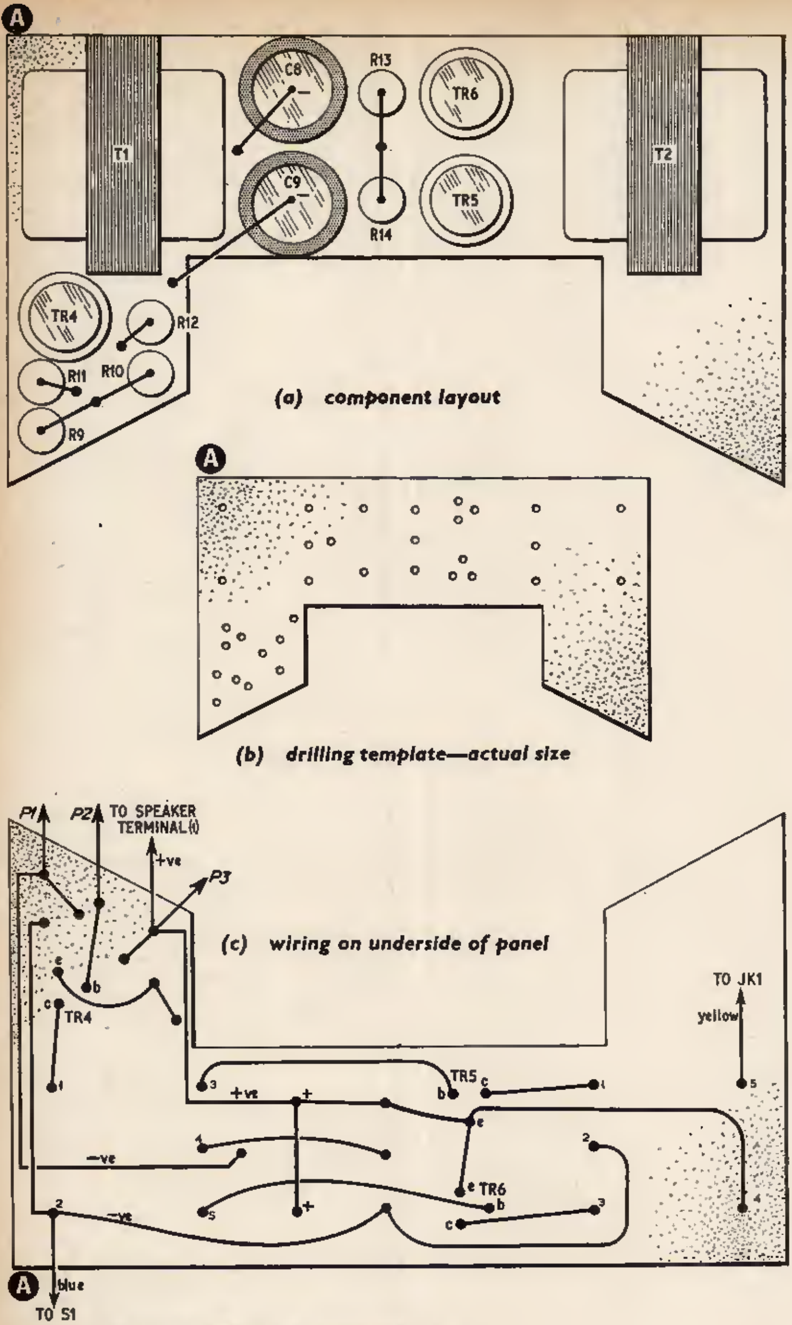


Fig. 3. The a.f. amplifier sub assembly

CIRCUIT ASSEMBLIES

Construction commences with the two sub-assemblies which carry the majority of the circuit components. These are shown *in situ* in Fig. 2a.

The a.f. drive amplifier is assembled on a piece of laminated plastics board, shaped to fit the loudspeaker magnet, shown in Fig. 3. The drawing given in Fig. 3b is full size and may be used as a drilling template. When all components have been mounted and the wiring on the reverse side of the panel completed, the unit should be tested. Short leads (about 2in long) should be soldered to points P1, P2 and P3 (see Fig. 3c). Note that this does not apply to the blue and yellow connections marked "to S1" and "to JK1", respectively. These leads are added at the final wiring-up stage.

After this the a.f. amplifier panel should be glued to the loudspeaker frame with Araldite and temporarily held secure with rubber bands. (To hasten setting of this epoxy glue, an assembly may be placed in a cool oven, at around 50 degrees C for a few hours.)

The cascode amplifier unit is built up on another, smaller, plastics board, details of which appear in Fig.4. Here again, a template is provided—see Fig. 4a. After testing this unit, the final assembly work can be tackled.

A considerable amount of care is required during this final assembly work. Place the cascode amplifier unit, wiring side uppermost, on the loudspeaker chassis so that ends "A" of both panels are facing the same direction. Solder the three flying leads to points P1, P2, and P3 on the cascode amplifier. Note that these leads must be of sufficient length to permit routing around the insulating panel which will be sandwiched between the two sub assemblies.

Place a piece of thin plastics board (approximately $2\frac{1}{4}$in × $\frac{11}{16}$in) against the underside of the a.f. amplifier panel, apply glue to the edge of the second sub assembly and fix this latter unit in position on the loudspeaker magnet. Secure the completed assembly with rubber bands until the glue has hardened.

For future repairs or component replacement the panels may be carefully prised away from the loudspeaker with a screwdriver, and afterwards re-glued.

HOUSING AND BOOM ASSEMBLY

The housing and boom assembly can now be dealt with.

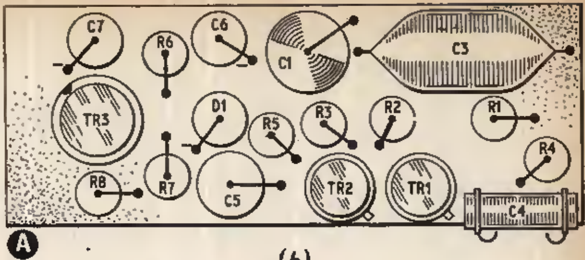
Cut a circular hole in the lid of the tin, leaving a narrow rim. Glue some plastic gauze to the outer surface of this rim. Fit the loudspeaker unit inside the lid. If the loudspeaker is a reasonably tight fit, a little glue will suffice to make this secure; otherwise it may be advisable to bolt the unit to the rim of the lid—this operation should, of course, be performed before the gauze is stuck in position.

Drill a hole in the side of the tin to suit the aerial socket SK1.

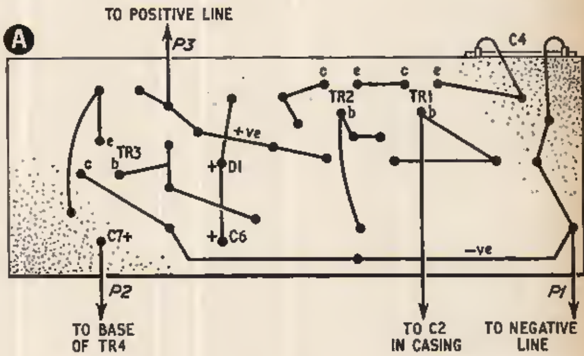
Next drill the base of the tin to suit the outside diameter of the brass tube and solder the tube to the tin. A large soldering iron is essential for this purpose.

Line the interior of the tin with cartridge paper or plastics material. Secure the aerial socket in position and solder one end of C2 to the socket.

(a)



(b)



(c)

Fig. 4. The cascode amplifier sub assembly
(a) drilling template—actual size
(b) component layout
(c) wiring on underside of panel

COMPONENTS . . .

Resistors

R1	2·2kΩ	R8	4·7kΩ
R2	4·7kΩ	R9	15kΩ
R3	10kΩ	R10	10kΩ
R4	100Ω	R11	560Ω
R5	1kΩ	R12	1kΩ
R6	22kΩ	R13	10kΩ
R7	10kΩ	R14	150Ω

All 10%, ¼ watt carbon

Capacitors
C1 0·01μF paper
C2 100pF ceramic tubular
C3 0·01μF paper
C4 50pF ceramic tubular
C5 2,000pF plastic-paper
C6 2μF elect. 9V
C7 15μF elect. 9V
C8 100μF elect. 12V
C9 100μF elect. 12V
All are miniature types

Transformers
T1 Push-pull driver. Rex LT44
T2 Output. 3Ω secondary. Rex LT700 (Henrys Radio Ltd.)

Transistors
TR1 BFY19 } Suitable alternatives:
TR2 BFY18 } BSY27, BSY29, 2N753, 2N744
TR3-6 OC72 (4 off)

Diode
D1 OA81

Loudspeaker
LS1 2 in dia., 3Ω

Battery
BY1 9V layer type. PP3 or equivalent

Switch
S1 Single pole toggle on/off

Sockets
SK1 Wander plug and socket (Radiospares)
JK1 Miniature jack socket, with shorting contact

Miscellaneous
Circular tin 2¾in dia. × 2in high (see text). Brass tube 5/16in outside dia., 26in long. Plastic speaker gauze. Laminated plastics board. Timber ⅞in. square. Hardboard. 14 s.w.g. tinned copper wire. Connecting wire. Araldite glue.

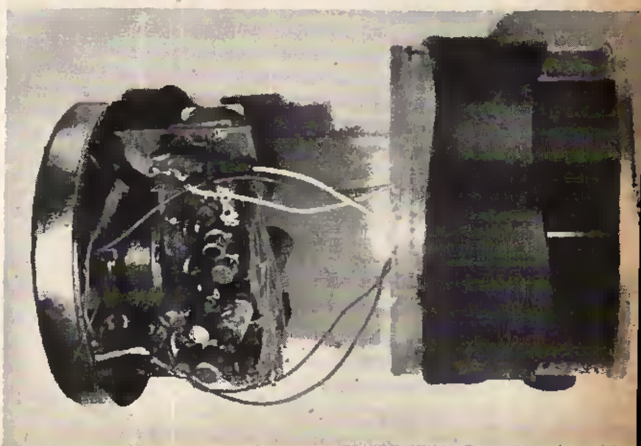
THE HANDLE

The handle is built up from two pieces of ⅞in planed timber and two pieces of hardboard.

The cut outs should be fashioned with a tenon saw and chisel and the various holes drilled as indicated in Fig. 2c. Two hardboard panels, of identical size and shape, should be prepared—an additional hole for the headphone socket is needed in one panel. Assemble and glue together the two timber pieces and the hardboard side with the additional hole.

Push the brass tube into the hole at one end of the handle. Fit the jack socket, switch and battery into the handle housing. Pass four differently coloured connecting wires down the boom tube and connect these to the components as shown in Fig. 5.

Secure the handle lid with three woodscrews.



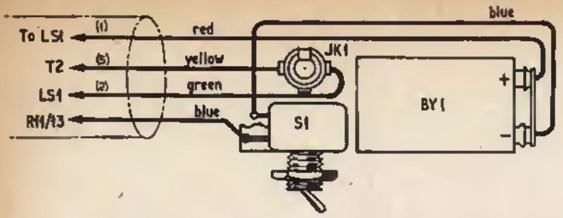


Fig. 5. Wiring diagram for the handle compartment. The four coloured leads pass through the boom tube and terminate at the points indicated on the loudspeaker assembly

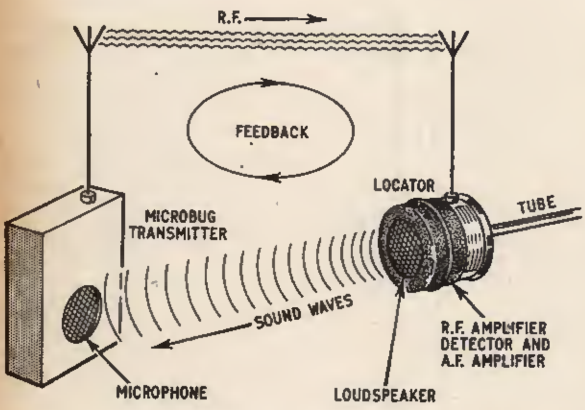
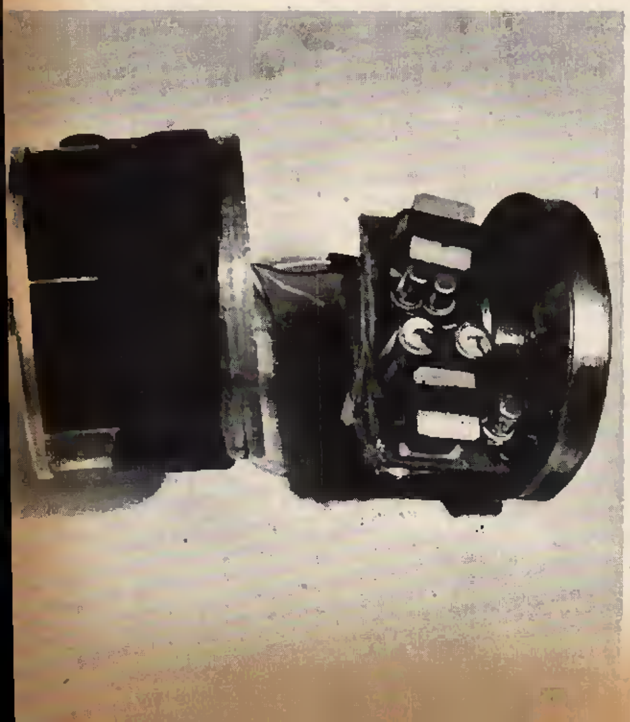


Fig. 6. This illustrates the technique used in detecting hidden radio microbugs. The hidden snooping device is activated by the operator whistling in a "suspect" area. This sound is transmitted by the bug, and received by the locator, the audio output of which is picked up by the bug, and so a self-sustaining feedback loop is created around the two devices. The intensity of the loudspeaker output will increase as the locator is brought closer to the concealed bug, whose hiding place is thus soon discovered



FINAL WIRING-UP

Returning now to the "business end", connect the four wires to the appropriate points on the loudspeaker/electronic assembly as indicated in Fig. 5. Connect the free end of C2 to the base of TR1 (see Fig. 4c). Carefully instal this assembly inside the tin, checking that the various wires are not strained or fouled in any way.

To hold the lid in place, and to protect against knocks and abrasions, a slice of bicycle inner tube can be stretched over and around the lid and tin, as shown in the illustrations.

The aerial consists of a 21in length of 14 s.w.g. tinned copper wire with a wander plug soldered to one end.

FIELD TESTS

It might be useful to mention some field tests carried out with the prototype locator.

At first, the tin and tube were earthed to the battery positive but this was found to attenuate response above about 50Mc/s, probably because of the additional capacitance thus introduced, so the connection was removed.

With a long outside aerial plugged in to the locator socket, just about every transmission within skip distance came in at fair volume, dominated by the local B.B.C. Home Service and Light Programme. Tests with a signal generator indicated that the limits of usable response were greater than 100kc/s to 180Mc/s. As for sensitivity, with headphones plugged in and a short whip aerial on the Locator, a 60mW radio control transmitter could be clearly detected at a distance of 25ft.

