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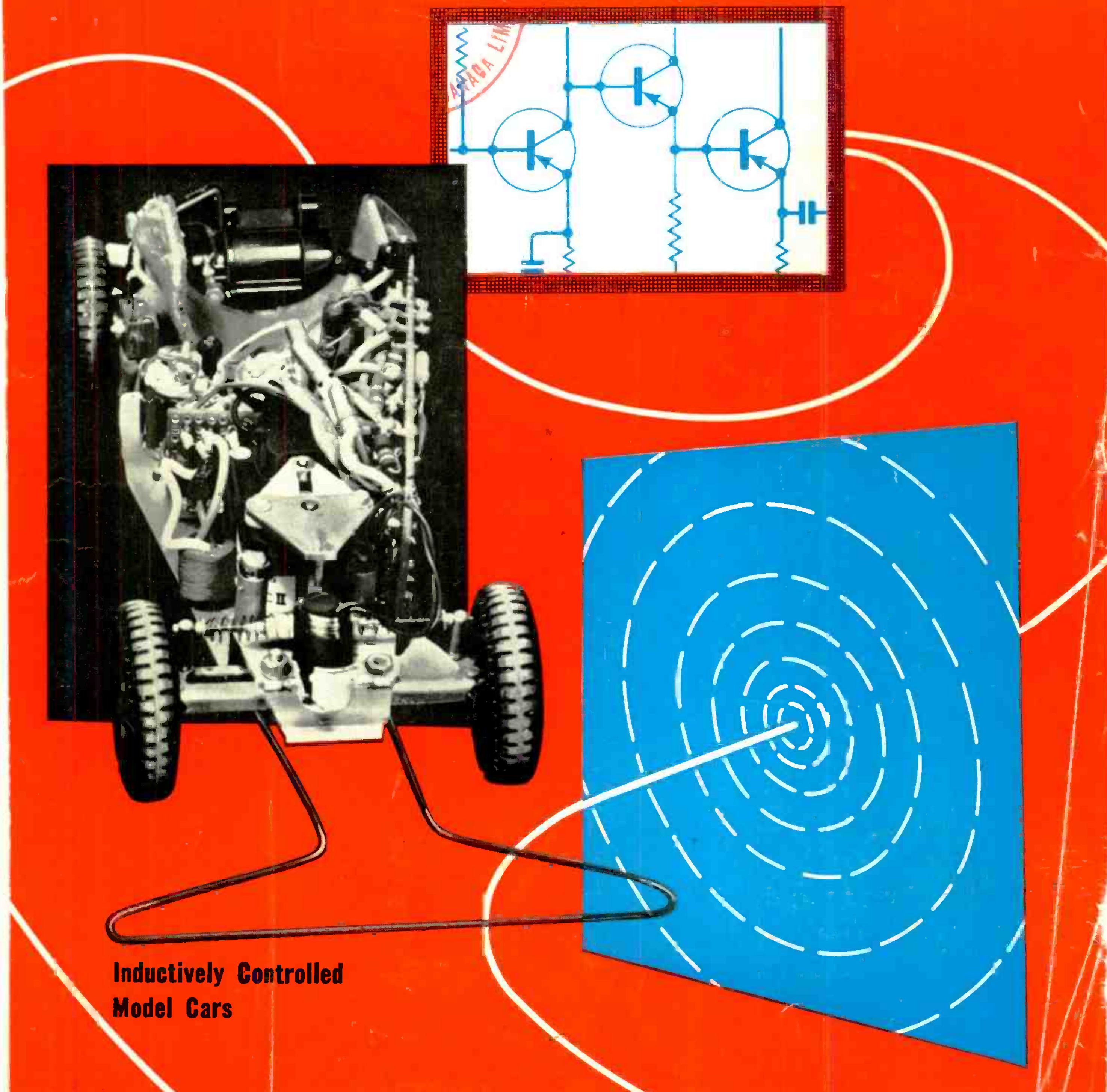

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Wireless World

ELECTRONICS, TELEVISION, RADIO, AUDIO

Whither British Television?

THIS journal has been an ardent supporter of the 405-line television standard from its inception in 1936 and campaigned for its retention rather than a change to 625 lines which we considered gave only a marginal improvement in definition. When, however, in the light of the 1960 recommendation of the Television Advisory Committee (endorsed by the Pilkington Committee) the Government decided in 1962 that all television in the U.K. should eventually be on 625 lines with negative modulation and f.m. sound, we accepted the inevitable; or did we? Over the past four years there has been a good deal of correspondence in our pages on the problems of propagation in the u.h.f. band; on the pros and cons of 625 (50 c/s) and 525 (60 c/s); and on the question of an international standard.

Now, once again, the question of 405 lines is raised by a correspondent who advocates the introduction of colour on this standard. The technical arguments have been aired again and again and despite the Government's decree there is a strong and increasingly vociferous band of engineers both in the broadcasting organizations and in industry who consider that there is ample justification in the light of experience with the BBC-2 monochrome u.h.f. service for the retention of the 405-line standard—and furthermore the introduction of colour on this standard forthwith.

We must not lose sight of the fact that some of the more vociferous advocates of the introduction of colour on 405 lines are in the I.T.A. and programme contracting companies and it may therefore be claimed that they have a vested (*mot juste*) interest. We would remind readers, however, that in 1959 the B.B.C. asked the Postmaster-General for permission to introduce colour on its 405-line service but was refused.

It may be asked why, if they so desire, the I.T.A. programme contractors do not start colour transmissions as part of their existing programmes? The answer is, of course, the P.M.G. has decreed that colour television in the U.K. is to be on 625 lines and as they are licensed by him to operate they cannot go against his ruling.

It seems that the introduction of colour television in this country is bedevilled by political, economic and technological intrigue. We are not qualified to speak on the political and economic climate, but what of the technological? We do not need to go over all the arguments for and against the various systems (a letter in this issue brings to light a deficiency in PAL which has not previously been aired) although we wish it were permissible for us to make public a report prepared by the B.B.C. engineering department for the T.A.C. in which three systems N.I.R., PAL and N.T.S.C. are compared. This report is said to be confidential although we know it has been circulated to some organizations in this country and abroad.

Irrespective of what colour system is finally adopted, whether independently in the U.K. or in concert with our European neighbours, we in this country have still to decide when colour will be added to BBC-1 and the I.T.A. services. Are viewers of these programmes to be denied it until some unforeseeable date when these services will be transferred to the u.h.f. band? If, as seems likely, the P.M.G. stands by his decision for colour on 625 lines both BBC-1 and I.T.A. should be given the opportunity of sharing with BBC-2 the time devoted to colour transmissions. Our associate journal *Electrical and Electronic Trader* says that such a compromise "has much in its favour and could well be the initial answer to a difficult problem, if both sides are prepared to collaborate in making it work."

VOL 72 NO 7
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Remotely Controlled Model Cars

System uses inductive coupling with a.f. control signals. One model is steered by a conventional actuator, the other by differential drive to the rear wheels

By
W. D. GILMOUR,
B.A., A.M.I.E.E.

THE remote control of small, free, model cars presents certain differences from the control of other free models. First, because of the small-diameter wheels used, a smooth surface on which to run is essential, and this precludes outdoor running except under very special conditions; the area available will therefore be measured in (tens of feet)^2 at the most, and the maximum distance over which control will be required will be of the same order. Secondly, the control accuracy required will be greater, as running will generally take place on a track bounded upon both sides, thus reducing the permissible margin of error. Thirdly, because cornering in such a small area will be frequent, the control system must be quick in operation and proportional. Probably because of these limitations, model cars have received less attention from control enthusiasts than model ships or aircraft. However, the control system to be described is simple, using only audio frequency techniques, and is well within the capabilities of the amateur constructor to assemble and use.

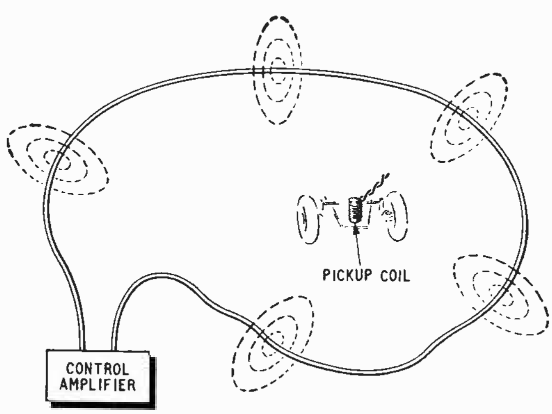


Fig. 1. Plan view of cable loop surrounding an area. The pick-up coil on the vehicle is mounted vertically.

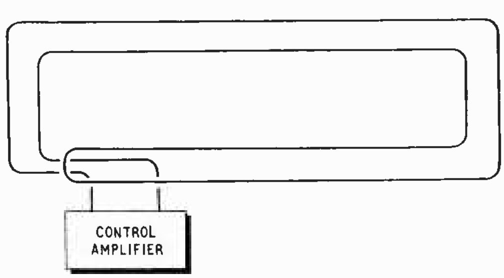


Fig. 2. Plan of cable delineating a track.

W. D. Gilmour graduated at St. John's College, Oxford, and after wartime service as T/Captain in R.E.M.E. was employed by St. Dunstan's on guiding devices and reading machines for blind people. He then went to Westinghouse Brake & Signal Co. Ltd. where he worked on semiconductors ; then to Marconi International Marine Communication Co. Ltd. and since 1954 has been with EMI Electronics Ltd. on applied research. Mr. Gilmour, who is 43, and has written for *Wireless World* on several occasions, is the author of the Iliffe book "Electronic Equipment in Industry."

Radio control over these short distances is quite unnecessary. Instead use is made of inductive loop signalling, in which the area within which the cars are to run is encircled by a cable carrying the audio frequency control tones. This cable acts as a large single turn solenoid, thus producing a magnetic field as shown in Fig. 1. If a coil, mounted on the model as shown, is introduced into the field, a voltage will be induced in it from the field, and this may be amplified in a simple audio frequency amplifier, detected, and used to perform the necessary control functions. If running on a track is required, the cable may be laid at the edge of the track, as shown in Fig. 2; this arrangement gives a very uniform field across the track, whereas in the single loop arrangement the field is stronger near the cable.

Each car requires a minimum of two channels, to control its speed and steering, and a third channel is often convenient to act as an automatic gain control channel so that variations in strength of the picked-up signal as the car moves about the track can be automatically allowed for. Naturally this last channel is common to all the cars on the track. The number of cars that can be simultaneously controlled will be set by the difference in frequency between the channels necessary to avoid interaction. It has been found that, using well designed tuned inductance-capacitance circuits on the cars, a channel spacing of 500 c/s with frequencies ranging from 800 c/s to 4,000 c/s proves satisfactory; and thus seven channels are available, allowing three cars to be simultaneously and independently controlled.

A common audio amplifier for all the control tones (Fig. 3) feeds signals to the cable. It is important that this amplifier should not overload when peaks from all tone generators occur simultaneously in one polarity, and thus the amplifier must not distort for input signals seven times the amplitude of a single input signal. The current in the cable for a single tone should be about 0.5 A, and thus the peak current in the cable will be about 3.5 A. The inputs to the amplifier (Figs. 8 and 11) will be dealt with later.

In the model car, a common amplifier amplifies all signals picked up from the coupling coil. A suitable design is shown in Fig. 4, but almost any small audio amplifier could be used. Care must be taken to design the amplifier to work over a large variation in supply voltage, as the model's battery discharges, and steps must also be taken to eliminate interference from the motors on the model—this is most easily achieved by limiting the high frequency response of the amplifier. A typical detector is included in Fig. 4. The series tuned circuit, C_{13} and L_2, filters out the desired frequency (see table for values), and the transistor Tr 6 acts as an infinite impedance detector, delivering a direct control voltage at the emitter, which may be amplified and used to control the desired function. An a.g.c. arrangement, Tr 4, is also included. If a negative voltage is applied to the base of this transistor it will conduct, thus shorting out some of the amplified signal at the output from the high impedance amplifier, Tr 3. The emitter follower, Tr 5, delivers a low impedance output to the filters, thus reducing mutual interaction.

The pick-up coil in Fig. 4 is a short length of Ferroxcube rod (type A2 or A4 material) wound with 1,500 turns of 48 s.w.g. wire.

A non-reversing drive circuit for the propulsion motor is shown in Fig. 5. The output from the detector is amplified in Tr 1 and applied to the emitter follower, Tr 2, with the motor as load. A drive using a tapped

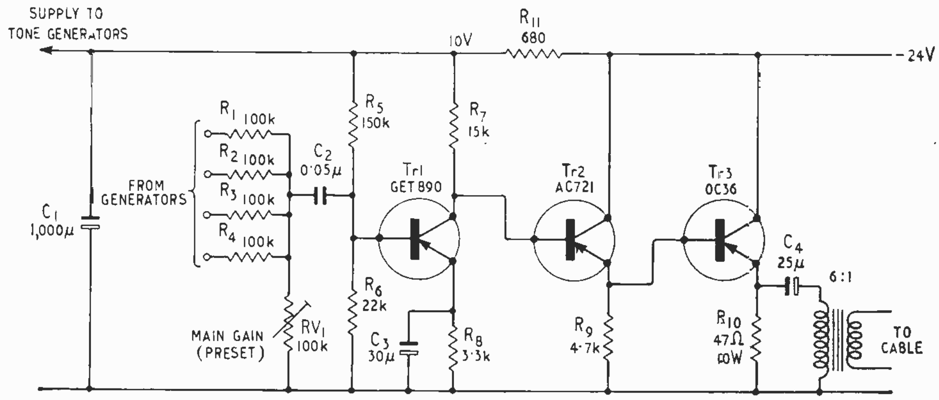


Fig. 3. Circuit of control amplifier (common to all tone generators) feeding the cable.

TUNED CIRCUIT DATA

In the car receiver L_2 consists of 2,000 turns of 48 s.w.g. single enamel coated wire wound on a Mullard Vinkor Type LA 2702 core. The tuning capacitances, C_{13}, are then as follows:—

Model and function	Frequency (c/s)	Value of C_{13} (μF)
Mk. I, a.g.c.	800	0.056
Mk. I, steering	1,300	0.021
Mk. I, speed	1,800	0.011
Mk. 2, full left	2,300	0.0068
Mk. 2, full right	2,800	0.0046

In the control panel tuned circuits (Fig. 8), similar L and C values to those in the car can be used.

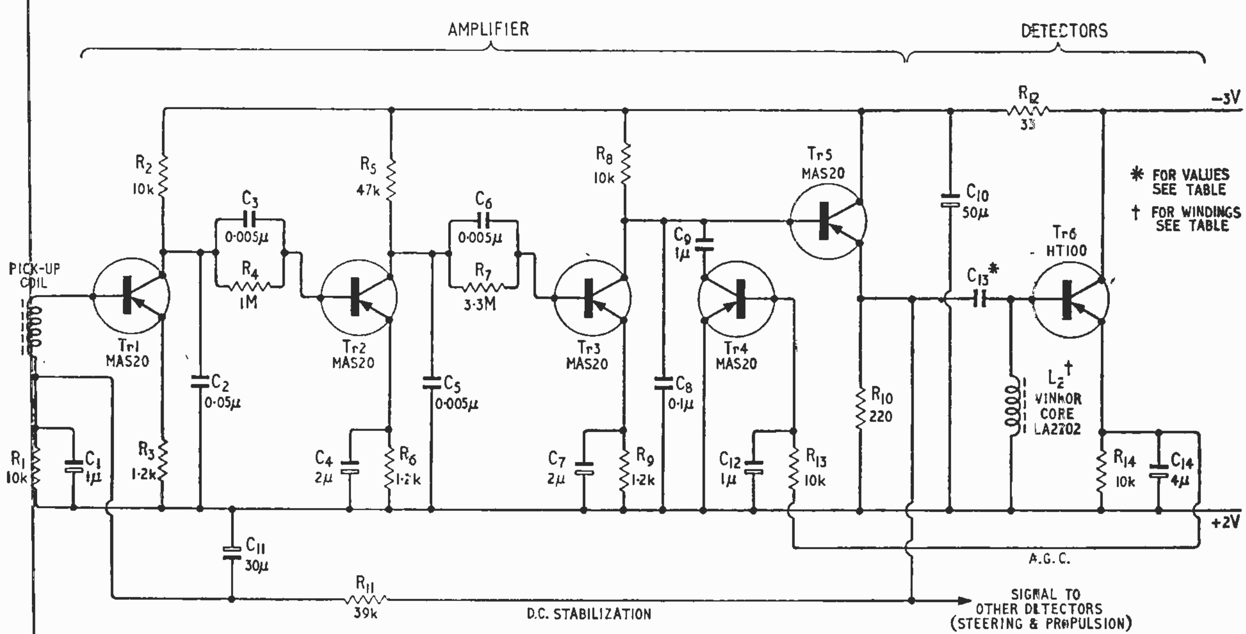


Fig. 4. Receiver circuit for the cars. D.C. control voltages are taken from the emitters of the steering and propulsion control detectors corresponding to Tr6.

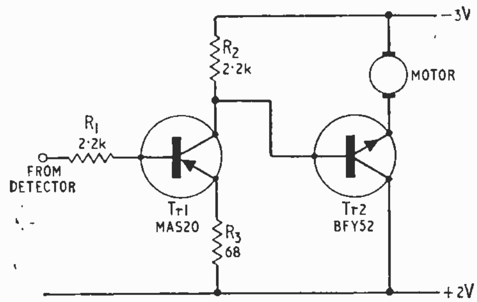


Fig. 5. Circuit of non-reversing drive for cars.