Another test was with a microphone and amplifier input to the modulation transformer of the signal generator. When the locator loudspeaker was brought close to the hook-up, acoustic feedback occurred—a distinctive warbling note. The onset of feedback could be initiated by a sharp whistle from the mouth or, better still, by using a toy whistle to jerk the system into oscillation.

"DEBUGGING" PROCEDURE

In use then, the mode of operation might be as follows. With headphones connected, the area to be "cleaned" is scanned while the operator emits a few strident whistles. If a bug is close at hand the operator will hear his whistles plus room echos reproduced in the headphones. Next, he will remove the headphones, unplug them from the locator and use the instrument like a feather duster, going round the room in a search for the source of the transmission he has picked up, while still whistling loudly. Sooner or later the warble note from the loudspeaker will give him a clue to the bug's exact whereabouts.

The microbug locator can, of course, be used for purposes other than that for which it was especially designed. It will effectively trace sources of electrical interference, check for mains borne r.f., serve as a zero beat detector where two close frequencies are to be compared, or it can be coupled to the i.f. output of a superhet receiver as a temporary detector and a.f. amplifier.

It only remains to wish would be Hemipterists, *happy Bug hunting!* ★

EXPERIMENTS in LOGIC DESIGN

2

by S. T. ANDREWS

THE system shown in Fig. 1.12 last month, although capable of adding binary digits in the form of voltage pulses, has one disadvantage. The input pulses have to be applied simultaneously, and must be of identical waveform and identical duration. It may well be that two numbers become available at different times, this is especially true if the numbers are applied by an operator punching them on a keyboard, one after the other. Obviously some form of storage system is required, capable of holding the numbers to be added, and preferably capable of holding the result as well.

A store which is intended to hold one complete binary number is known as a *register*, and the number is held as a series of on/off signals, each representing one binary digit. The term *binary digit* is usually contracted to *bit* and this term will be used from now on.

STORING BINARY NUMBERS

Of the various ways of storing binary numbers, the most convenient method in small-scale equipment is to use rows of bistables, each storing one "bit" of the number. In the three-input adder five bistables are needed, three to hold the input digits and two to store the output; one of these can be dispensed with later.

Using bistables to hold the numbers solves the immediate problem of storage, but raises another problem in its place. It is now necessary to provide some form of gating circuit between the input store and the adder itself to prevent the digits from entering the adder until required to do so. Each of the three input bistables must have its own gate, but since all three gates will operate simultaneously it is legitimate to consider them as a single unit and draw the block diagram of the adder as in Fig. 2.1a.

A set-up of this sort is of far greater use than the three-input adder by itself. The binary digits can be written into the bistables at any time and added at leisure by applying a suitable gating pulse to the gate.

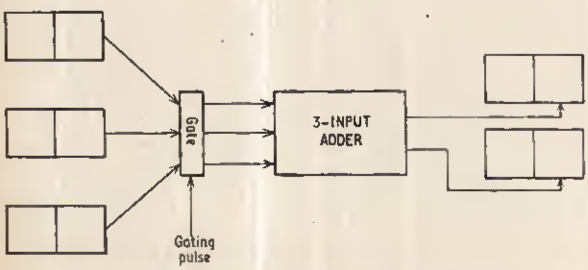


Fig. 2.1a. Block diagram of the adder with storage bistables and gating circuits now included

The circuit of a suitable gate can take several forms. Essentially the requirement is for a form of AND gate with the gating pulse and the output from the bistable as inputs, as in Fig. 2.1b. The action of this is obvious and it would be quite possible to use an AND gate of the type shown in Fig. 1.5 followed by a suitable amplifier.

Another version is shown in Fig. 2.2 and this runs the gating amplifiers off the +9 volt line. In this circuit the bias developed across R_X is sufficient to maintain TR4 cut off whatever the state of the bistable, as long as TR3 is conducting. The gating pulse is arranged so that it causes TR3 to cut off for a short time. When this happens the state of the amplifier depends on how the bistable is set: if TR2 is conducting then its collector will be nearly at zero potential and TR4 will remain cut off; if TR2 is cut off then its collector will be at about the potential of the −9 volt line and TR4 will conduct.

TR4 and TR5 form a voltage amplifier which drives an emitter follower output, TR6. In effect this circuit is an AND gate in which only one input is applied in the conventional way and the other is used to remove the bias which makes the gate into an AND.

Three bistables, and three gated amplifiers, are required to drive one three-input adder. The gating transistor, TR3 is common to all three gates, the bottom ends of all three R_Y resistors (Fig. 2.2) being connected to the collector of TR3. The output from the adder can be coupled directly to the output bistables, no gating circuits are needed at this point.

SET AND UNSET CONDITIONS

Having devised the circuit of the input gate we have effectively set the convention for the bistable switch. We have already explained how a bistable can hold a 0 or a 1 depending on whether it is SET or UNSET. In the circuit of Fig. 2.2 the convention for use with the input registers is: the bistable is SET, and holds a 1, when the transistor on the output side (TR2) is not conducting; the bistable is UNSET, and holds a 0, when the output transistor is conducting. This convention is an inevitable result of the way in which the circuit is arranged.

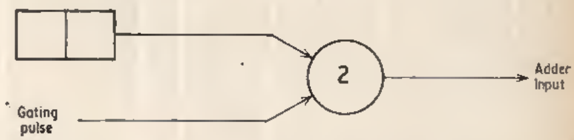


Fig. 2.1b. A gating circuit based on an AND gate

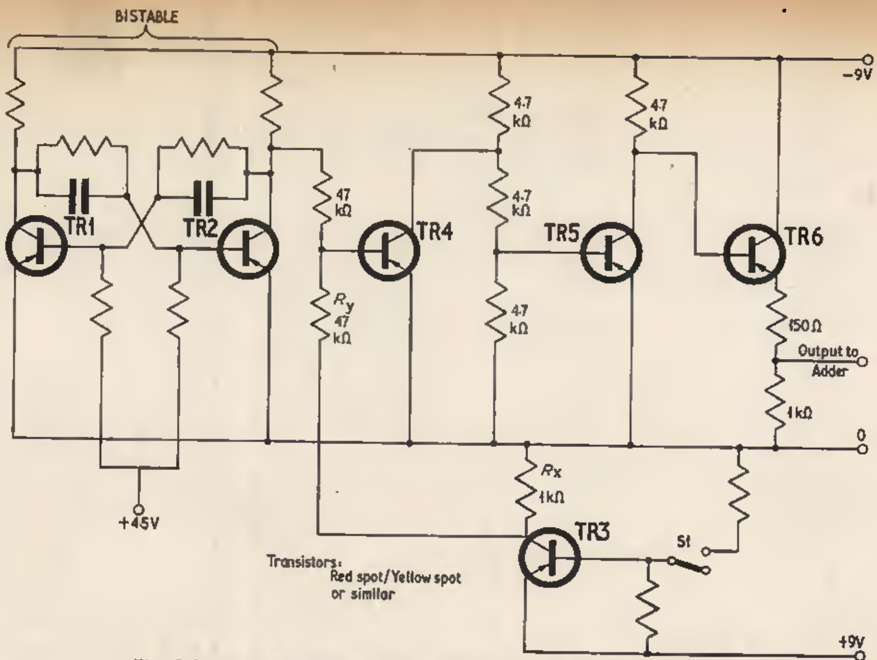


Fig. 2.2. The storage and gating circuits for the adder input

The sequence of events for adding three digits is now as follows: the digits are read into the input store of bistables in any order, and with any time delay between writing individual ones. A suitable pulse is then applied to TR3, causing it to stop conducting, and allowing the contents of the three bistables to pass through the gates, enter the adder and be added. The resulting pulse outputs from the adder set the output bistables where appropriate. After the gating pulse ends all three inputs fall back to zero as TR3 starts to conduct again and the output can be read off from the output bistables; the input bistables can all be reset to zero if required.

So far, then, we have produced a three-input binary adder capable of storing the numbers to be added, adding them when a suitable pulse is applied, and storing the result of the calculation. We can use a set-up of this kind to build up a complete adding unit which can be made quite automatic, but before going on to do so a little theory of addition might be useful.

THEORY OF ADDITION

When adding two numbers, not only in binary but in any numerical system, there is a certain pattern to be followed. Assuming that the numbers are written down one above the other, then the process of addition will be: (1) Add the extreme right-hand pair of digits, writing the result underneath and, if necessary, writing a 1 in the CARRY column of the next stage to the left. (2) Add the digits in this next column, including the CARRY if appropriate, and again write the result underneath and, if necessary, a 1 in the CARRY column of the next stage on the left. (3) Add this column in the same way . . . etc., etc.

The process is summarised in Fig. 2.3. This may seem very elementary but it is important to realise what happens when an addition is done on paper, so that an electrical analogy can be produced.

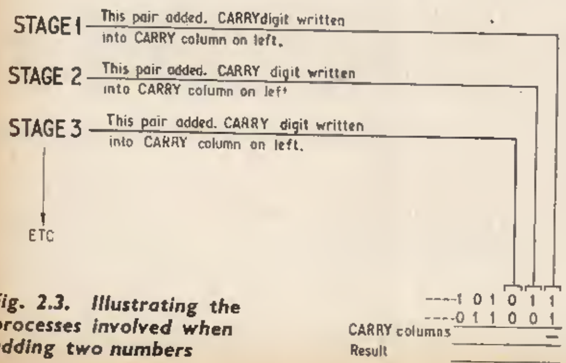


Fig. 2.3. Illustrating the processes involved when adding two numbers

THE COMPLETE ADDER

The three-input adder so far discussed can store three binary digits and add them when required to do so. This is what is needed in each of the vertical columns in Fig. 2.3 and in order to add multi-digit numbers one three-input adder is required for each vertical column of addition. The numbers to be added are held in storage units consisting of rows of bistables and it is these which are used as the input to the adders. There are two rows, each of which is one register, and the block diagram of a complete adder is shown in Fig. 2.4. Several points arise from this.

The two input registers are on the left and are made up of some of the bistables that feed the three-input adders. The CARRY output of each adder, except the last, is used to set the remaining bistable of the subsequent adder, thus the CARRY signals are passed from one stage to the next. The CARRY output of the final stage forms the left-hand digit of the final answer. The extreme right-hand adder (the bottom one in Fig. 2.4) will not have a CARRY signal input since there is no stage on its right, consequently a simpler two-input adder will do in this position.

An adder such as this can be extended almost indefinitely by including more three-input adders, the "repeating unit" is also shown in Fig. 2.4. Each additional unit will double the size of number which the adder can handle.

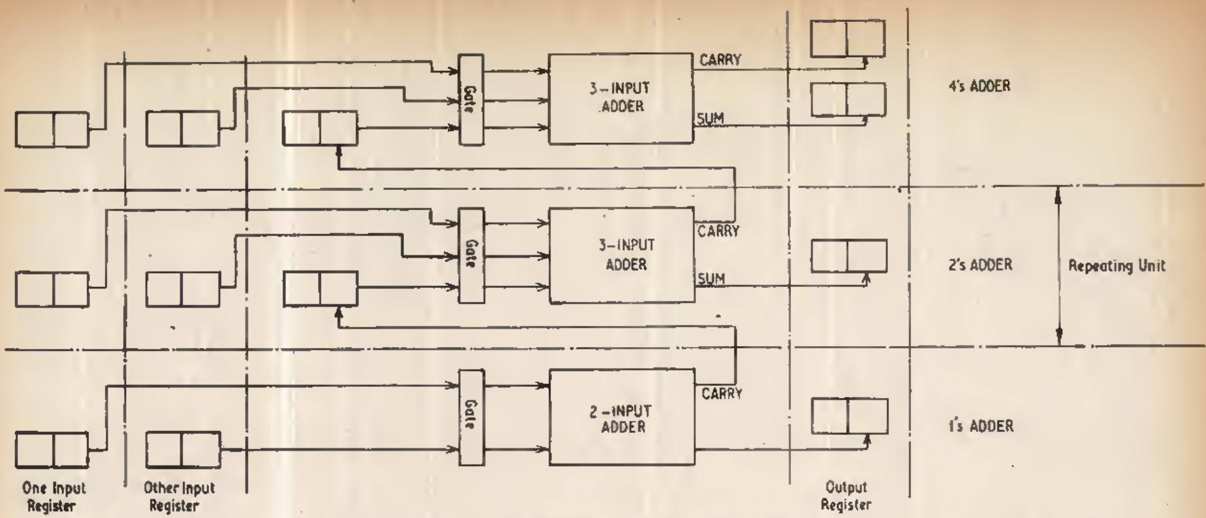


Fig. 2.4. Logical diagram of complete adder

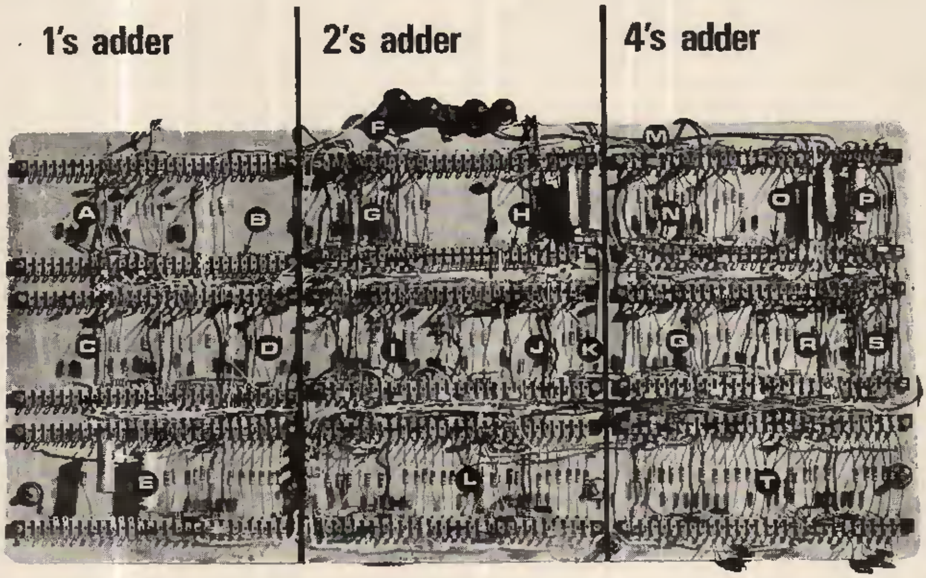
TIMING CIRCUITS

Each individual adder in Fig. 2.4 has its own gate which, when triggered, will allow digits from the appropriate parts of each register to enter the adder. In the arrangement of Fig. 2.4 these gates must be opened in sequence, first the two-input adder, then the three-input one above it, then the three-input one above that, and so on, right up the adder. The larger the registers, the longer a complete addition will take, and the result appears gradually in the output register as the addition proceeds.