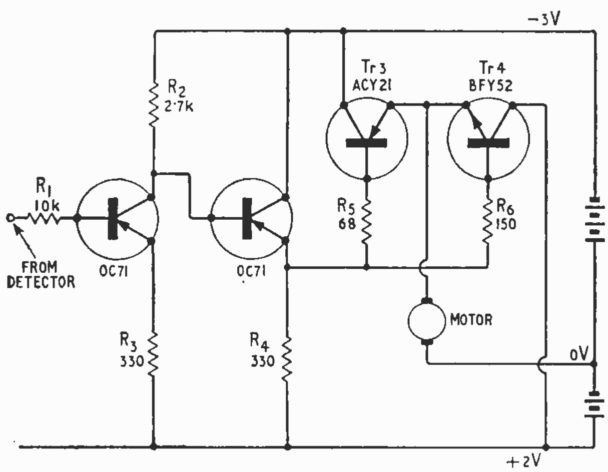


Fig. 6. Reversing drive circuit for cars.

battery to secure reversing is shown in Fig. 6. When the amplitude of the control tone is low the control line feeding the common base drive of the complementary pair of transistors, Tr 3 and Tr 4, will be negative, and Tr 3 will be conducting. When the control tone is at maximum, the control line will be positive, and Tr 4 will conduct. At intermediate levels of the control tone the common emitter point of Tr 3 and Tr 4 will be intermediate in voltage. Thus proportional bidirectional control of the motor is achieved.

Model with controlled steering (Mk. 1).—The first model to be described (Fig. 7) uses two control channels for steering and speed (non-reversing) respectively, together with a third a.g.c. channel. The tone generators are identical, except for the value of the tuning capacitance (C_9 in Fig. 8), and have proved very stable in frequency. The amplitude of the output is controlled by the potentiometer, RV_1. The frequencies used are 800 c/s for the a.g.c. tone, 1,300 c/s for the steering control, and 1,800 c/s for the speed control.

In the vehicle, which was based on a 1/24th scale model of a sports car, the receiver of Fig. 4 is used with the circuit of Fig. 5 controlling the propulsion motor. The circuit of Fig. 6 controls the steering, driving a Graupner Bellamatic II actuator, which is equipped with heavy self-centering springs so that the steering motor is allowed to stall against these springs for small angles of steering. At full lock, an integral slipping clutch prevents damage to the steering motor. The maximum scale speed of this model is about 100 m.p.h., and an adjustment of steering from lock to lock takes about 0.25 second. Five DEAC type DK450 nickel-cadmium rechargeable cells give a running time of about forty minutes.

Simplified model (Mk. 2).—The steering actuator for the first model, Mk. 1, is expensive and occupies a fairly large volume. In the second model each rear wheel is driven by a separate motor, with its own control tone, and steering is effected by energizing these differentially. A third, castor mounted, wheel in the nose automatically follows the changes of direction resulting from the differences in speed of the driving wheels. The two visible front wheels are dummies and do not touch the ground. This technique allows 1/32nd scale models to be easily built.

In the receiver, a.g.c. is not used, but otherwise the circuit of Fig. 4 is used, together with two driving circuits, Fig. 5, modified as shown in Fig. 9 to provide rapid deceleration of a de-energized motor. Normally, when Tr1 is conducting, its base is slightly positive relative to its emitter, and Tr2 is accordingly cut off. When drive is removed, however, the base of Tr2 is negative with reference to its emitter, which is held positive by the back e.m.f. from the motor. Tr2 is thus bottomed, and the armature of the motor is effectively short circuited, and thus rapidly decelerated.

For its power supply the Mk. 2 model uses a non-tapped battery of 3.75 V nominal output, and this suits the 3 V max. requirement for the drive motor. In this case the +2 V line is earthed and the receiver (Fig. 4) and driving (Fig. 5) circuits operate between earth and −3.75 V. The chassis of the car is left floating.

The motors are Graupner type 03/60, geared 60:1, and give a maximum scale speed of about 60 m.p.h. The steering is naturally effective only when the vehicle is in motion, and reversing is not possible because of the pivoted wheel, but within these limitations the vehicle handles well. A rear view is shown in Fig. 10. A

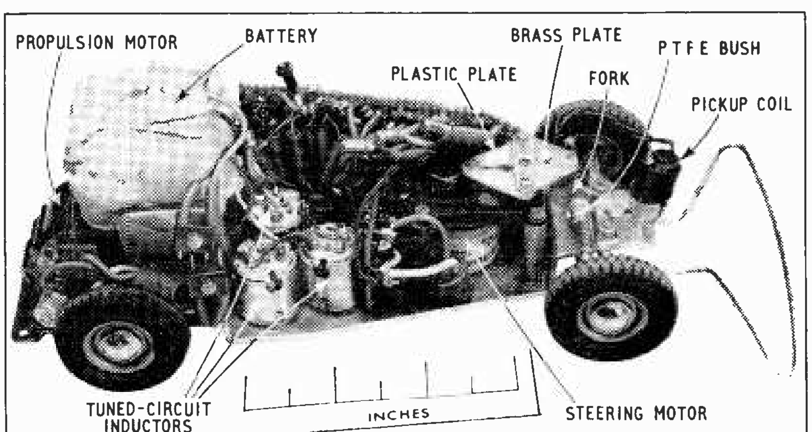


Fig. 7. Model with conventional steering by actuator. The pick-up coil is just ahead of the front wheels (right). The wire structure in front of them is a bumper. The large battery is mounted between the rear wheels.

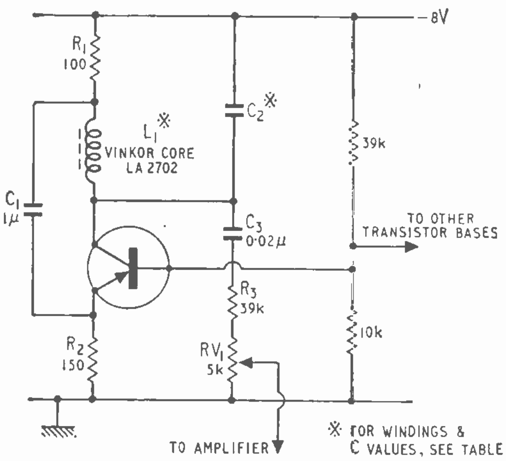


Fig. 8. Audio frequency control tone generator.

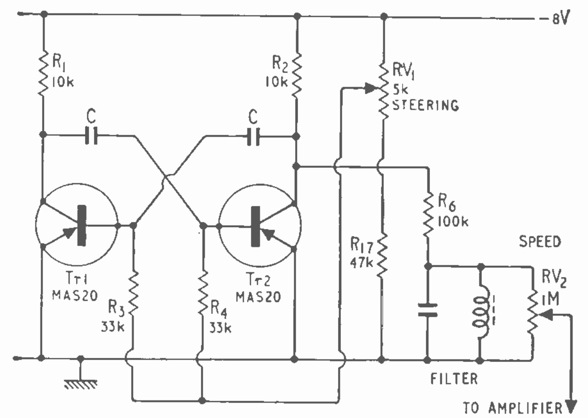


Fig. 11. Control tone generator for simplified model in Fig. 10. Capacitors C are about 0·01μF and can be found by experiment, as can the L and C values of the filter (using a Vinkor core for the inductor).

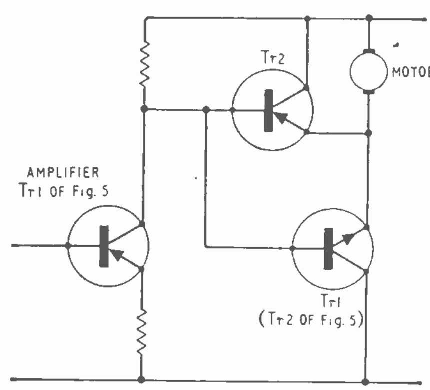


Fig. 9. Braking circuit.

battery of three DEAC type 225 DK cells gives a running time before recharging of about 60 minutes.

For the control tone generator for the second model, although it would be quite possible to use two generators of the type shown in Fig. 8, with the potentiometers RV_1 ganged differentially, a simpler scheme is shown in Fig. 11, where a voltage controlled oscillator generates a frequency between 2.3 kc/s and 2.8 kc/s, which is passed via a filter tuned to 2.55 kc/s to the common amplifier. The two channels in the model are tuned to 2.3 kc/s and 2.8 kc/s respectively. Thus for a full left turn, the control tone is transmitted at 2.3 kc/s, for straight ahead at 2.55 kc/s, and for full right at 2.8 kc/s. The speed of the model is controlled by the amplitude of the control tone. The 2.55 kc/s filter ensures that the transmitted voltage is increased to overcome the reduced response of the model's filters at the mid-frequency.

The transistors in the models are selected for small size. Any small transistor will serve in the amplifier, and one of the new plastic encapsulated types such as the Texas Instruments 2N3702 would be very suitable. Tr 6 in Fig. 4, however, must be selected for low leakage current, and should therefore be a silicon type, such as a 2N3702 again, or the HT 100 as shown in the circuit diagram. The transistors in the control panel are normal types.

The control box contains appropriate equipment to control both models, i.e. three circuits of Fig. 8, one of Fig. 11, and one of Fig. 3, together with a normal power

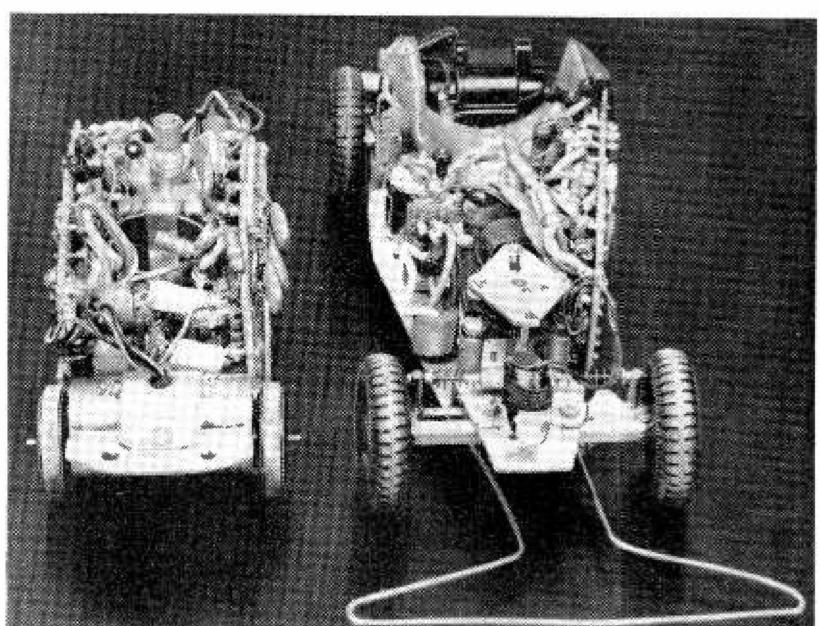


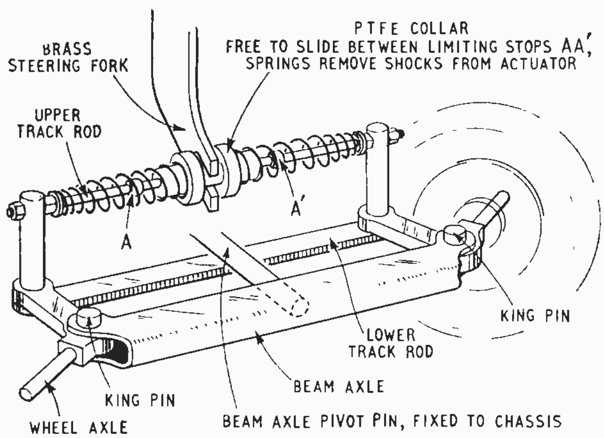
Fig. 10. (Left) Rear view of the simplified model with steering by differential drive to rear wheels. The battery fits in the circular holder amidships. In this model the drive motors are not equipped with spring mounting. (Right) Front view of the Fig. 7 model.

supply delivering −24 V at about 1.5 A. A constant-current charger is also provided for recharging the DEAC batteries used on the models; this provides 22 mA for the 225DK battery used on Mk. 2, and 45 mA for the DEAC DK450 battery used on Mk. 1. Recharging times are about 10-15 hrs from fully discharged, and therefore a switch is provided so that the electronic circuits can be switched off if the control unit is needed for charging only. The accelerator and steering controls are fitted with knobs that can be distinguished by touch.

Operation.—The two models described have now run for several tens of hours and have performed satisfactorily. The precision of control is limited by the operator rather than by the vehicles themselves, and it takes several hours practice to become proficient in handling the cars.

NOTES ON MECHANICAL CONSTRUCTION

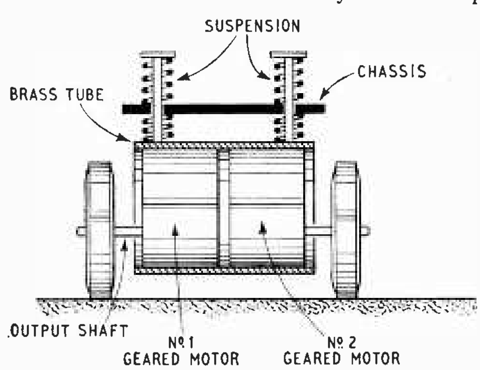
Mk. 1 model.—The general arrangement of the Mk. 1 steering system may be followed from the accompanying sketch and Figs. 7 and 10. The Graupner Bellamatic II steering motor is mounted as shown. To the plastic plate supplied with the mechanism is attached a brass plate with a fork, which engages with the spring loaded



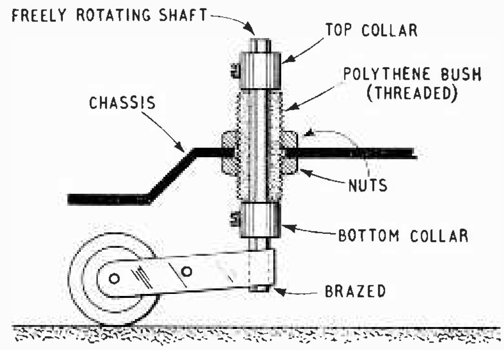
upper track rods, which are joined at their extremities to the firm lower track rod, supplied with the model. The whole front axle assembly is mounted on a single central pivot, so that it can accommodate itself to rough surfaces.

The model is driven on the near side rear wheel only by a Mighty Midget motor (made by Victory Industries (Surrey) Ltd., of Guildford, Surrey).

Mk. 2 model.—The two propulsion motors (Graupner type T03/60) are mounted back to back in a brass tube, which is mounted onto the chassis by means of springs,



so that the whole tube can absorb shocks, etc. (As a three-wheeler suspension is used, springing is not primarily necessary to hold the wheels in contact with the ground on rough surfaces.) The Graupner motors are equipped with integral 60 : 1 reduction ratio gearheads, and the road wheels are fitted directly to the gearhead output shafts. The front wheel is mounted as shown below. In the prototype the height of the shaft, and



hence the clearance given to the dummy front wheels is adjustable, as is the effective length of the castor arm.

The chassis itself is just a sheet of 12 s.w.g. Dural, bent up at the sides for stiffness and at the ends to pick up the mounting points of the model body.

All the mechanical components may be obtained from RipMax Ltd., 39 Parkway, London, N.W.1 (Tel: Gulliver 1818).

THE MONTH'S CONFERENCES AND EXHIBITIONS

Further details are obtainable from the addresses in parentheses

LONDON

July 4-6 — Imperial College
The Economics of Automated Materials Testing
(Inst. Phys. & Phys. Soc., 47 Belgrave Sq., London, S.W.1)

July 6-12 — Olympia
Ships' Gear Exhibition
(Brimtex Ltd., 3 Clements Inn, London, W.C.2)

July 11-14 — Imperial College
Applications of Thin Films in Electronic Engineering
(I.E.R.E., 8-9 Bedford Sq., London, W.C.1)

BRISTOL

July 7-8 — The University
Spectroscopy and Automation
(Inst. Phys. & Phys. Soc., 47 Belgrave Sq., London, S.W.1)

GLASGOW

July 7-8 — University of Strathclyde
Chemically Grown Surface Films
(Inst. Phys. & Phys. Soc., 47 Belgrave Sq., London, S.W.1)

LEEDS

July 10-22 — The University
Microwave Techniques (Summer School)
(I.E.E., Savoy Pl., London, W.C.2)

ABROAD

July 3-8 — Warsaw
International Measurement Conference
(IMEKO Secretariat, P.O.B. 457, Budapest 5, Poland)

July 8-24
British Industrial Exhibition
(Industrial & Trade Fairs, 1-19 New Oxford St., London, W.C.1)

July 11-13 — San Francisco
Electromagnetic Compatibility
(A. Fong, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Cal.)

July 11-14 — Seattle
Aerospace Systems
(T. J. Martin, 3811 E. Howell St., Seattle, Wash.)

Anglo-American Defence Communications

USING SPACE "JUNK" AND NON-SYNCHRONOUS SATELLITES

A RECENT visit to the Signals Research and Development Establishment at Christchurch, near Bournemouth, the site of the first of three ground stations being built by the U.K. for the U.S. Initial Defence Communications Satellite Project, disclosed some interesting facts regarding the Anglo-American experimental defence communication project. Although a cloak of security covers some of the research work being carried out, especially as regards detailed technical information, one intriguing aspect discussed was the use of the moon and space "junk" as passive communication satellites. Space junk is the term used for the various "dead" objects in orbit round the earth including for example defunct satellites and the final booster stages of rockets. There are about 900 in orbit but apparently only about 200 are suitable for reflection of signals.

Flashing

Paths of signals transmitted in a beam width of 0·25° from the ground station obey to a very close approximation the laws of geometric physics. It was disclosed that the received signal power was normally in the order of pW, but if the object—which is continually turning—happened to be in a particular orientation during the reflection of a signal, a phenomena termed "flashing" occurred. This causes a mirror-like reflection of the signal and a large increase in the power of the received signal is evident. Apparently, this phenomena has been investigated by using specially shaped objects (possibly a spheroid) to give continual flashing but pitting of the surface caused by meteorites prevents full use of the optical effect.