CLOCK PULSES

In order to make all this happen some form of timing chain is required, which must be able to trigger the gates one after another, in the correct sequence. There is no real harm in a gate opening twice, but it is best if each one opens only once, at its correct place.

One method of obtaining the desired result is to generate a constant stream of pulses all the time and use these to generate all the other special waveforms needed. Such pulses are called *clock pulses* and are generated in an oscillator which runs all the time the



Terminals at top are digit outputs to indicator unit. Clock-pulse generator and STARTADD generator are not on this board

A Two input bistables
B Gating transistor
C Two input gates
D Sum output bistable
E 2-input adder
F Three input bistables
G 1's adder carry
H Gating transistor
I Three input gates
J Carry *OR*
K Sum output bistable
L 3-input adder
M Three input bistables
N 2's adder carry
O Gating transistor
P Carry output bistable
Q Three input gates
R Carry *OR*
S Sum output bistable
T 3-input adder

Photograph of the adder built by the author. This is depicted in block diagram form in Fig. 2.4

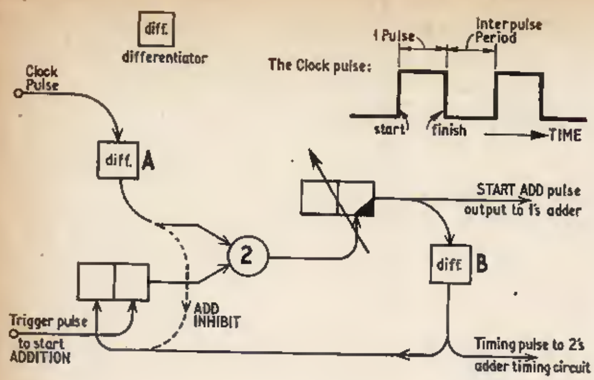


Fig. 2.5. Logical diagram of STARTADD pulse generator and waveform of the clock pulse

adder is switched on. (There is one new circuit element to be mentioned here, the differentiator. For the purpose of this article a differentiator can be considered as a black box which gives out a short voltage pulse whenever the input voltage changes suddenly. Using the clock pulse as input the output will be a succession of alternately positive and negative-going pulses, each of which is of very short duration compared to the input clock pulses.)

In order to start the addition, once the numbers have been written into the input registers, the first available clock pulse is made to open the 1's adder gate. This requires a circuit which, when triggered, will give a single output pulse coincident with one of the clock pulses, this being done irrespective of the phase of the clock pulse at the instant the initiating pulse is applied. In this type of circuit it is sometimes useful to give names to particular pulse sequences, thus the constant stream of square pulses which ultimately controls the whole circuit is known as the clock pulse. The pulse produced by the trigger which opens the 1's adder gate and initiates the adding process can be called the STARTADD pulse. The logical diagram of a suitable STARTADD pulse generator is given in Fig. 2.5; this also shows the details of the clock pulse itself.

STARTADD PULSE GENERATOR

The differentiator (A) produces a constant stream of negative-going pulses, each of which is co-incident with the start of a clock pulse. These are AND-gated with the output from a bistable which is set by the trigger pulse used to begin the addition. In the resting state the output from (A) is the only signal applied to the AND and so there is no output from it. When a trigger pulse is applied to the network the bistable changes over and a signal appears at the second input of the AND. As soon as the next pulse from the differentiator arrives it passes through the AND and triggers the flip-flop into its quasi-stable state. The time-constant in this flip-flop is set so that the circuit flops back again after the duration of exactly one clock pulse, so since differentiated signals occur only at the beginning of a clock pulse this circuit ensures that the STARTADD pulse, taken from the flip-flop, occurs exactly co-incidentally with a clock pulse.

The output from the flip-flop can be used to drive TR3 in Fig. 2.2 directly, the base of TR3 being connected to the transistor in the flip-flop which is normally cut off. It is better, though, to have a buffer transistor between the two sections of the circuit.

The output from the flip-flop also passes through a differentiator (B) and is used to unset the bistable. Successive pulses from (A) do not then cause further operation of the circuit which is thus seen to be self-resetting.

Fig. 2.5 contains one version of the STARTADD generator, but this can be modified. The flip-flop could be replaced by a second bistable which is supplied with a constant supply of unset pulses, each at the *end* of a clock pulse. This would require a third differentiator. Alternatively the one bistable of Fig. 2.5 could be replaced by a flip-flop set to spend exactly one clock pulse duration in the quasi-stable state, but although this method dispenses with one of the differentiators it is not recommended. The output from (A) can be applied to the bistable as shown in the dotted line in Fig. 2.5. This would be done by an (electronic) switch and would serve to inhibit the STARTADD generator, and could be used as an additional safety check to prevent addition from occurring while checking the contents of the registers.

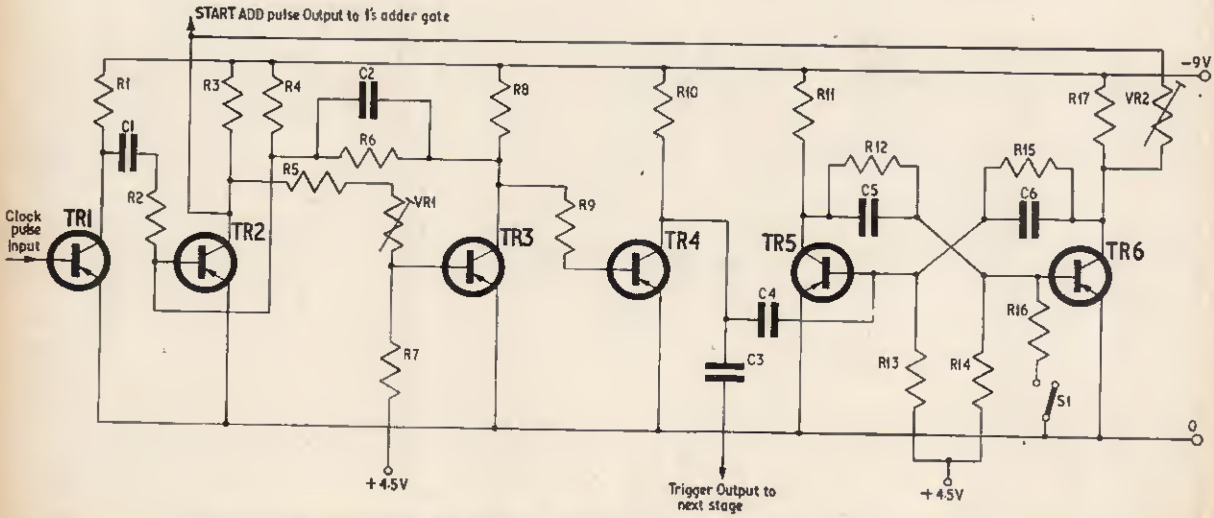


Fig. 2.6. Circuit of a STARTADD generator based on the logical diagram of Fig. 2.5

A DETAILED CIRCUIT

A special version of the STARTADD generator is given in Fig. 2.6 and although it follows the logical diagram of Fig. 2.5 there are some unusual points to be mentioned. TR1 is the buffer amplifier for the clock pulse and it feeds a form of differentiator, C1 and R2. From this a stream of trigger pulses pass to the base of TR2 which, together with TR3, makes up the flip-flop. TR5 and TR6 form a bistable which, in the resting state is set so that TR6 is conducting and TR5 is cut off. The collector of TR6 is connected to the collector of TR2 through VR2 and this holds TR2 collector at a low potential making it impossible for it to cease conducting despite the pulses being applied to its base.

The instruction to begin adding closes S1 and causes the bistable to change over, the collector of TR6 rising nearly to the potential of the −9 volt line. The inhibiting bias on TR2 collector disappears and the next trigger pulse from TR1 sets the flip-flop into its quasi-stable state. The resulting pulse from it, the STARTADD pulse proper, leaves on the 1's adder output wire to open the adder gate. At the end of the quasi-stable period (which in this case is one clock pulse) the flip-flop reverts to its normal state, TR4 and C4 provide a pulse which resets the bistable, and a pulse to start the next stage of the addition leaves via C3.

TIMING UNIT

Each stage needs a single pulse to open the appropriate adder input gate, and it is quite easy to make one stage trigger the next. The output from C3 in Fig. 2.6 is used to set a flip-flop whose time in the quasi-stable state is about half of one clock pulse. When this returns to its stable state it sets a bistable which can only be unset by a pulse at the end of a clock pulse. The output from the bistable is AND-gated with the main clock pulse to give the pulse needed to open the 2's adder gate. The logical diagram for this is given in Fig. 2.7.

The sequence of operations is: a constant stream of unset pulses is applied to the bistable, one at the end of each clock pulse, but these have no effect since it is unset anyway. The gating pulse from C3 in the 1's adder occurs at the end of a clock pulse and this triggers the flip-flop. Sometime about the middle of the inter-pulse period (see Fig. 2.5) this flops back again and in doing so sets the bistable, during the next clock pulse, then, the AND has two inputs, the permanent one from the clock pulse line, which is normally ineffective, and now the second one from the bistable. This next clock pulse then passes through the AND and opens the 2's adder gate. When it finishes the bistable is unset by the pulse from the differentiator, the adder gate closes, and the second differentiator provides a pulse which triggers the 4's adder timing unit. This, of course, is identical with the 2's adder circuit, and will be opened by the next clock pulse.

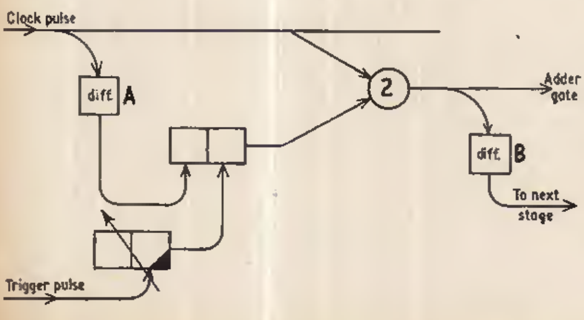


Fig. 2.7. The timing unit for each stage of addition

As we have seen, there is no limit to the number of digits which the whole adder can add, the "repeating unit" of Fig. 2.4 being repeated as many times as desired. Fig. 2.7 is the repeating unit of the timing chain, and again there is no reasonable limit to the number which can be used, each will operate once, then reset itself and trigger the next stage. One "timer repeating unit", as in Fig. 2.7 must accompany each "adder repeating unit" of Fig. 2.4. In the final stage of the addition, corresponding to the extreme left-hand digit of the answer, the output from the timing stage could be used to initiate a process to print out the result of the addition and/or unset the bistables in the input registers.

We now have a complete adding unit which can be made to handle numbers of any size, the numbers being stored before addition, and the result being stored afterwards. The actual addition is started by applying a single trigger pulse after which the process is automatic. By itself this adder is not much more than a toy since in general it cannot do anything which cannot be done equally well by a human operator. However it can be extended to include other mathematical functions and these will be considered shortly, but first a few practical considerations will be mentioned.

PRACTICAL CONSIDERATIONS

There is no special way of constructing the adder and standard circuit techniques can be used. The writer constructed a small version across a number of tagstrips which were fixed to a large aluminium panel. This gave, effectively, a two-dimensional layout in which each component and circuit element was easily accessible, but the overall result was rather large. This unit is shown in the accompanying photograph.

Alternatively, tagboards could be used, bolted in parallel rows, and this would yield a more compact design but one in which many of the components would be inaccessible. The mechanical layout is not too important and, like the finer points of the circuitry, will probably be varied by individual constructors.

The clock pulse generator is most easily a multivibrator, since this will provide a good square wave with little variation in frequency. The pulse frequency is largely a matter of choice, it can be extremely low, 1c/s for example, so that the circuit action can be followed on a voltmeter, or several kc/s—though slight modifications to the circuit would then be necessary. There is no point in trying to make an adder with a very high clock pulse rate since the long time needed for information to get into, and out of, the adder would make this quite pointless.

INPUT AND OUTPUT DEVICES

So far no mention has been made of how to get information into or out of the adder. The more sophisticated electronic calculators have several methods of exchanging information with their human operators; these include punched paper tape with 5, 7 or 8 tracks, punched cards, and various forms of electric typewriter. Mere cost makes all these arrangements impossible for the amateur constructor, and a good deal of ingenuity is required when constructing input/output devices.

About the best that can be done is the modification of an ordinary typewriter by the addition of switches to the numbered keys (to get information in) and, possibly, electromagnets attached to the same keys (to get the results out). This must be regarded as something of an ideal and in most cases a simpler arrangement will have to be used, for example, a row of small lamps as the display unit.

We are not concerned in this series with the mechanics of input/output devices as these will probably be different in the case of each constructor. However, a few notes will now be given dealing with the conversion from one numerical system to the other, i.e. binary to decimal and back again. This requires some form of converter which can unfortunately get somewhat complex as large numbers are handled, but which can be kept reasonably simple with smaller numbers.

As an example, a simple decimal-to-binary converter is shown in Fig. 2.8. The number is applied by closing the appropriate decimal key which sends a pulse along whichever of the binary output wires is appropriate. The three binary output wires supply SET signals to the input registers. A two-way switch is also needed to connect the output from the converter to one or other of the input registers. It would be possible to arrange things so that pressing a + key made the switch change over so that the first number went into one register and the second automatically went into the other.

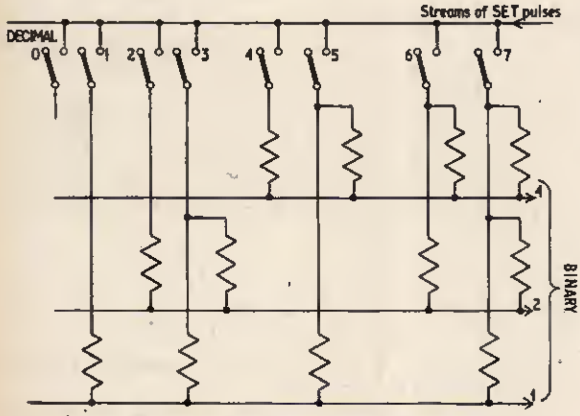


Fig. 2.8. A simple decimal-to-binary converter

Output converters are rather more complex: these take a binary input and produce a decimal output. One experimental type is given in Fig. 2.9 and the mode of action is thus: the striated wires carry the output signals from the adder and these pass through gates to a series of bistables which are arranged to act as gated amplifiers. The timing unit of the last section of the adding chain produces an output pulse which initiates printing by setting flip-flop (A). This opens the adder output gates and the appropriate bistables are set. As it flops back to its stable state it triggers bistable (B) via a differentiator, this bistable is AND-gated with the main clock pulse line, so clock pulses now enter the decoder proper through the AND and leave at one of the eight outputs. Which output this is depends on which bistables were set and this, of course, is a property of the adder output. The decimal output wires can be made to operate display lights or type out the number, as required.

EXTENSIONS TO THE ADDER

The adder so far described can add two numbers quite efficiently but is unable to do anything else as it stands. Extra circuitry, however, will increase the abilities of the adder and enable such mathematical operations as subtraction, multiplication and division to be performed, as well as certain logical functions, for example the "non-equivalence" operation.