The ground station

The ground station, designed and constructed by the Marconi Company in 12 months and believed to have cost about £1·5M, will work in conjunction with six or eight non-synchronous active satellites (life expectancy of three to four years) to be launched from Cape Kennedy later this summer. However, the station has already proved itself by bouncing 200 message elements a second off the moon or space junk. Some idea of the directional accuracy of which the equipment is capable is given by the fact that at an altitude of about 400 miles it is possible to detect a reflecting surface of about $0{\cdot}1m^2$.

The ground station has been designed to be fully transportable and it takes only about 48 hours to assemble. Each station comprises a fully steerable dish aerial with a number of separately mounted containers housing the transmitter, its power supply and cooling system and control and computer equipment. The aerial system consists of a 40ft diameter paraboloid, with a focal length of 12 feet and a surface accuracy of better than 10 thousandths of an inch within 20ft of the centre, increasing progressively to 25 thousandths of an inch at the edge.

The base of the support structure contains a circular track, running on six bogie units rigidly attached to the ground and which allow the complete aerial to be driven in azimuth. The aerial can be turned in elevation through an arc of 320° and in azimuth through an arc of 350°. Cables are run through the two planes of rotation without the use of slip rings. The transmitter power supply and cooling system are mounted in two units in the base of the aerial structure and they rotate in azimuth with the aerial. The transmitter is a five-stage, cavity klystron, driven by a travelling-wave tube amplifier. The output from the klystron passes through a waveguide to a rotating coaxial joint in the elevation mounting, and then to a horn feed assembly at the centre of the dish aerial. A cassegrain feed system is used, with a hyperbolic sub-reflector mounted at the focus of the dish. Energy from the feed horn is then reflected from this hyperboloid on to the main dish. Four separate waveguide horns in the aerial system are fed into a waveguide network which produce a signal from the sum of the four input signals. Two difference signals, are also derived from pairs of horns in two planes at right angles and the dish is automatically controlled to direct itself until 0° phase occurs between the two horns. These three outputs are then amplified by two-stage cryogenic parametric amplifiers operating at 20°K (−253°C) and mounted directly on the backing structure of the dish aerial together with mixer stages for the three channels.

Intermediate frequency signals of 70 Mc/s are then routed by coaxial cable to the control container, where after further amplification and demodulation, the final communication output is produced. The outputs of the two difference channels are used in a servo system to provide automatic tracking, i.e. the dish locks on to the satellite after the initial acquisition. Tracking information derived from the receiving system, is translated into suitable co-ordinates to control the motors which drive the aerial in these two planes of rotation as required. The dish together with transmitting, receiving and control equipment is housed in a double-walled, inflated radome approximately 60ft in diameter and 60ft high and is strong enough to support a weight of about two tons.

The station has been designed to operate as part of a larger system of satellite links, and a Marconi Myriad computer performs a major function in ensuring continuity of operation in multiple satellite systems, particularly during the hand-over of high-speed digital data transmission from one random-orbit satellite to another. All traffic will pass through the computer which will insert a variable path delay, depending on the position of the satellite, to produce a constant total path delay, irrespective of the actual distance of the satellite from the ground station and it will be possible to transfer high-speed digital data traffic from one satellite to another without any break in the transmission.

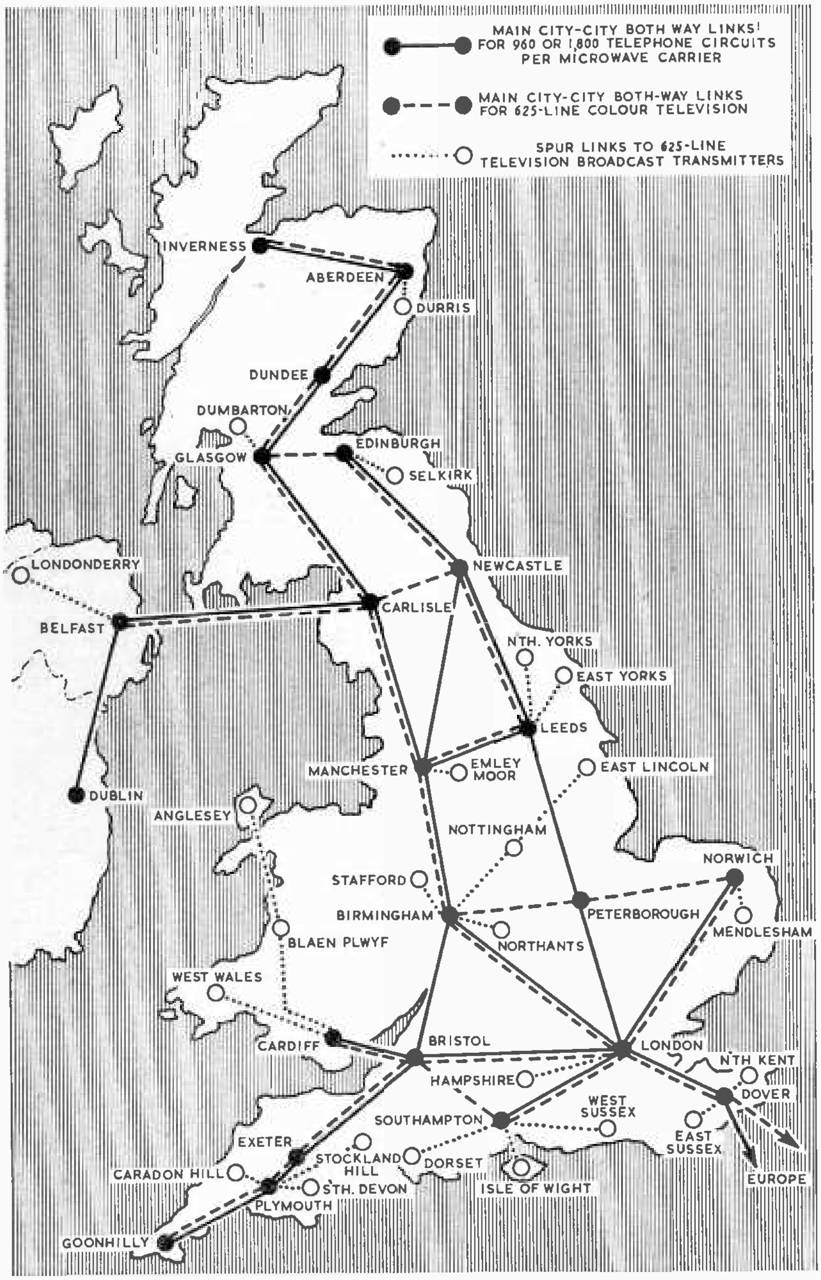
The computer may also be used to control the acquisition of new satellites appearing over the horizon. In this role, orbital prediction data would be supplied for each satellite, and fed into the computer in the form of a paper tape from which initial information for directing the dish would be required. When signals have been received the system would revert to the auto-tracking mode, using error information derived from the horns.

In addition to the earth station itself an experimental system-control and analysis centre has been set up at S.R.D.E. to co-ordinate the operation of the satellite network.

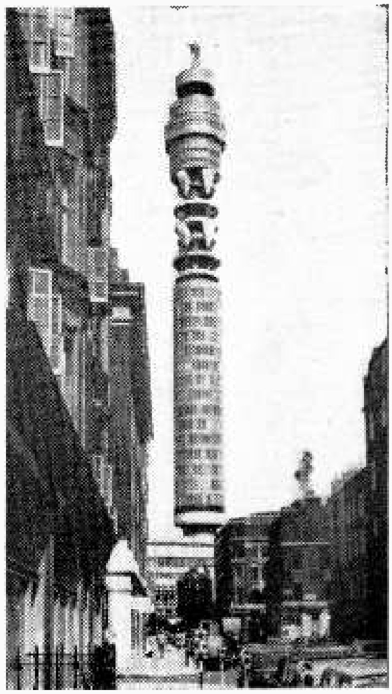
POST OFFICE TOWER

FROM the publicity given in the lay press to the recent official opening of "The G.P.O. Tower" it would appear that it has been built primarily, if not exclusively, to give visitors a bird's-eye view of London while enjoying a meal in the slowly revolving restaurant some 500 ft above street level. The fact is that the restaurant and public observation galleries were an afterthought which necessitated modifications to the original plan in order to accommodate them above the aerial galleries which initially were to top the tower.

Primarily, of course, the tower was



To meet expected trunk telephone and television traffic the Post Office plans this microwave network for 1970. Relay stations at intervals of 25-30 miles are being built along each route.



The new landmark on the London skyline. On the right of the new 580 ft Tower is the 150 ft lattice mast and paraboloids which it replaces.

conceived as the hub of what will eventually be a national radio telecommunications network which by 1970 will be able to handle as many as 150,000 simultaneous telephone conversations and up to 40 television channels.