The non-equivalence function is useful in recognising whether or not two numbers are the same, i.e. doing a direct comparison. The exact procedure might be: considering the numbers a digit at a time, write a 0 in the answer register when the pair of digits of the compared digits are the same, and write a 1 when they are not the same. An example of non-equivalencing is: perform the non-equivalence function between the numbers 1011001011 and 1101100010. (Numbers on which arithmetical operations are performed, for example the above two, are called *operands*)

$$\left.\begin{array}{l}1011001011\\1101100010\end{array}\right\}\longleftarrow\text{operands}$$

$$\overline{0110101001}\longleftarrow\text{result}$$

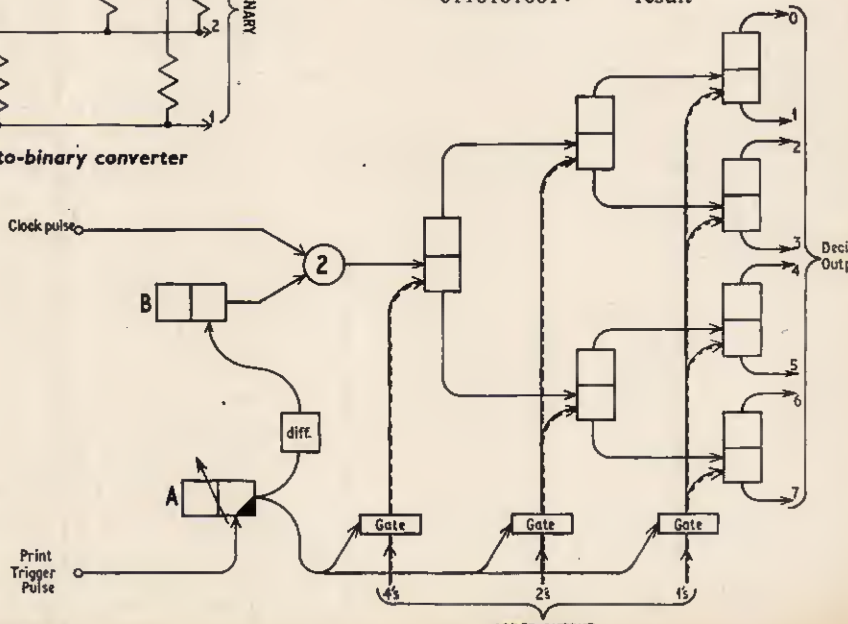


Fig. 2.9. A binary-to-decimal converter

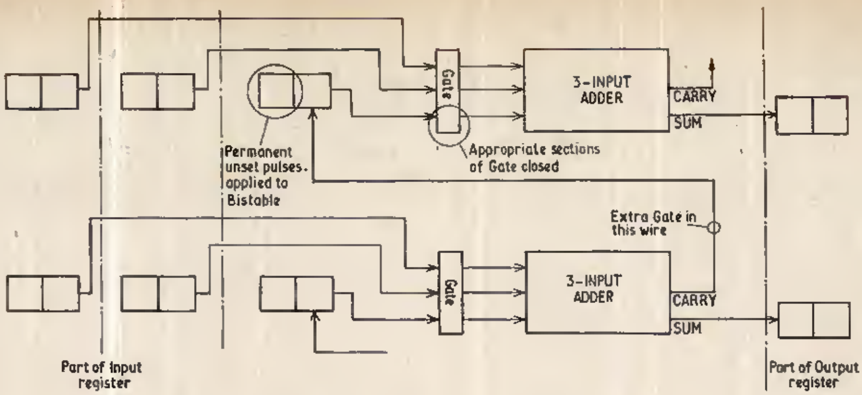


Fig. 2.10. Conversions for non-equivalence functions

In order to make the adder perform this function it is only necessary to inhibit the CARRY signals which pass from one stage to the next. Three possible ways of doing this are shown in Fig. 2.10. An extra gate, normally open but closed in the non-equivalence operation, can be placed in the CARRY output from each three-input adder; the input gate in each adder which passes the CARRY from the previous stage can be held permanently shut; a constant stream of UNSET pulses can be applied to the CARRY bistable at the input of each three-input adder. If the CARRY's are inhibited in one of these ways (or any other way) then the two operands are written into the input register in the usual way. A STARTADD pulse is applied and the timing chain operates in the usual way, the non-equivalence result then appears in the output register in the usual way.

Subtraction, multiplication and other operations can all be done on the adder by putting in extra circuits, as with the non-equivalencing. The additional logic is somewhat complex and so for the time being only an outline will be given of the requirements.

ADDER CONTROL UNIT

Since all the various functions use the adder to a greater or lesser extent, it can be regarded as the central piece of the calculating machine, and the various mathematical operations all use it in their own particular way. We thus require an additional unit which is told which function is required and brings the appropriate sections of the circuit into operation; this can be called the adder control unit. The whole logical set-up, containing the adder itself and the control unit, can be called the *arithmetical unit*.

Since there are several functions which can be called into action it is necessary to have some method of telling the adder control which function is needed in a particular case. This could be done with a set of switches which would be set by hand before each operation, but this would waste a lot of time. A better arrangement would be to allocate a code-name or code-number to each function and feed this into the machine with the numbers themselves. For example, 01 could be the code for addition, 02 for subtraction, 03 for multiplication, and so on.

A complete instruction to the machine would then have three parts, *A* the code-number, or function-number, which states which operation is required, and *B* and *C* the two numbers on which the operation is being performed, i.e. the operands. To add the two binary numbers 10110 and 01111 the input to the machine would be:

01 10110 01111

and to multiply them it would be:

03 10110 01111

The block diagram of the whole machine is now that given in Fig. 2.11.

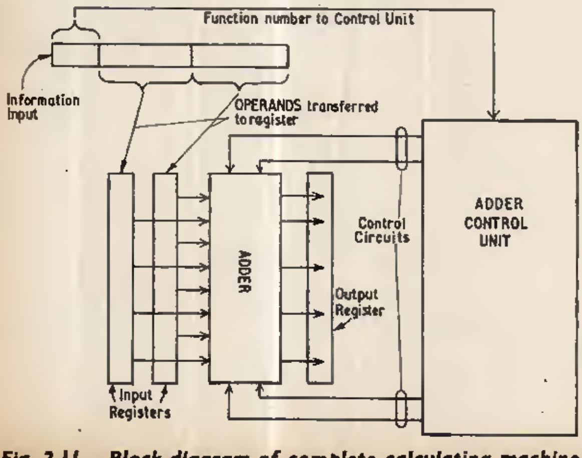


Fig. 2.11. Block diagram of complete calculating machine

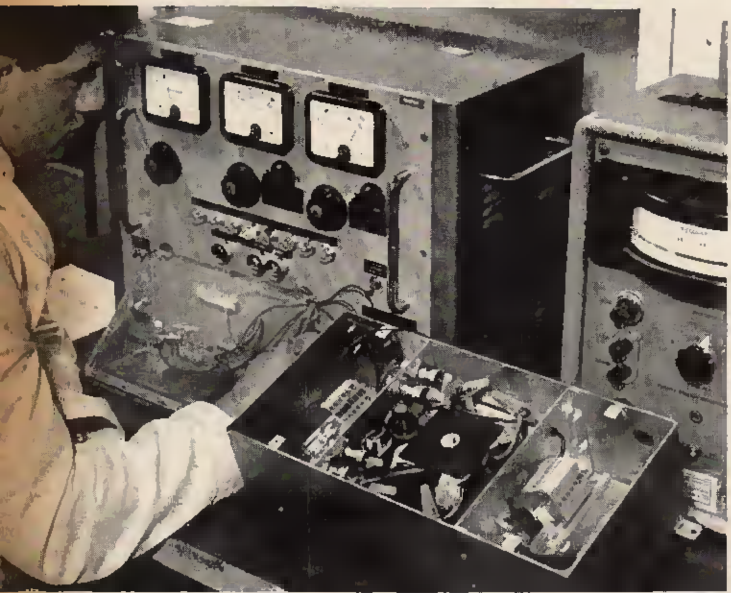
If some more extensive form of storage is available then large numbers of instructions and operands can be stored until required. Since the result of one operation can be one of the operands of another, quite complex mathematical calculations would become possible. The snag, of course, lies in the storage methods available, or rather the lack of them. Vast numbers of bistables are impractical due to the increasing possibility of failure and the large amount of space required; core and drum stores are also impractical due to the very high cost and complexity of the equipment required to run them. Magnetic tape, used perhaps on a modified commercial tape deck, is about the only practical method available to amateurs and even this is expensive and very complicated.

Despite this last discouraging note it is possible for a keen constructor (or better still a group of keen constructors) to build some form of calculating unit, provided that this is not made too complex. The problems involved in building arithmetical circuitry are great, but not too great to be solved, and attempting to solve them is a fascinating branch of experimental electronics.

To be continued.

ELECTRONORAMA

HIGHLIGHTS FROM THE CONTEMPORARY SCENE

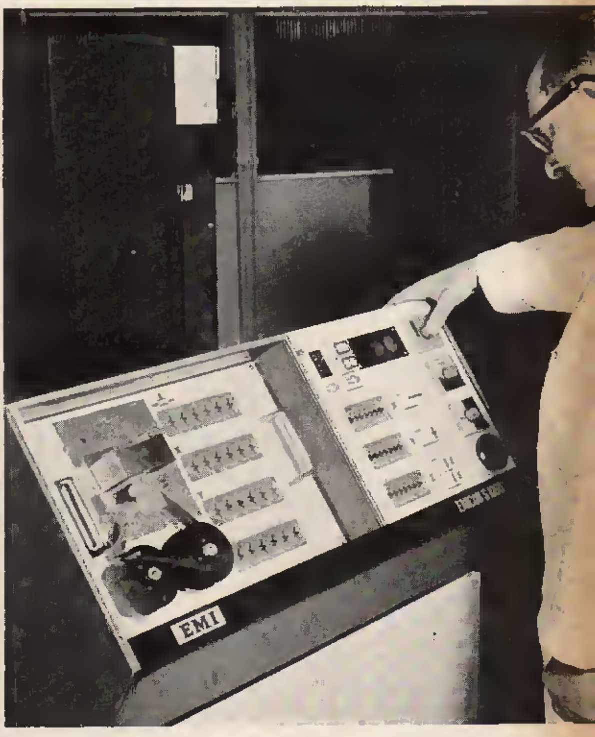


Suppressing Transients in Computers

A MEANS of reducing unwanted transient pulses in computer supply systems has been developed by engineers of the Plessey Components Group. These transients are causing increasing errors of calculation in modern computers of high operational speed and complexity.

Normal voltage or current pulses for operations are generated by stabilised circuits, but transients in the power supplies can upset the normal function of the pulse generators.

An experimental suppressor unit, currently in production for a leading computer manufacturer, is shown on the left undergoing final tests.



Combining Filter for U.H.F

ONE of the many items of equipment required for expanding the u.h.f. television services throughout the U.K. is the vision and sound radio frequency combining filter. This picture (left) shows the filter being assembled in the Cambridge factory of Pye TVT Limited. Later, it will be installed with other parts of the transmission system for broadcasting on the BBC2 network.

"Divcon" Character Display ▶

TELEVIEWERS on election night may know that a computer was used for predicting the final election result, but few probably realised that a new system was used by the BBC for displaying some of the constituency results on the screen. This system, although tried for the first time in this country, has had a successful run in Canada.

Known as the RCA "Divcon" (digital to video conversion) system, it accepts data from a variety of sources, stores the data and converts them into a signal suitable for display on television screens (right). Cameras are not necessary for this system since all information is supplied to the transmitter in pulse code form.

One interesting feature is that it is not necessary to "rewrite" a complete message in order to change one or more characters.

The system responds to all functions carried on an electric typewriter such as shift and back-space.

◀ Numerical Control

DEVELOPMENT work on the automatic control of machine tools has been in progress for some years, but the first exhibition specially devoted to numerical control took place at the beginning of May this year.

The picture on the left shows the Emicon S1000 Positioning Control system, which is basically an analogue computer with electro-mechanical links to the various machine function controls. The nucleus of the system is a pre-punched paper tape of either five or eight tracks, which is printed in code according to the required milling or boring operations. Complex shapes in two dimensions can be machined under the control of this equipment.

Tape Time Announcer ▶

AFTER the first speaking clock in Sudan, installed five years ago to provide a service in English and Arabic for the Khartoum area, A.E.I. Telecommunications Group are supplying five more machines to give a complete service throughout the Republic.

These machines use tape recorded announcements in up to four languages at 10, 15, or 20 second intervals on one inch wide tape. The timing is based on a crystal controlled chronometer, the timed announcements having an accuracy of plus or minus one second per month.

The tape used is a heavy duty instrumentation sandwich type 489 manufactured by the 3M Company. The oxide coating is completely covered with a thin smooth non-abrasive plastic material to prevent wear to the replay heads. Hence the heads are maintained slightly "out-of-contact" at a uniform distance.

BEGINNERS start here... 21

An Instructional Series for the Newcomer to Electronics

FOLLOWING on from the discussion on semiconductor diodes last month, we stated that a transistor can be considered as a pair of diodes connected back-to-back. Now we will investigate the operation of a transistor in some detail. It must be appreciated of course that what follows is of necessity an extremely simplified description — but will serve our immediate purpose which is to impart a basic understanding of this most important electronic component.

TRANSISTOR OPERATION

The action of transistors can be fairly readily visualised if the forward and reverse ideas in connection with semiconductor diodes are remembered.

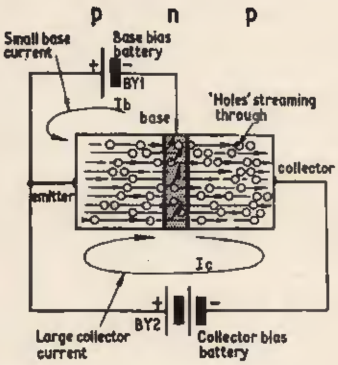
Fig. 21.1 depicts a transistor of the *pnp* type. The first "diode", formed by the electrodes known as the *emitter* and *base* in the transistor, is biased in the forward direction by a small battery BY1. The other "diode" junction, formed by the base and *collector* electrodes, is biased in the reverse direction by a larger battery BY2.

The interesting thing is that the current (heavy, because of the forward biasing) from emitter into the base, drifts right on through to the collector. Thus collector current flows in spite of the reverse bias on this second "diode". Only a fiftieth or so of this current flows into the base via the connecting lead.

If a small current signal is injected into the base-mitter circuit, the collector current varies in sympathy. Since the collector current is some fifty times greater than the input signal, amplification is achieved. The transistor thus acts as a current to current change converter.

It is of great interest to note the differences between valves and transistors. Valves are *voltage* operated at the grid, and convert grid voltage changes into current changes through the valve. Transistors are operated by *current* changes at the base electrode. Base current changes produce much greater current changes through the transistor collector-emitter circuit.

To sum up, the transistor can be looked on as two semiconductor diodes back-to-back, but the common region (the *base*) is so thin that current carriers crossing the forward biased emitter-base junction are nearly all swept straight across the reverse biased collector-base junction. The current actually allowed to reach the collector connection is controlled by the base current, not directly by the collector battery. (This is reminiscent of the action of the grid *voltage* in the triode valve.)



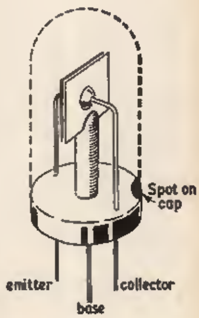


Fig. 21.1. A graphical illustration of transistor action. Holes in the p-n-p junction transistor move across the first junction, and about 98 per cent of them reach the second junction, and are swept off as collector current. The 2 per cent forms the base current. Any change in this base current gives a proportionate change in the current arriving at the collector, so a few microamps at the base might control many milliamps through the transistor (emitter to collector

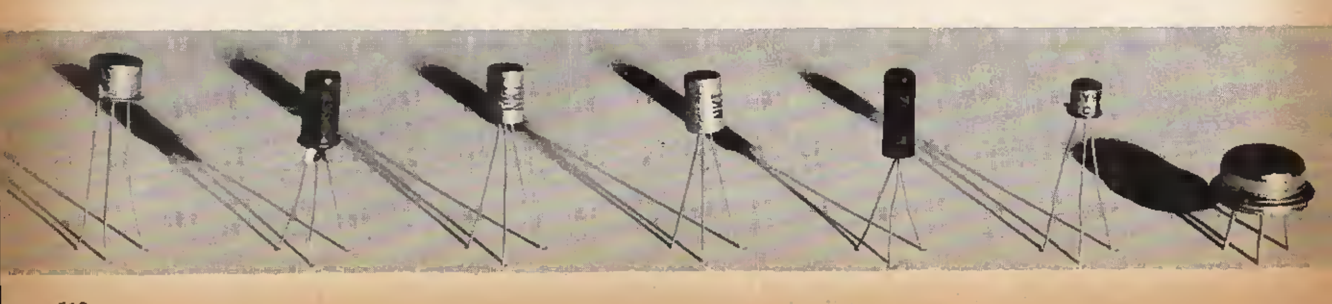
Fig. 21.2 (right). This is one form of transistor construction in common use

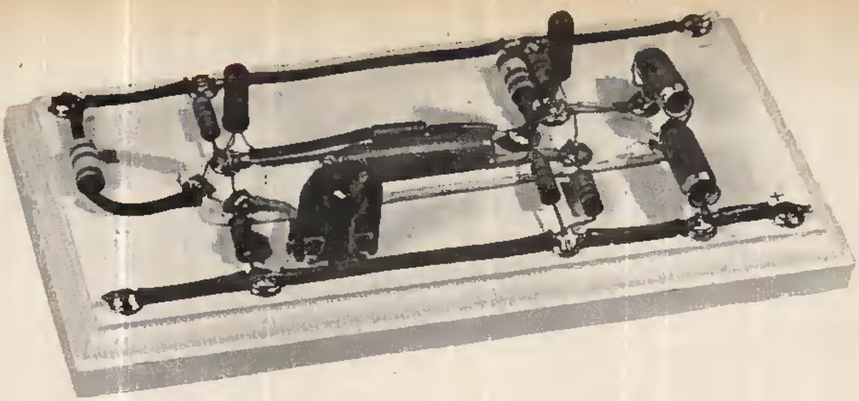
WATCH THE POLARITY

Most transistors at present in use are of the *pnp* type, but *npn* types are often found and are becoming increasingly common.

With *npn* types the battery connections (as indicated in the accompanying diagrams) must be reversed to give correct operation. Also, the arrow on the emitter symbol is reversed for *npn* types, as shown in (*e*) of Fig. 20.3 last month.

Fig. 21.2 gives an idea of the actual construction of a common type of junction transistor. The collector lead is usually spaced widely from the other two, and a spot of paint is placed on the cap beside this lead to assist the identification.





Now, to put theory into practice, here is a constructional project. It is an audio frequency oscillator employing two transistors and should be simple to build if the accompanying diagrams are carefully followed.

A TRANSISTOR OSCILLATOR

First it would be a good thing to remind ourselves of the two main requirements to be met in all electronic oscillators that produce a continuous signal. (In fact, all vibrators that go on and on, electronic or otherwise.) First we need a source of energy which can be used to operate devices with *gain*, or *amplification* properties and, secondly, an arrangement to feed back part of the amplified signal *in the correct phase* to boost the oscillating circuit.

In the first oscillator we built (Part 19), a valve was used as the gain producing device and the phase was carefully chosen, by selecting appropriate points in the circuit, so as to maintain the oscillations in the parallel tuned circuit.

As we have just seen, transistors also have gain or amplifying properties, and as a practical example of the use of these devices the present oscillator has been designed for you to build.

COMPONENTS . . .

Resistors

R1	39kΩ	R5	4·7kΩ
R2	4·7kΩ	R6	4·7kΩ
R3	1kΩ	R7	1kΩ
R4	39kΩ	R8	4·7kΩ

All 10%, ¼W carbon

Potentiometer

VR1 10kΩ linear skeleton potentiometer

Capacitors

C1	1μF elect. 6V	C3	0·01μF elect. 6V
C2	10μF elect. 6V	C4	0·01μF elect. 6V

Transistors

TR1 OC71
TR2 OC71

Miscellaneous

Wooden baseboard. Brass wood screws. Wire and sleeving.

ACTION OF THE CIRCUIT

This oscillator produces a sine wave signal within the audio frequency range, and does so by means of the following circuit action.

Referring to the circuit diagram Fig. 21.3, the base of the first transistor TR1 receives a small signal from point "A", the junction of the parallel C4 and R8

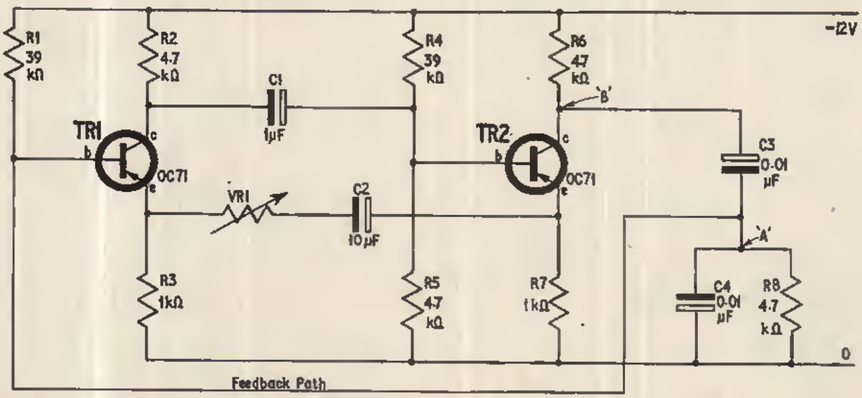
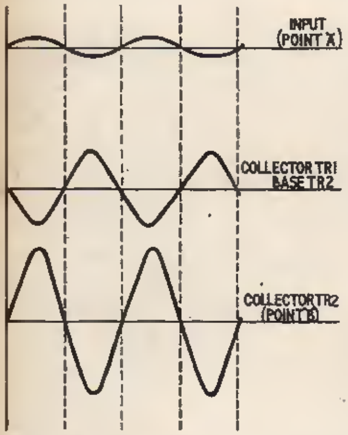


Fig. 21.3. The circuit diagram of the transistor oscillator. The output of the two stage amplifier (point "B") supplies its own input (point "A") via the "Wien Network" of C3, C4 and R6, R8

with the series C3 and R6. This signal appears amplified *and inverted in phase* at the collector of TR1. It is fed into the base of the second transistor TR2 via C1 where it is further amplified and appears as a large signal, again *inverted in phase*, at the collector of TR2. This signal is fed into the series/parallel CR network, and the whole action keeps on repeating—the circuit is oscillating.

Notice the important phase changes as well as amplification that occur. Using two stages means that the phase is inverted twice, which means in turn that the final phase is the same as the initial signal. Fig. 21.4 shows the signal relationships in a clear manner.

Which part of the circuit determines the frequency? It is not a coil and capacitor circuit as in the case of the valve oscillator. In this present oscillator we have used capacitors and resistors to set the frequency:



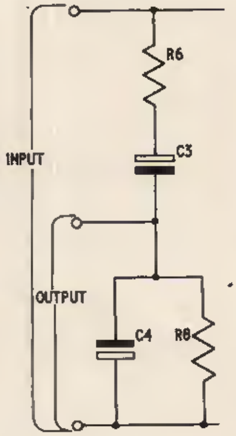


Fig. 21.4. The relationships of amplitude and phase at various points in the circuit

Fig. 21.5. The Wien network redrawn to show clearly the series and parallel branches

this is partly in order to show that there is more than one method available. We have mentioned the series/parallel CR network, and this is redrawn in Fig. 21.5 to increase the clarity of our argument. This is a well-known combination of components known as part of a Wien Bridge Network. The oscillator circuit is, in fact, a Wien Bridge Oscillator. The network has the property of supplying an output signal in phase with the input, *at one frequency only*. At all other frequencies, the C's and R's shift the phase relative to each other. Thus when the amplifying section is added, oscillations start to be produced, at this one particular frequency only.

We say that the Wien network is *frequency selective*. By changing the values of the capacitors, a different frequency is obtained, but it is usual to keep the values of both the capacitors equal. In most oscillators it is important that the amount of amplification should be just right—not too much, not too little. In this circuit the gain is adjustable by the potentiometer VR1 which can be set to give the purest note from the circuit.

We therefore see that all the requirements for an oscillator have been met, and this simple two transistor circuit will produce a sine wave signal over a range of frequencies according to the values of the controlling capacitors C3 and C4. You will probably think up some uses for the audio frequency signal which you now have available, and once again the unit is a useful signal generator for testing purposes.

POINTS ON CONSTRUCTION

We will conclude this part with a few ideas concerning the construction. First, remember that transistors are very sensitive to heat. Keep the transistor leads long. Complete the soldering operation as speedily as possible so that the component does not become unduly heated. By the way, never let the transistor envelope accidently touch the body of the soldering iron.

The baseboard used in this project is a white painted electrical fitting board—readily obtainable from multiple stores.

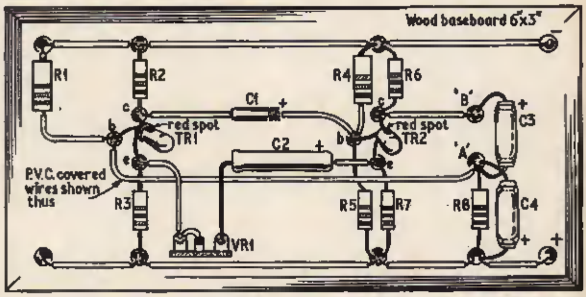


Fig. 21.6. The practical layout following the usual mode of construction on a wooden baseboard

It is a good idea to choose a colour code for the wiring of any electronic unit. This helps greatly in later servicing or circuit tracing. The obvious colours are red for the positive supply rail and black for the negative. Signal paths can be green. The main point is to choose a colour scheme, and use this consistently so that no confusion arises in the future.

OPERATION

Power for the oscillator can be obtained from a 9 volt dry battery such as type PP3 or equivalent; or alternatively the mains operated power unit and filter unit described in Parts 16 and 17 can be employed.

The output signal from the oscillator can be taken from the collector of either transistor, via a small capacitor of about 5,000pF. Actually, there is less effect on the frequency of oscillation if the collector of TR1 is used. The other output terminal can be either the positive or the negative supply line.

Radio enthusiasts can use this oscillator straightaway for morse practice, by employing headphones across the output, and putting a key in series with one of the supply leads.

Another use, which we will consider in a later article, is as the source of audio signals for a component measuring bridge. When we deal with simple test and measuring equipment, the oscillator will be mentioned again.

In creative tape recording a mixer unit has many uses. It enables multiple sound sources to be individually controlled as input levels so that a balanced output can be achieved. The monitoring of group instruments or voices from microphone inputs, by way of this unit, can provide flexible levels before amplification, also acoustic feedback is minimised in the greater separation of microphones and amplifier loudspeaker when using fixed microphone lead lengths. Any type of high impedance crystal or dynamic microphone may be used.

The simplest mixer that can be constructed consists of a purely passive network, as in Fig. 1. This suffers from the disadvantage that even on maximum output the input to a tape recorder or amplifier is less than a single input would be if it was connected directly. Although "virtual earth" mixers can be used to overcome this disadvantage, the easier solution is to add an amplifier after the passive network.