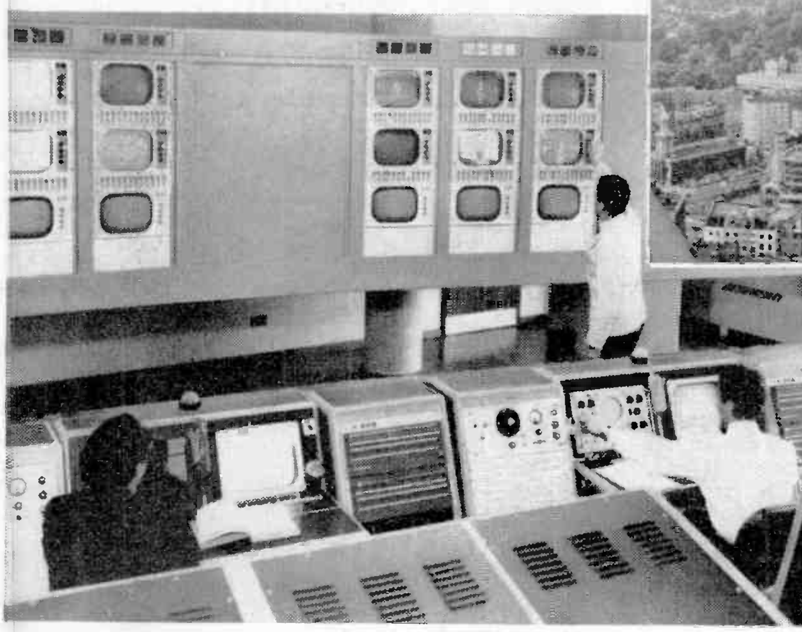
Below the galleries for the horn and paraboloid aerials are 15 floors on which are housed the radio and line equipment. The floor immediately below the aerial galleries is used mainly for routing the waveguides and cables from the aerials to the equipment floors below on each of which are radio transmitters and receivers in a descending order of frequency from 11 Gc/s to 2 Gc/s. It is interesting to record that with the advent of solid-state equipment it has been necessary to provide space on one of the floors for 24- and 50-volt batteries.

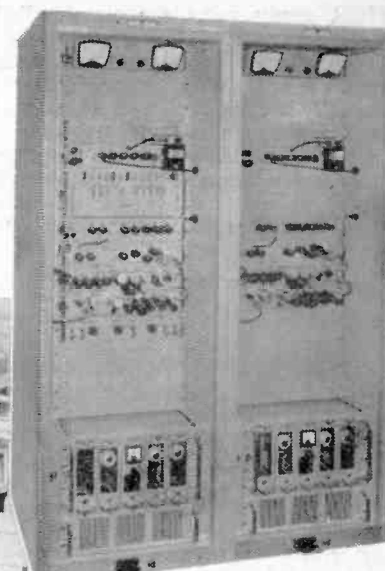
The first link to be brought into service was that to Birmingham which operates in the 7 Gc/s band and initially provides 5,400 telephone channels and three 8 Mc/s television channels.

In addition to providing the focus for the country's telephone network the Tower also houses the London switching centre for the television network. Although both the B.B.C. and I.T.A. are responsible for providing and operating their own transmitters the links between studios and transmitters and between the stations in each network are provided by the Post Office. Because the B.B.C. network is essentially national the amount of switching from region to region is small, but in the case of I.T.A., each programme contractor is free to sell or buy programme material from any other contractor and therefore the number of changes in interconnecting links required by the I.T.A. is considerable.

Fixing one of the horns, supplied by G.E.C., on the aerial gallery.

Control room of the Television Switching Centre in the Tower.

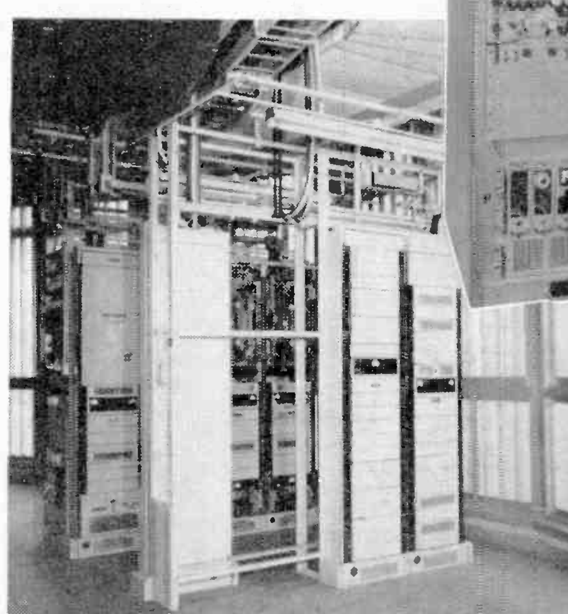




A Pye microwave (6-8 Gc/s) transmitter and receiver as supplied for the Tower.

The Post Office, through the network switching centre, provides circuits for organizations who perform specialized work (such as videotape recording) for the various programme companies. It may not be realized that there are permanent cable links from the London switching centre to over forty studios, centres of entertainment and programme contractors' offices in the area. The input to and the output from all these points are routed through the switching centre. In fact, the new control room in the London switching centre is the focal point of well over 100 incoming and outgoing vision links, in addition to which there are 250 sound and 300 control lines.

One little known aspect of the work of the switching centre is its use in the educational television scheme introduced by the Greater London Council. It will provide over 1,300 schools in the G.L.C. area with six educational television channels.



Typical racks of transmitting and receiving gear on one of the equipment floors (G.E.C. photograph).

The Diode-transistor Pump

PRINCIPLE OF PUMP OPERATION, APPLICATIONS AND A USEFUL CIRCUIT

By D. E. O'N. WADDINGTON, A.M.I.E.R.E.

The principles of the diode and diode-transistor pump are outlined. A diode-transistor pump and limiter circuit using silicon transistors and developed by the author is given. The circuit may be used as a discriminator in f.m. receivers giving very low distortion, and requiring only 10 mV for proper limiting, or as a frequency meter, the response extending up to around 1 Mc/s. Other applications of the diode-transistor pump are also discussed.

FOR many years the simple diode pump has been known and used in applications where an untuned frequency to voltage converter or frequency divider has been needed. With thermionic valve circuits it has, generally speaking, proved adequate but with the lower supply voltages usual with transistor circuits, it no longer supplies a sufficiently linear output. This has led to a fuller appreciation of the action of the diode pump and, hence, to the development of several diode-transistor pump circuits which out-perform the original circuit.

The diode pump

In its most basic form, the pump principle is as follows (see Fig. 1). The first half cycle of the input signal causes the pulse standardizing circuit to produce a pulse containing a fixed amount of energy, e.g. CV. This energy, or a proportion of it, is then transferred either automatically (or by using the second half cycle of the input signal to operate a switch) to a reservoir where it is stored. For use as a frequency-to-voltage converter, a discharge path is added which drains the reservoir at a rate dependent upon the level of energy stored in it. Thus, the voltage developed across the discharge path will be directly proportional to the rate at which the pulses are generated, i.e. the input frequency.

The practical implementation of this principle is very simple. In the diode pump (see Fig. 2), the pulse standardizer is a diode and capacitor (D1 and C_1), the energy transfer mechanism is a diode D2, the reservoir is a capacitor (C_2) and the discharge path is a resistor (R). The full action of this circuit may be analysed as follows. The input square wave is simulated by means of S_1. When the switch is in position 1, D2 is reverse biased but D1 switches on allowing C_1 to charge up to the supply voltage thus storing a charge of VC_1. (For the purposes of simplicity, the effect of the forward voltage drop across the diodes is neglected. In practice, this voltage is only a very small proportion of the supply voltage.) When S_1 is moved to position 2, D1 is reverse biased and D2 conducts allowing the charge on C_1 to be shared between C_1 and C_2. C_2 will now charge up to a voltage $e=VC_1/(C_1+C_2)$. When S_1 is returned to position 1, C_1 is again charged to VC_1. When S_1 is again moved to position 2, charge sharing takes place once more but, as C_2 already has a charge of $VC_1C_2/(C_1+C_2)$, the total charge to be shared is $VC_1+VC_1C_2/(C_1+C_2)$. Thus the voltage across C_2 will now be:—

$$e=\frac{VC_1}{C_1+C_2}\left(1+\frac{C_2}{C_1+C_2}\right)$$

A third cycle will produce a voltage of across C_2 of:—

$$e=\frac{VC_1}{C_1+C_2}\left[1+\frac{C_2}{C_1+C_2}+\left(\frac{C_2}{C_1+C_2}\right)^2\right]$$

Hence it may be shown that the voltage across C_2 after n cycles will be:—

$$en=\frac{VC_1}{C_1+C_2}\left[1+\frac{C_2}{C_1+C_2}+\left(\frac{C_2}{C_1+C_2}\right)^2+\ldots+\left(\frac{C_2}{C_1+C_2}\right)^{n-1}\right]$$

$$\text{or}\quad en=V\left[1-\left(\frac{C_2}{C_1+C_2}\right)^n\right]$$

From this expression it is readily seen that the increment in output voltage, due to each input cycle, is less than the previous one by an amount proportional to the charge already present on C_2. Thus, the relationship between the number of input cycles and the output voltage will be non-linear.