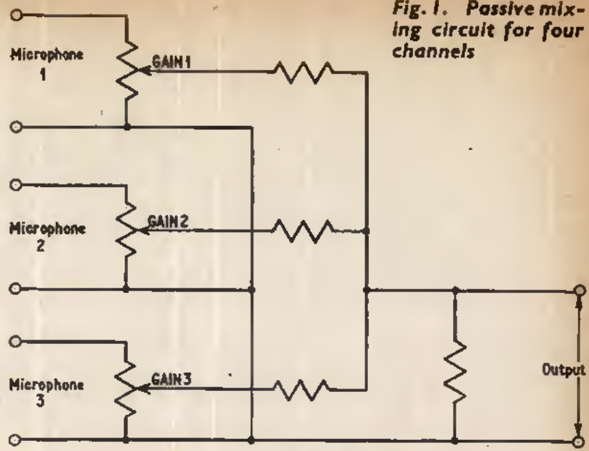


Fig. 1. Passive mixing circuit for four channels

Four Channel Microphone Mixer

by A. FOORD

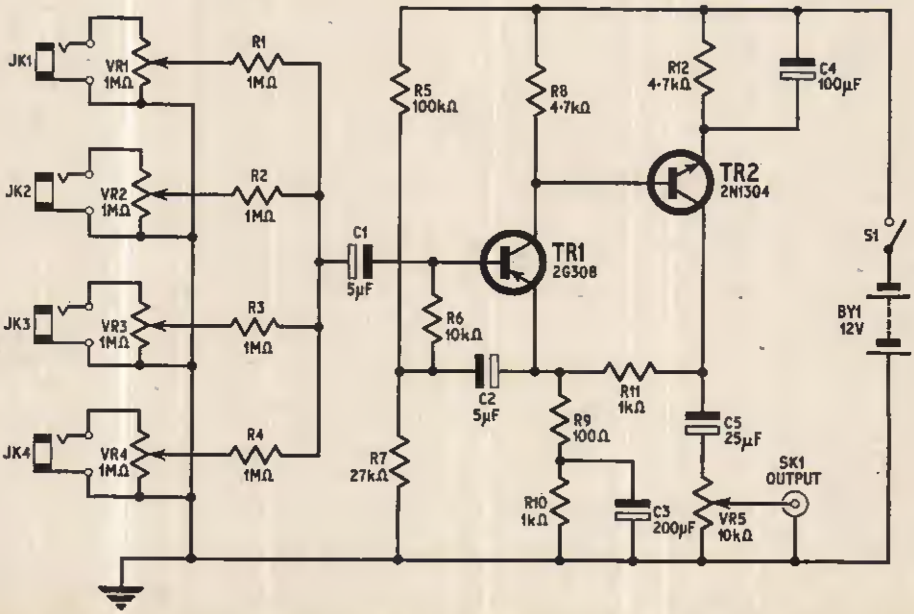
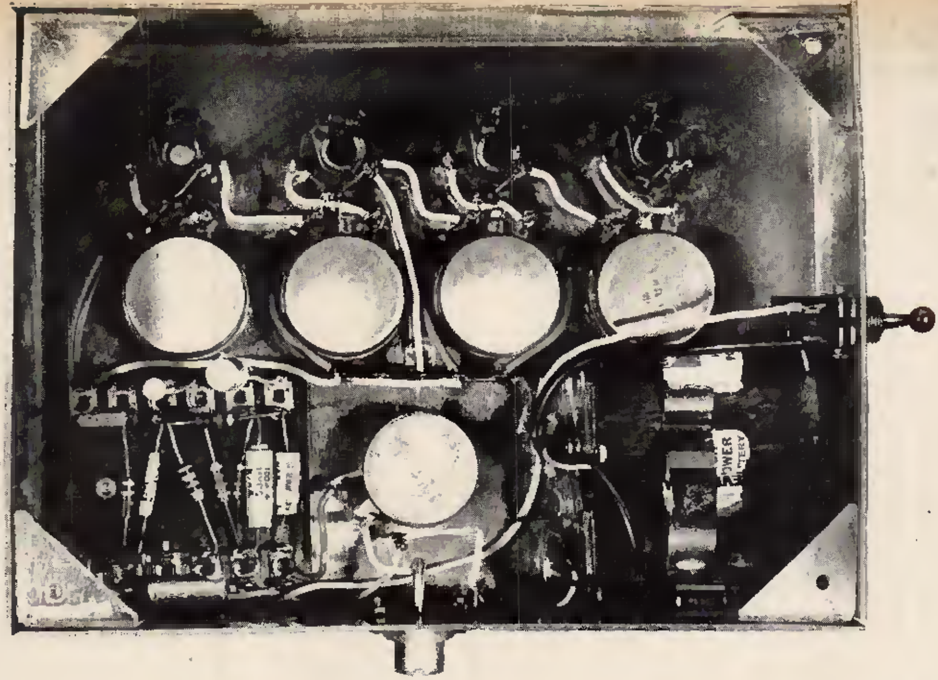


Fig. 2. Circuit diagram of the four-channel mixer with transistor amplifier



THE CIRCUIT

The circuit diagram is shown in Fig. 2. As can be seen there are four input jacks, JK1–4, and associated gain controls, VR1–4, which allow for selective monitoring. The individual signals are fed by way of stopper resistors, R1–4, which isolate their respective inputs against level changes in the other channels.

Mixing is achieved at the juncture of these resistors and the resultant complex signal is fed to the base of TR1 by way of C1. The amplified signal at the collector is applied to the base of the *npn* transistor TR2 and the output of this is developed across the master control VR5 via the blocking capacitor C5, a part of which is re-routed to the emitter of TR1 by R11. This provides negative feedback to the amplifier and fixes the overall gain at a value independent of the variation of transistor current gains normally encountered due to the spread of the transistor characteristics. Bias stabilisation to fix the working points is achieved in the normal way; C3 and C4 acting as signal by-pass capacitors to their stabilising resistors.

CONSTRUCTION

The unit was designed with an eye for symmetry and compactness which enabled lead lengths to be kept reasonably short and a point-to-point wiring layout to be easily maintained.

The component disposition and wiring arrangement shown in Fig. 3, if followed, should provide the performance specifications as set out below.

SPECIFICATION

Single input impedance—500 kilohms

Maximum Output—250mV

Frequency Response—20c/s to 20kc/s ± 3dB

Overall Gain with any input—approximately × 1

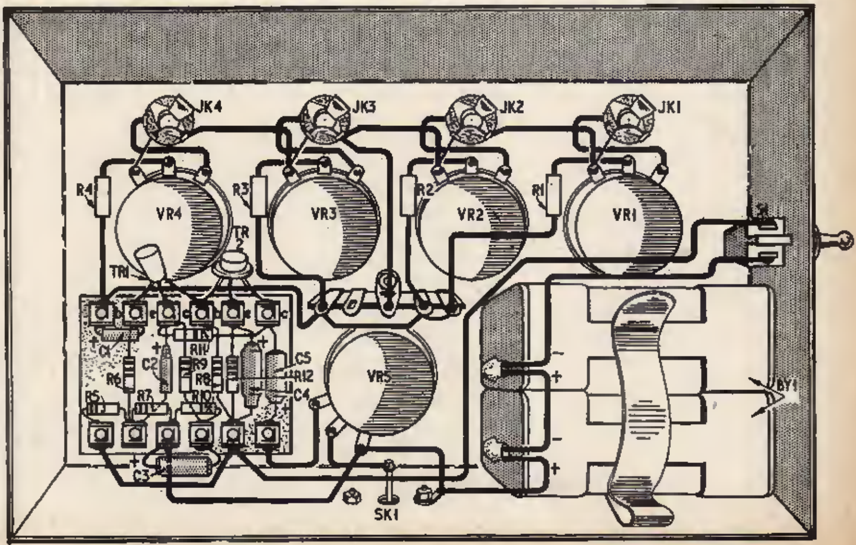


Fig. 3. Component layout and wiring of the four-channel mixer

COMPONENTS . . .

Resistors

R1	1MΩ	R7	27kΩ
R2	1MΩ	R8	4·7kΩ
R3	1MΩ	R9	100Ω
R4	1MΩ	R10	1kΩ
R5	100kΩ	R11	1kΩ
R6	10kΩ	R12	4·7kΩ

All 10% ½ watt carbon

Potentiometers
VR1 1MΩ carbon, log
VR2 1MΩ carbon, log
VR3 1MΩ carbon, log
VR4 1MΩ carbon, log
VR5 10kΩ carbon, log

Capacitors
C1 5μF elect. 12V
C2 5μF elect. 6V
C3 200μF elect. 6V
C4 100μF elect. 12V
C5 25μF elect. 12V

Sockets
JK1–4 Standard type jack sockets (4 off)
SK1 Coaxial socket

Switch
S1 Single Pole on/off switch

Battery
BY1 12 volt pack made up from four 3V batteries type 72 or eight 1·5V cells type 1915

Transistors
TR1 2G308
TR2 2N1304 } Texas Instruments, Ltd., Supplies Division, 12 Wellcroft Road, Slough, Bucks.

Miscellaneous
Chassis 7½in × 5½in × 2¼in. Group component panel 2in long. Backing plate to suit. Five-way tag strip. P.V.C. covered wire. Battery connectors and plastic cases (see text). Five knobs. One Terry clip.

The input jack sockets are ¼in standard types. It will be noted from the photograph that shorting type jacks were used to enable the inputs to be grounded until the plugs are inserted—however, these are not essential.

The main circuitry was wired on to a 2in length of standard group panel with a similar sized plastics backing plate acting as a chassis insulating mounting, the whole being retained with a single screw fixing.

The battery pack was made up from four batteries type 72, each of which consists of two cells, type 1915. They can be housed in containers obtainable from G. W. Smith & Co. (Radio) Ltd., 3 Lisle Street, London W.C.2.

There is a wide range of suitable control knobs on the market and so the individual constructor has scope here for satisfying personal preferences. A useful addition would be graduated escutcheons which would provide a reference scale. Here, of course, pointer knobs would be required.

The cost of the unit, for materials and components worked out at approximately £4. ★

THE BC 342 *Classic*

Origin

THIS receiver has certain features of resemblance to the popular aircraft BC348, dealt with here earlier, in several respects electrically, though not mechanically. For example, it includes two r.f. stages, six switched bands and several other features in common with the aircraft version—and it is of much the same age, too, being manufactured in quantity in America 20 years ago as a general purpose ground station receiver.

Basic Circuit

Two r.f. amplifiers, both	VT86	(6K7)
First detector	VT87	(6L7)
Separate local oscillator	VT65	(6C5)
Two i.f. amplifiers, both	VT86	(6K7)
Separate beat oscillator	VT65	(6C5)
Second detector & audio	VT88	(6R7G)
Output valve	VT66 or VT107	(6V6G)

COMMENT: This valve line-up is typical of that to be found in most versions of the BC342. The combination of two radio frequency stages, two i.f. amplifiers and an audio stage driving the 6V6 output stage ensure a level of sound output more than adequate for most needs. As befits a sensitive receiver the screening is exceptionally good, the case, of copper sheet, being virtually "leakproof" from the r.f. point of view.

Waveranges Covered

Band no. 1	1,500–3,000kc/s.
Band no. 2	3,000–5,000kc/s.
Band no. 3	5,000–8,000kc/s.
Band no. 4	8,000–11,000kc/s.
Band no. 5	11,000–14,000kc/s.
Band no. 6	14,000–18,000kc/s.

Intermediate frequency

470kc/s on most versions.

COMMENT: Four of the six main h.f. communication bands allocated to the amateur service are embraced within these ranges, though to cover the 21 and 28Mc/s regions (and of course v.h.f.) external converters would be needed.

Power Requirements

If the valves are rewired for 6·3 volts l.t., a mains power unit giving about 3 amps at this voltage and approximately 80mA at 250V will be satisfactory. Because the BC342 was intended to operate under service conditions from a variety of power sources, space was allowed for a small mains power to be inserted at the rear left. Almost certainly this will be found to be for the American supply voltage of 110 to 120 volts, in which case a step-up transformer to the British 240 volt level will be required. In many samples of this receiver this change will have been made already by modifying the existing power pack, but the point should be checked at the time of purchase.

Controls

Central is the frequency scale (with detachable escutcheon) operated by the tuning knob below through a set of sturdy brass gearwheels, and a convenient vernier logging scale: one rotation of the main tuning handle rotates the logging control through four revolutions—a commendable order of mechanical bandspreading.

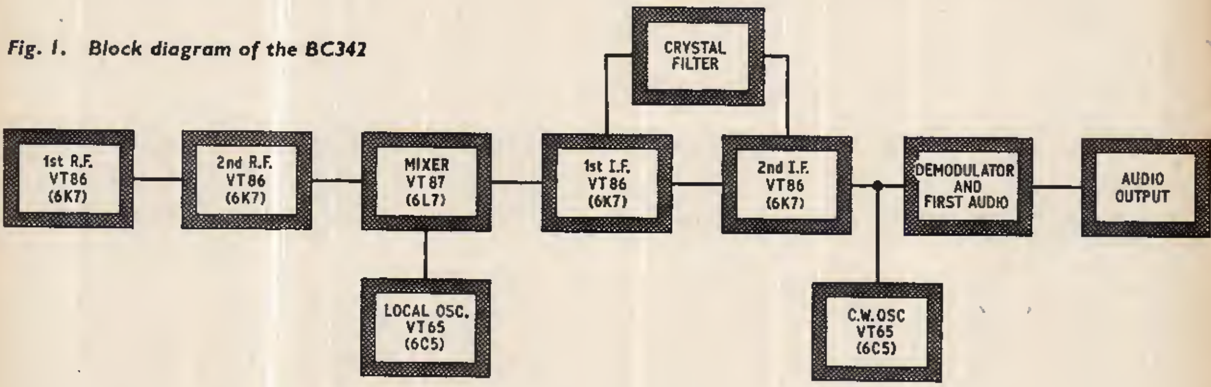
Along the top of the front panel are the aerial alignment control (it operates a 10–210 pF midget trimmer well screened to obviate unwanted pick up), the crystal phasing control ganged with the crystal filter switch, and the c.w. oscillator knob. Below, left: the bandchange switch. Below, right: combined i.f. and a.f. gain control.

COMMENT: Inspection of the control actions and of the general construction of the BC342 discloses its essentially rugged construction. The wavechange

We present this month the third article in our series "Classic Communication Receivers". Intended as a guide to the prospective purchaser of a high performance receiver for use on the h.f. bands, this series gives the basic technical information he will need without delving too deeply into the circuitry. Readers should always make sure that a handbook or circuit diagram, at least, is supplied with any receiver purchased..

COMMUNICATION RECEIVERS

Fig. 1. Block diagram of the BC342



switch goes over with a heavy and positive "clank"; within, massive screening of all coil sections is combined with an arrangement of covers readily removable for inspection purposes—though they need not be for trimming, for all signal frequency inductors are accessible from the back, and are clearly identified, as indeed are all stages and their major associated assemblies.

The refinement of internal screening puts the oscillator section of the gang capacitor in a separate box, an insulated spindle conveying the drive from the other three sections of the gang.

The spread of each amateur band is as follows, using the main tuning knob as bandset and the vernier as bandspread:

BAND	REVOLUTIONS	SCALE WIDTH
1·8Mc/s	$5\frac{1}{2}$	1 in
3·5Mc/s	$5\frac{1}{2}$	$1\frac{1}{2}$in
7·0Mc/s	$1\frac{1}{2}$	$\frac{3}{8}$in
14·0Mc/s	$5\frac{1}{4}$	2 in

Used as an i.f. strip for 144–146Mc/s, tuning over the popular range of 14–16Mc/s required no less than $22\frac{1}{2}$ revolutions—an admirable degree of bandspreading.

Recommended Basic Modifications

Heaters: Pairs of valves have heaters series connected, with suitable l.t. equalising resistors where appropriate, to permit use in the field (in a military sense!) where a 12 volt accumulator and vibrator pack might be the power source. The private user can with no difficulty rewire all heaters for the more convenient 6·3 volt service by earthing pin 2 or 7 of each socket and connecting the other to the a.c. low tension rail.

Aerial Input: Two terminals are provided. One may with profit be disconnected and a coaxial socket substituted (see illustration) to accept low impedance input for an external tuner unit or converter (in the latter case this modification is essential to obviate i.f. breakthrough).

Separating the Gain Controls: An unsightly "spout" at the bottom right hand corner of the front panel conveyed cableform connections to an associated transmitter in some wartime applications. The related microphone and key jacks are redundant and can be turned to more useful service, to feed a second headset, perhaps. The "spout" should be removed, the resulting orifice being covered by a blanking plate and the combined gain controls separated and mounted on it as shown in the illustration.

The redundant switch labelled "Rec Send" can either be removed entirely or used to switch on the mains power unit.

The three position switch furnishing a.v.c. or manual control will upon being turned to the left (to "OFF") mute the receiver output.

Capacitors—the usual warning: The age of every BC342 means that many capacitors will be suspect—and it is better to test these for leakage before switching on rather than wait for smoke to emerge from the case! Even better, ask for a demonstration of the set before purchase.