When the resistor, R, is connected across C_2, the circuit becomes a frequency to voltage converter. It may be shown[1] that in this case

$$e=fRC_1(V-e)$$

$$\text{or } e=V_1 f\frac{C_1R}{1+fCR},$$

a non-linear relationship similar to that obtained above. However, if e is made a small proportion of V, the equation

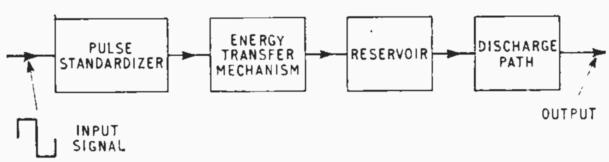


Fig. 1. Basic pump arrangement.

approximates to $e = f\,C_1RV$. Practical tests have been made[2] using this circuit as the frequency discriminator of an f.m. receiver and the distortion introduced due to discriminator non-linearity has been claimed to be less than 0.1%. This was achieved by using an input voltage of the order of 150 V pk-pk and an output of less than 1 V pk-pk. Thus, while this circuit was adequate when used with thermionic valves, where the high voltages may relatively easily be obtained, with transistors, the output voltage to retain linearity would generally be very low.

Diode-transistor pump

In order to improve the linearity of the circuit, a simple modification may be carried out[3] (see Fig. 3). The diode D2 is replaced by a transistor, the base of which is connected to the junction of D2 and C_2. This transistor acts as an emitter follower and causes the voltage at B to follow the voltage at C fairly closely. This permits C_1 to always charge to $V+e$ thus ensuring that, during the charge sharing process, C_2 receives the same amount of additional charge each cycle and hence the frequency-voltage characteristic will be linear, i.e. $e = f\,C_1RV$.

A more advanced form of diode-transistor pump[4] is shown in Fig. 4. The operation is similar to the simple diode pump but *charge transfer* takes place instead of *charge sharing*. When S_1 is in position 1, D1 conducts and a charge VC_1, is stored in C_1. When S_1 is in position 2, C_1 is discharged through the emitter-base diode of Tr1. The actual charge which will be conducted through this diode will be C_1Vf coulomb/sec (i.e. the current will be C_1Vf amperes) and, as the common base current gain of a transistor approximates to 1, the collector current will be C_1Vf amperes. Thus, the voltage drop across R will be C_1VfR, the same result as was achieved in the previous circuit. This circuit has the advantage, however, that the output circuit is entirely isolated from the input.

It is also interesting to note that, whereas the output of the simple diode pump circuit is limited to the peak-to-peak value of the input signal, the maximum output of the diode-transistor pump depends mainly upon the supply voltage to the collector of the transistor. Thus, by using a supply voltage of 100 V and a transistor having a V_{CBO} rating in excess of this, it would be possible to obtain an output of up to 100 V more or less regardless of the peak-to-peak value of the input signal.

Applications

The uses for this type of circuit are many and varied as the following examples show.

Frequency discriminator

Recently[5,6] the use of pump-type discriminators in f.m. receivers has aroused a certain amount of interest. Table 1 gives a comparison between pump and tuned circuit discriminators. From this it is seen that the pump has considerable advantages. Probably the only reason why it has not been generally exploited in commercial radio receivers is that the components necessary may prove more expensive, particularly as a low intermediate frequency is essential for efficient operation.

The circuit shown in Fig. 5 is an example of a practical discriminator using the diode–transistor pump. The input amplifier (Tr1) serves the dual purpose of providing a reasonable input impedance (about 1 kΩ) and of converting the signal into a suitable form to drive the limiter. As the gain of this stage is relatively unimportant, no negative feedback has been applied to it. The signal from

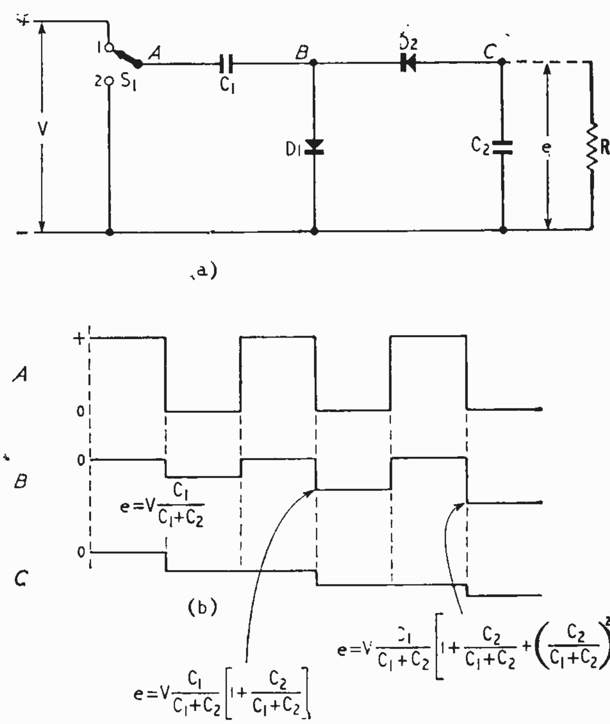


Fig. 2(a). Simple diode pump circuit. S_1 simulates a rectangular wave input. (b) Voltage waveforms at points A, B and C in (a).

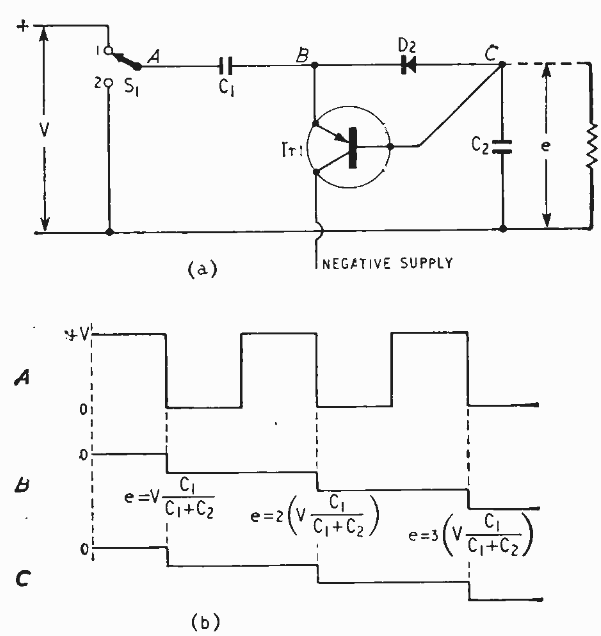


Fig. 3 (a). Diode-transistor pump (original version). D_1 is replaced by theemitter follower Trl so that the voltage at B follows that at C. (b) Voltage waveforms at points A, B and C in (a).

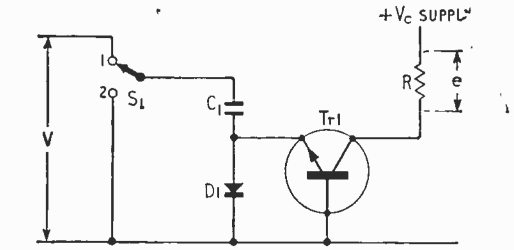
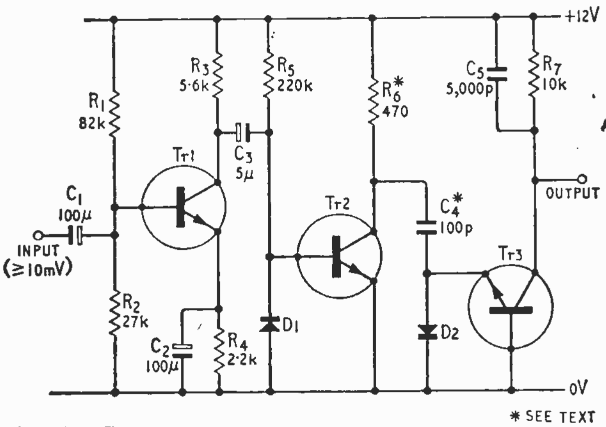


Fig. 4. A more refined version of the diode-transistor pump.



Tr1,Tr2,Tr3
ST 53
BC 108
BCY 42
BFY 12
PEP 5
TI 416
ZT 80
2N 706
2N 914
2N 2926
2N 3708
2S 512

D1, D2
IS 44
IN 914
ZS 140
SD 10
BAY 31
BAY 38
BAY 41

***Fig. 5.** Practical discriminator circuit. For use in f.m. receivers, C_1, C_2 and C_3 may be reduced to 0.1µF, 0.1µF and 0.01µF respectively. 2N2926 transistors (coded red) are obtainable from Amatronix Ltd. at 306 Selsdon Road, Croydon for 5s. each.*

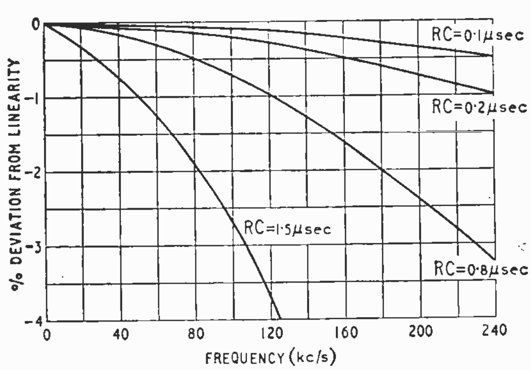


Fig. 6. Effect of charging time constant on linearity.