Readout—
A SELECTION FROM OUR POSTBAG

Healthy and constructive

Sir—If the tone of this letter appears to be one of criticism I hope that it will be received in the spirit intended—i.e. healthy and constructive.

For years most relevant technical magazines have issued a succession of "Process Timers" for photographic and other uses. I observe from the June issue that another version is published. The world of electronics can be so useful to the amateur (and professional) photographer. What a pity, then, that we do not appear to explore it fully. From the description given it would seem to me that the purely audible device implied would have been very useful some 20 or 30 years ago. I can see no point in constructing a device purely for the sake of constructing it and which can do little more than simpler (and perhaps cheaper) devices which already exist.

The photographic timer would have been of use in the days when, say, film development was carried out by hand in the darkroom. But, surely what the photographer requires these days is firstly, an interlocked enlarger lamp and timer. Secondly, assistance in determining correct exposure for given negatives and preferably that this information be automatically coupled to the timing device. Commercial devices such as this already exist and so surely it would be not too difficult to produce an amateur design.

A comparable device for use with production of colour prints would also be most acceptable but here, I would agree, we may be too ambitious.

I would also be interested in more information with reference to electronic flash equipment. There appears to be a gap here which has not been adequately filled.

In passing, I must also express some personal disappointment in the lack of detailed constructional information on transistor transmitters for Radio Control. The recent series, I felt, concentrated too much on valves and this is one field where the tremendous advantages of transistors must render valves obsolete.

In a nutshell, this is a plea for devices which are really worthwhile. I hasten to add that worthwhile devices have appeared in your publication but the ones quoted, in my opinion, do fall short in value.

D. Coney,
Lincoln.

Your comments concerning the timer for photographic processes were particularly of interest since we are proposing to publish details of a rather more ambitious device within the next few months. This device will be designed specifically for colour prints.

We have already published a design for an electronic flash gun. However, in view of the considerable interest shown in this particular field, we shall be offering another design next month.

Finally, with regard to your comments concerning the Radio Control of Models series, I should explain that this was intended primarily as an introduction to the subject, and no attempt was made to introduce detailed designs. We hope to publish constructional projects for radio control in the future.—Ed.

New Zealand calling

Sir—I have been interested in some of the pictures you have shown in your *73 Page* and thought you might like one from overseas.

New Zealand changed its licence plate system a couple of years ago and I managed to hunt down the one in the photograph which has an added interest with the "88".

Best of luck to you and your page.

ZL2RP,
Lower Hutt,
New Zealand.

Keyboard cantata

Sir—I wonder if any of your readers can suggest an answer to a problem that I am faced with.

I am designing a machine to play any piano. Briefly, the method is that the music will be played first by a pianist on a specially adapted master piano. This adaptation will consist of electrical contacts being placed beneath each of the 85 notes plus the sustaining pedal, the contacts being wired to 86 tracks on specially wide magnetic tape. When any note or the pedal is pressed, an impulse is recorded on the appropriate track on the moving tape.

The playback can be on any piano, by means of the following: The playback mechanism is contained in a casing, the length of a keyboard, and can be placed on the keyboard of any piano. There is an additional mechanical device to be clamped to the left pedal, to reach over and motivate the right pedal.

The tape is played back over 86 magnetic heads, each impulse charging an electro-magnet which motivates a plunger above one of the 85 notes on the keyboard, or the sustaining pedal. Thus the entire piece of music is replayed.

However, the problem is: Can the velocity at which each individual note is struck by the pianist on the master piano be faithfully recorded by the impulse and transmitted to the playback plunger? It is quite essential, of course, to record and transmit the comparative velocities of the various notes, for without this there can be no expression in the music when replayed.

I am assuming that impulses at the recording stage and electromagnets at the playback stage are the best means to employ for this mechanism.

Percy Kramer,
London, N.W.11.

A method which might be helpful here, in obtaining control over the expression, would be by means of d.c. recording techniques and use of magnetic amplification.

A recently developed type of playback head uses a ferrite core, and is sensitive to direct unchanging magnetic fields, and to magnetisation of the tape at very low speeds, and even provides an output when the tape is stationary! This is because the ferrite is arranged to comprise a saturable reactor.

If the pulse is picked up by means of an iron-cored search coil situated near the piano mechanism of each individual note, it may be passed on to a magnetic amplifier. Small magnets may be attached

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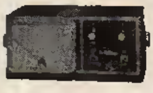
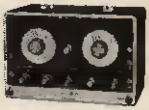

VALVE VOLTMETERS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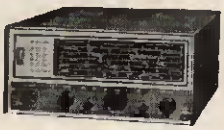
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Readout—
A SELECTION FROM OUR POSTBAG

continued

to the mechanism of each note in order to induce a pulse in the search coil. There is thus, in the master piano, a search coil and magnet, and a magnetic amplifier for each note which may be situated either in the piano itself or in the ancillary equipment.

The output of each magnetic amplifier may be arranged to be d.c. of one polarity only, and this is used to activate the recording head coils.

Upon playback the saturable playback heads will react to the d.c. magnetisation (which is proportional to or a function of the original pulse). Further magnetic amplifiers would then activate the electro-magnetic actuators, causing the keys to be struck with a force related to the original.

It appears that magnetic amplifiers would have certain advantages over valves or transistors in this application. Not the least would be the high sensitivity, power obtainable, and better control over the energy transfer characteristics. Possibly with a system of this nature, timing problems would be a big factor, and it may be possible to achieve best timing only by making a simultaneous audio recording of the master piano piece and correcting the master tape after careful comparison with the audio recording.

You will no doubt find there are many technical difficulties involved in this project. It is quite a hefty development job. I hope my suggestion of magnetic amplifiers and a saturable ferrite playback head is of some help.—A.J.B.

British amateur electronics club

Sir—I am writing to inform you that the St. Cyres Electronics Group has changed its name to The British Amateur Electronics Club.

The aim of the B.A.E.C. is to fulfil a similar function in the field of general electronics to that performed by the British Amateur Television Club in its own particular field. I am very grateful to Mr. D. Mann, the Hon. Secretary and Mr. Grant Dixon a founder member of the B.A.T.C. for their help and for allowing me to copy a large part of their constitution.

The first project this session will be an electronic shooting gallery which we hope to have ready to demonstrate to the public in aid of charity by August. All the components will be supplied to the members free by the club, being paid for out of the membership fee of 10s 0d per year.

If anyone is interested in starting an electronics group elsewhere I would be very pleased indeed to give them any help they may require based on my own experience when I started the St. Cyres Electronics Group and this club.

We have other very interesting projects lined up for the future and also hope to publish a Newsletter giving details of our activities, together with reports on affiliated groups. Starting next September we will show technical films at meetings and have discussions on them, as well as our special projects.

Cyril Bogod,
Penarth,
Glam.

Regenerative feedback

Sir—I would be obliged if you could help with a point of electronics theory.

I am at present working on a project to design a school electronics course, approached via semiconductors. One of the circuits I have constructed is a perfectly conventional, RC coupled, three stage amplifier using three GET113 transistors.

The amplifier functions perfectly while I used a 9V bench supply in the laboratory. Recently the l.t. unit was being changed and I used in its place a 9V battery. The amplifier immediately produced a very high audio frequency oscillation. When the input terminals where shorted together the oscillation reduced in frequency but emerged at full gain from the loudspeaker.

Returning to the bench supply the oscillation disappeared. Using separate 9V packs for each stage also removed the oscillation.

I have not yet found a theoretical explanation for this effect. Can you shed any light on the problem?

P. Green,
Beckett Park,
Leeds, 6.

The impedance of the 9V battery was providing regenerative feedback. The internal impedance of a battery increases with its discharge state.

Since the loop gain of the unit is greater than unity, with the input grounded conditions are right for the amplifier to function as a phase-shift oscillator. This might be proved by inserting a low value potentiometer in the battery lead. If this is varied you will probably find that the pitch of the oscillation will change.—G.G.

CAN YOU HELP?

Letters for inclusion under this heading should be as brief as possible. Replies should be made direct to the readers concerned.

Sir—I would be very much obliged if any reader could let me know where I can get the March 1966 issue.
R. Schofield, 23, Alwyn Avenue, Litherland, Liverpool, 21.

Sir—Could any of your readers supply me with the January 1966 issue. I will pay full charge and of course postal rates.
C. J. Dee, 13 Vulcan Crescent, North Hykeham, Lincoln, Lincs.

Sir—I am interested in purchasing back numbers of Vol. I. I am willing to pay cost price of each copy and postage.
A. Clement, 14 Greenmill Road, Longtown, Cumberland.

Sir—I have been trying to obtain the following copies: November 1964 to September 1965 inclusive. I am willing to pay a fair price for these copies in reasonable condition.
John Carrell, 41 Atkinson Road, Sale, Cheshire.

Sir—Could any of your readers supply me with the February and March 1966 issues.
R. B. Summer, Bruce House, Stowe, Buckingham.

Sir—I need the December 1964 and January 1965 copies to complete my set of issues.
M. Beeforth, 2 Sunset Rise, Meanwood, Leeds 6, Yorkshire.

Sir—Please would any reader send me an August 1965 issue.
P. Ashford, 24 Sunningdale Road, Denton, Manchester.

Sir—If any reader has the November to March 1965, also May and September 1965 issues, complete with blueprints, to dispose of I would pay him a fair price.
A. J. Campbell, "Uplands", 101 Oliver's Battery Road, Winchester, Hants.

Sir—I would be very grateful if any reader of PRACTICAL ELECTRONICS could sell me a handbook for Hallicrafters Model S-38A.
M. A. Batt, Post Office, Rokewood Junction, Victoria, Australia.

Sir—I would be grateful if any reader could sell or loan me information on the cells, lens system or a suitable power supply for "Tabby, Type E", Infra Red binoculars.
J. C. Duncan, 18 Grove Park, Wanstead, London, E.11.

Back numbers are usually very quickly exhausted. We strongly advise all our readers that a standing order be placed with their newsagent to avoid any future disappointment.

Audio TRENDS...

A Commentary on Sound Reproducing Equipment by Clement Brown

THIS month, more than the usual variety of technical developments compete for attention. Not only were many new products introduced at the Audio Fair, but a wealth of American equipments, many of them unfamiliar to British enthusiasts, were also shown at an exhibition in London.

BETTER RECORD REPRODUCTION

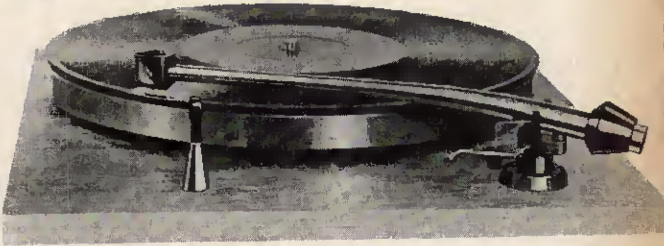
As far as British and some imported disc equipments are concerned, the Audio Fair provided confirmation of trends that were apparent during the last year or so. Greater understanding of pick-up requirements have taken us well beyond a quest for wider response: manufacturers can now claim more success in lessening the audible effects of distortions inherent in record reproduction. Tracking distortions can detract more from clear, musical results than any other flaws in the audio system are likely to do; but disc reproduction at its best is superior to anything achieved with other programme sources.

Customers for pick-ups of really high quality will of course look for such features as low playing weight, smooth response and high head compliance. However, there can be no warranty of secure tracking and good performance unless the pick-up presents a small mechanical impedance to the groove; hence a greater emphasis on small effective tip mass (as low as 1 milligramme) and the taming of resonances. The mass of arm/head combinations are further reduced in recent models.

NEW PICK-UPS

Leak's new stereo pick-up, an integrated arm and head, is a variable reluctance design intended to track at 2 grammes. The tip mass is quoted as less than 1 milligramme. Other specification points include 10×10^{-6} cm/dyne compliance, channel separation of 25dB at 1,000 c/s, and average output of 6mV. An elliptical stylus is fitted. The arm, which features a viscous-damped unipivot, has a raising and lowering device. Price is £26 16s. 6d.

A new version of the Ortofon moving-coil head, imported by Metro-Sound, is basically similar to the



Leak stereo pick-up

already familiar model but has the high compliance of 20×10^{-6} cm/dyne and a vertical tracking angle of 15 degrees. An elliptical stylus is fitted, and there is a new method of stylus arm mounting to give better protection against damage.

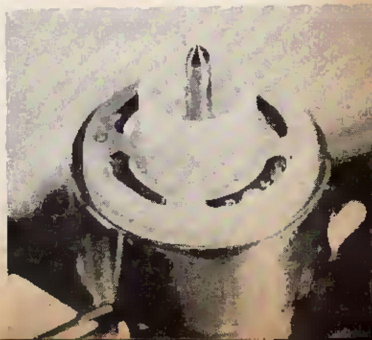
Further down the price range is the CS91/E, the most recent version of Goldring's ceramic stereo cartridge. Compared with the familiar CS90, it can be tracked at a lower pressure; the compliance is higher and there is an elliptical tip. This cartridge exemplifies what is being done to offer a good standard of performance with reduced record wear—at moderate cost.

In the more advanced arms, intended for very low playing weights, the reduction of pivot friction is essential. It is equally vital to ensure that connecting wires passing round the pivots do not introduce appreciable friction or torque. This particular snag does not arise in a new laboratory arm by Audio & Design, who have ingeniously incorporated mercury baths in the pivot pedestal. Signals from the head pass, via small electrodes, through the mercury and thence to the lead-out cables.

AUDIO ELECTRONICS

On the electronics side of audio the application of transistors is clearly the focus of interest. This is a time of steady development, and performance standards are gradually being raised. One of the most interesting amplifiers in the popular price range is

Audio & Design pick-up and mercury bath



the Goodmans Maxamp, which employs silicon transistors. Others include a new Elizabethan model: it is a shelf-mounting unit, catering for magnetic and ceramic pick-ups and rated at 10 watts per channel. The price is 39 gns.

Howland-West showed prototypes of transistor amplifiers which are due for production in August. System One, as the first model is called, incorporates a new type of output stage and is rated at $12\frac{1}{2}$ watts per channel. A power response of 20–20,000 c/s is claimed. A second model, System Two, is also promised.

Tape recorders, especially portables, are mostly transistorised, and exceptions to the rule become fewer. On the other hand it is noticeable that many professional machines depend on valves: this is true of the Brenell and Ferrograph recorders and some other top-class instruments seen recently.

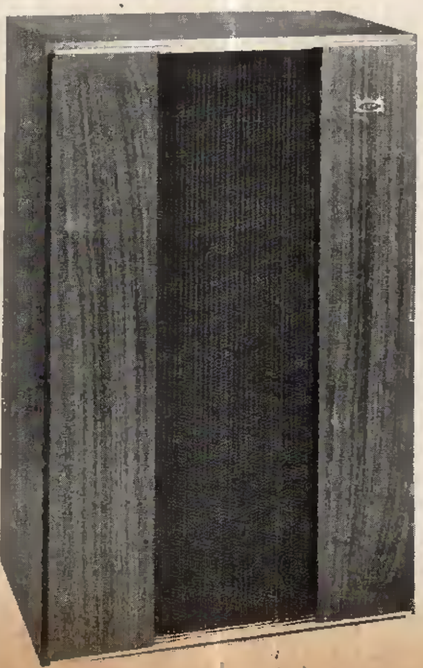
Decks include two by Scopetronics. Their type 825, costing £49 10s., has $7\frac{1}{2}$ and $3\frac{3}{4}$in/sec speeds, and the selection of speed is effected by changing over the number of poles in the capstan motor. Four heads can be fitted. A larger deck, type 1150, operates at 15 and $7\frac{1}{2}$in/sec and accepts spools of up to $11\frac{1}{2}$in diameter.

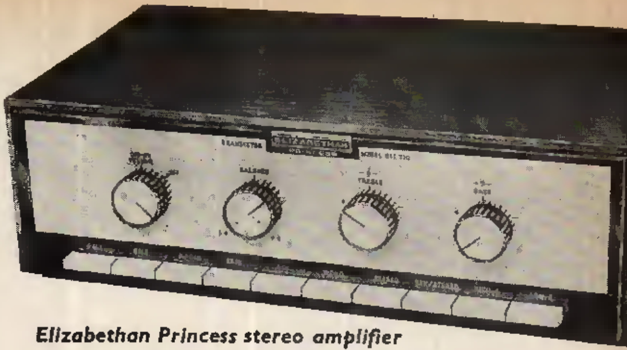
SPEAKER SYSTEMS

New speaker systems and drive units continue to arrive in variety. Among the compact systems are the Decca Kelly-Mini and the Leak Mini Sandwich. The latter employs methods of design and construction already made familiar in the standard Sandwich system. Other small speakers are the Rectavox Ambi (£36 10s.), the Sonotone Solent (£18) and the Truvox LS.120 (19 gns.).

Among the new floor-standing speakers is the KEF Concord, the successor to the Duette. This nice-looking model, measuring 24in × 15in × $9\frac{3}{4}$in, sells at £39 19s. Constructors should note that a brochure of enclosure designs is available from KEF Electronics Ltd., Tovil, Maidstone, Kent. The latest big speaker from Wharfedale is the Teesdale (£52 10s.), and there is also a new 12in drive unit, the W12/FRS.

KEF Concord loudspeaker cabinet





Elizabethan Princess stereo amplifier

Finally a note on audio from the U.S.A. The American manufacturers, at their recent hi-fi show, were seeking U.K. agents for their products. Of course, some firms—for instance Dynaco, Fisher and Shure—already sell in this country. Nevertheless there are untapped riches of which one hopes to see more in the future. Price levels are generally high, but the exhibition provided much evidence of technical ingenuity and smart design.

AMERICAN PRODUCTS

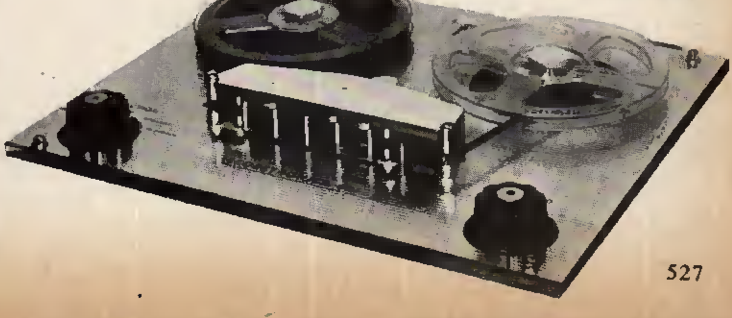
Firms represented by Delrama included Acoustic Research, whose excellent speakers and turntables have received limited attention in the U.K. before. Other turntables included two Rek-O-Kut models and the Marantz zero-tracking-error model, which has a radial pick-up arm. Empire, Grado and Pickering were among the pick-up specialists. Tape equipment included high-quality machines by Crown and Ampex, the latter's reputation being such that 800 and 2,000 series recorders were used for demonstrations by the other exhibitors.

Only one or two of the many speaker firms can be mentioned. Although compact models seem fairly popular, there are at least as many large, heavy-duty systems on the American scene. Those by J. B. Lansing and Sherwood are intended for large rooms and gracious living. Nearly all American speakers are multi-unit systems with crossover filters.

The first thing one notices about the tuners and amplifiers is the predominance of smart metal control panels. Then one becomes absorbed in technical matters, notably the wide use of elaborate transistor circuits (no expense spared). Some power ratings seem unnecessarily high, even taking low efficiency speakers into account; but obviously a generous power reserve means small distortion under practical conditions.

Some names to look out for are CM, Electro-Voice, McIntosh and Sherwood. As befits the size of the market, American enthusiasts enjoy an impressive choice, and the chances are that we shall be sharing some of it with them if things go well.

Scopetronics 825 tape deck



detached particles

JOHN VALENCE

TABS ON THE DABS

Quite a bit of controversy has arisen over the Home Office suggestion that perhaps everyone's fingerprints should be recorded as part of the campaign to stamp out crime. There will be bitter arguments about whether or not this is an infringement of individual liberty. This apart it is not altogether certain that the proposal is feasible from a technical point of view.

Classifying the "dabs" of some 60 million people would be quite an undertaking even for that prodigious machine the electronic computer. However some experts think that there is a good chance of sorting out the fingerprints by measuring the sines and cosines of the arches, loops and whorls which make up fingerprint patterns. At anyrate, IBM for one are busily investigating this possibility.

Where will all this recording and tabulating of persons end? Will the stage ever be reached where it will be possible to locate instantly any individual through the medium of an implanted device—as a colleague of mine suggested the other day? Perhaps a somewhat nightmarish thought, but it is reasonable to suppose that technology will be called upon to play an ever increasing role in the fight against crime.

GETTING IN STEP

Whether we ever get into the Common Market or not—we shall at least be going metric. The commitment has already been made by the Government and more recently the Minister of Technology announced his intention of establishing a nationwide calibration service. This has been decided upon with the full encouragement of industry as a further step towards getting our house in order and in tune with other countries.

Not least of the reasons behind this decision is the handicap our export trade is suffering because of the present lack of authenticated calibration certificates for certain measuring instruments and equipments made here.

Coupled with this plan is the intention to overhaul all relevant standards. The Ministry of Technology is now responsible for sponsorship of the British Standards Institution and so will have a direct influence upon its deliberations.

GOODBYE TO C/S?

So far as symbols and abbreviations used in electronics are concerned, there is already a fair degree of conformity between different countries.

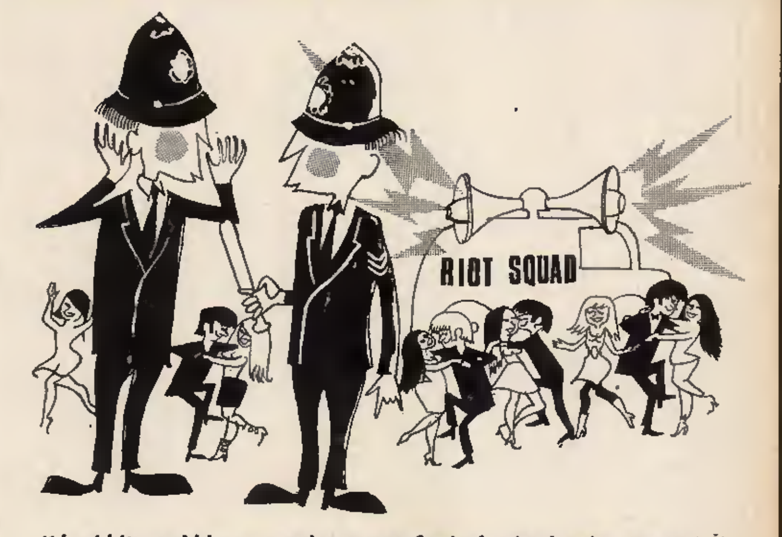
But one important case where we do differ from the continentals is in the terminology used for frequency. While we have been quite happy with cycles per second and the abbreviated form "c/s", it has long been common practice in other countries to use "Hertz", and the shortened form "Hz", for this purpose.

The Americans, although 3,000 miles or more from Europe, have now decided in favour of "Hertz" and the change is already apparent in technical literature originating in the U.S.A. In face of this, can we in this off-shore island hold out much longer against our close neighbours?

Well I suppose it is no good preaching standardisation and then raising objections in particular instances. The balance seems now decidedly in favour of Hertz and I am afraid we shall soon be saying a reluctant good-bye to our old friend "c/s". But it won't be easy to readapt oneself after years of writing kc/s, Mc/s and plain c/s.

RATHER SHATTERING

Those living in the vicinity of a major airport will readily accept the claims made for the demoralising effectiveness of the "Curdler."



"I said it would be no good at a pop festival—they're dancing to it!"

This, in case you have not already heard, is the latest device for quelling unruly mobs. A kind of super public address system with a built-in noise generator, the Curdler has been devised to bombard troublesome crowds with a raucous output of such intensity and tonal character that the disorderly elements are well and truly stunned, frozen in their tracks, and finally compelled to retreat with hands clamped to ears. They are luckier in this respect than some householders who just have to sit and take it when another VC10 or 707 shrieks its way over the roof tops.

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7 valves plus Rectifier. 4 Bands. 550 kc/s–31 Mc/s. "S" Meter—BFO—ANL—Bandspread Tuning. 200/250 v. A.C. Brand New **24 Gns.** Carr. Paid.

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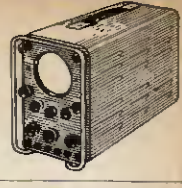

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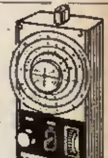

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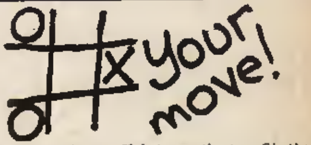

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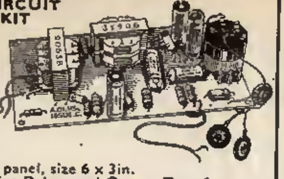

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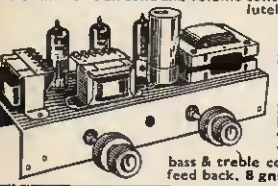

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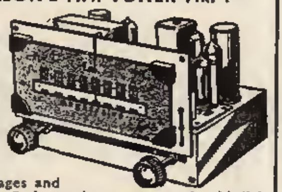

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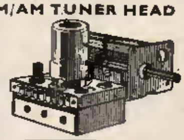

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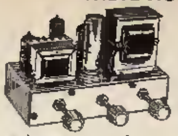
3-VALVE AUDIO AMPLIFIER MODEL HA34



Designed for Hi-Fi reproduction of records. A.C. Mains operation. Ready built on plated heavy gauge metal chassis, size 7½in. w. x 4in. d. x 4½in. h. Incorporates ECC83, EL84, EZ80 valves. Heavy duty, double wound mains transformer and output transformer matched for 3 ohm speaker, separate Bass, Treble and volume controls. Negative feedback line. Output 4½ watts. Front panel can be detached and leads extended for remote mounting of controls.
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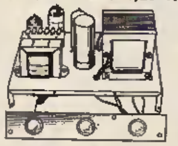
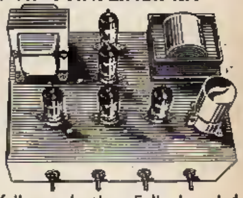
A.C. Mains 200/250v., 4 watt, using ECC83, EL84, EZ80 valves.



★ Heavy duty double-wound mains transformer with electrostatic screen. ★ Separate Bass, Treble and Volume controls, giving fully variable boost and cut with minimum insertion loss. ★ Heavy negative feedback loop over 2 stages ensures high output at excellent quality with very low distortion factor. ★ Suitable for use with guitar, microphone or record player ★ Provision for remote mounting of controls or direct on chassis. ★ Chassis size only 7½in. wide x 4in. deep. Overall height 4⅜in. ★ All components and valves are brand new. ★ Very clear and concise instructions enable even the inexperienced amateur to construct with 100% success. ★ Supplied complete with valves, output transformer (3 ohms only), screened lead, wire, nuts, bolts, solder, etc. (No extras to buy.) PRICE 79/6. P. & P. 6/-.
Comprehensive circuit diagram, practical layout and parts list 2/6 (free with kit).
This kit although similar in appearance to HA34 employs entirely different and advanced circuitry.

10/14 WATT HI-FI AMPLIFIER KIT



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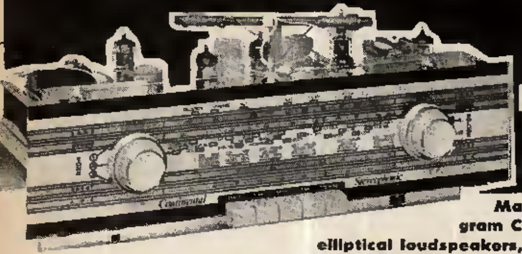

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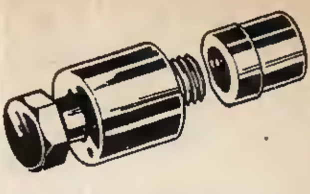

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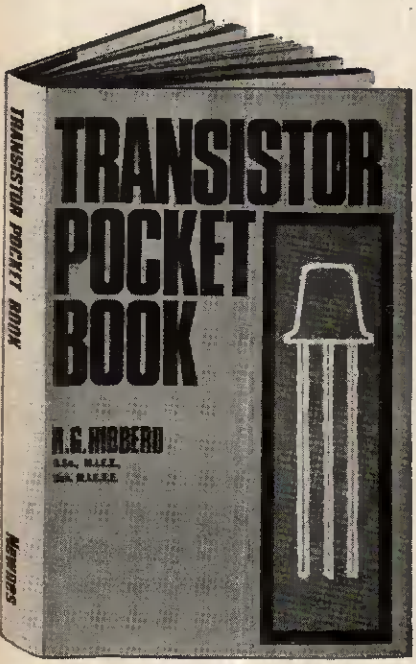

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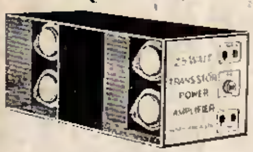

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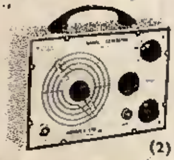

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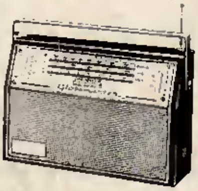

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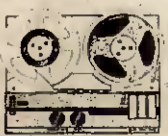

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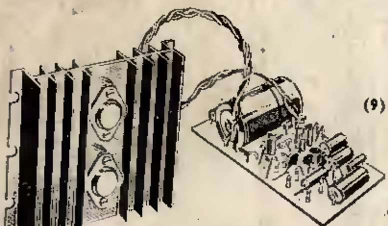

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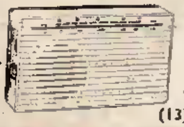

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