TABLE I.—RELATIVE MERITS OF PUMP AND TUNED DISCRIMINATOR CIRCUITS

	Pump Discriminator	Tuned Discriminator
Linearity	Good linearity is an inherent characteristic of the diode-transistor pump and the introduced distortion may be less than 0.1%.	Function of the accuracy with which the circuit has been set up.
Bandwidth	Limited only by switching speeds, design limits, stray capacity effects, etc. Bandwidths of up to 50 Mc/s have been achieved with experimental circuits.	Generally speaking, proportional to the centre frequency and is usually fairly restricted, although large bandwidths may be obtained at frequencies in the v.h.f./u.h.f. range.
Output level	The output voltage is proportional to the intermediate frequency chosen and thus the modulation signal will be a proportionate fraction of this voltage. In practice, this means that a relatively low i.f. must be chosen.	Virtually independent of the centre frequency.
Other Comments	No setting up required.	Setting up is a specialised procedure, usually requiring the services of a skilled operator.

the collector of Tr1 is fed *via* C_3 to the base of Tr2. Its amplitude is sufficient to switch Tr2 on and off, and the diode D1 ensures that the mark to space ratio of the switching waveform remains approximately 1:1. Thus a square wave having an amplitude very nearly equal to the supply voltage will appear at the collector of Tr2. This signal is then fed to the diode-transistor pump circuit which consists of C_4, D2, Tr3, C_5 and R_7.

In order to assess the linearity of the discriminator, the charging time constant R_6C_4 was varied. The graph, Fig. 6, shows the sort of variation to be expected. In practice, it appears that a time constant 1/50 of the period of one cycle of the highest input frequency to be encountered, is necessary in order to achieve less than 0.5% deviation from absolute linearity. However, from the curves it is possible to calculate[7] that the distortion which would be caused by 0.5% non-linearity would be approximately 0.044% second harmonic, 0.003% third harmonic and 0.006% fourth harmonic. Unfortunately, it is almost impossible to prove these figures at present as f.m. signal generators with distortion of this order are still a designer's dream. However, even if these figures are out by a factor of 10, the performance should be good enough to satisfy the most fastidious listener.

Frequency meter

This is an obvious development from the frequency discriminator. Thus the circuit of Fig. 5 may be adapted, as shown in Fig. 7, to provide a direct reading frequency meter. The main change is that the discriminator load resistor is replaced by a meter linearly calibrated in frequency. The required frequency range is then selected by switching the value of C_4. Tests made using the circuit over a frequency range from 10 c/s to 1 Mc/s have shown that an input of the order of 10 mV is all that is necessary to ensure proper limiting.

The accuracy of this type of frequency meter is limited by the meter accuracy and the absolute value of the capacitor C_4. In practice, a reading accuracy of the order of ±5% on the low frequency ranges and ±2% on the high frequency ranges should be fairly easy to attain.

Frequency divider

The diode-transistor pump is very easy to adapt to make a frequency divider, see Fig. 8. The action of the circuit is as follows. Initially, the potential at A is 0 V with the result that Tr2 and Tr3 are both cut off. When the input signal is applied, C_2 acquires a charge each cycle and the voltage at A builds up as shown in Fig. 8(b). When this point becomes sufficiently negative to switch Tr2 on, the collector current of Tr2 switches Tr3 on and the cumulative effect causes Tr2 and Tr3 to bottom, thus discharging C_2 very rapidly.

When the discharge is complete, the potential at A is at its initial condition, i.e. 0 V, so that the circuit is ready for its next operational cycle. It would be possible to replace the switch (Tr2 and Tr3) with a single unijunction transistor[9] but, although this would be ideal for low frequency work, the switching time would be too long for high frequencies (100 kc/s and above).

From the earlier discussion it will be recalled that the amplitude of the voltage steps at A will be proportional to the supply voltage and to the ratio between C_2 and C_1. The switch trigger level is set by the voltage at the junction of R_1 and R_2. Thus, the division ratio may be set by making the potential at A just exceed the switching level after the required number of cycles. In order to avoid spurious switching, the steps should be made as large as possible and the switching level should be chosen to be about midway between two step levels. When these precautions are observed, dividers of this type are very reliable, both over a range of temperatures and a wide range of input frequencies.

Oscilloscope deflection signals

The pump circuit may be used to advantage in applications where it is necessary to produce an oscilloscope, or *x-y* recorder, display[10] which has an axis proportional to frequency. Generally speaking, sweep generators provide an output voltage to perform this function but there are many swept frequency applications where no deflection information is available. The block diagram, Fig. 9, shows a method of connecting the equipment to use a pump discriminator. (The circuit given in Fig. 5 is still applicable.) If the centre frequency of the swept signal is too high to permit the efficient working of the discriminator, a simple heterodyne converter may be used to convert the input to a suitable frequency.

A rather novel application of the pump circuit is its use in the construction of a complete linear time-base system. The block diagram, Fig. 10, shows how this may be done. A 10 Mc/s crystal controlled oscillator is used to provide the time standard for the time base. The output of this oscillator is fed to a frequency divider chain consisting of a series of pump dividers, each dividing by a factor of 10, thus providing outputs at 10 Mc/s, 1 Mc/s, 100 kc/s and 10 kc/s. One output is selected from this section by the switch and fed, *via* a gate, to the final frequency divider which may be set to divide by approximately 100, 200, 500 or 1,000, thus providing a variable frequency output. In order to keep the sweep length constant, the division ratio is set by adjusting the value of C_2 (see Fig. 8). The gate is controlled by a bistable circuit which is switched on by the synchronizing signal and off by the fly-back pulse from the divider. The final frequency divider may be made to "free-run" by disconnecting the reset pulse time, in which case the synchronizing signal will start the time-base running initially and then have no further effect. This time-base system will provide a constant length output sweep having a frequency variable from 10 c/s to 100 kc/s.

Strictly speaking, this is not a linear time-base as the sweep is actually made up of 100 or more equal steps. This will only really distort a sine wave presentation when

METER FULL SCALE	C_4
100c/s	1μF
1kc/s	0·1μF
10kc/s	0·01μF
100kc/s	0·001μF
1Mc/s	100pF

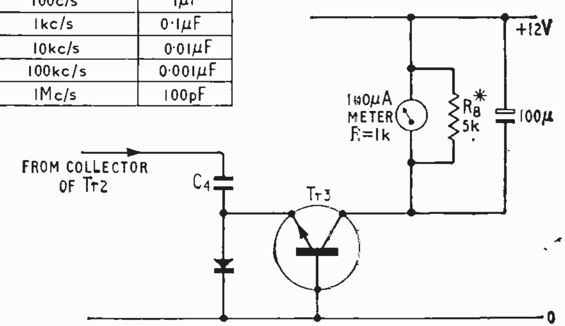


Fig. 7. Frequency meter modification. The value of the 5 kΩ resistor (R_8) should be adjusted so that f.s.d. is obtained with 120 μA collector current through Tr3.

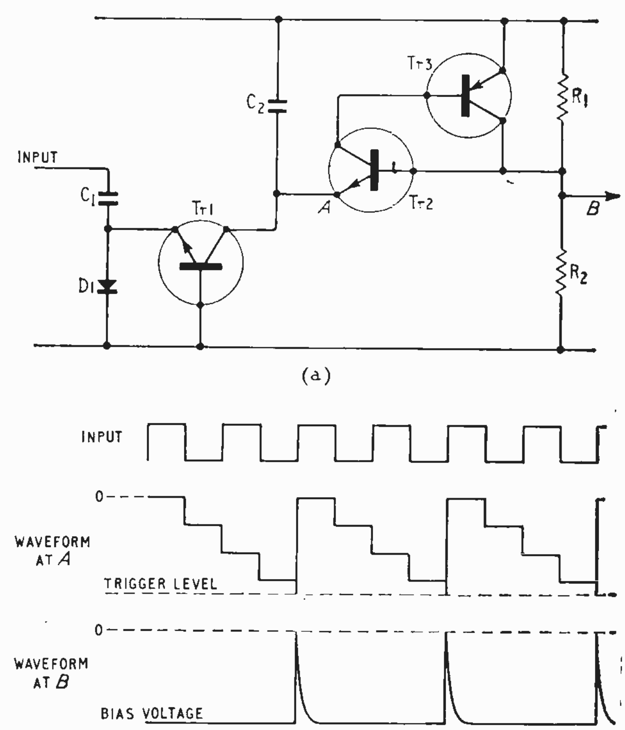


Fig. 8(a). Frequency divider circuit using the diode-transistor pump. (b) Voltage waveforms at points A and B in (a).

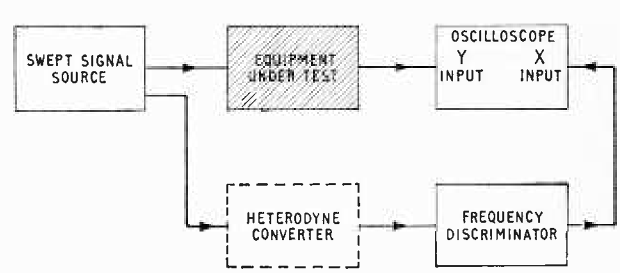


Fig. 9. "Frequency base" generation for oscilloscope displays.

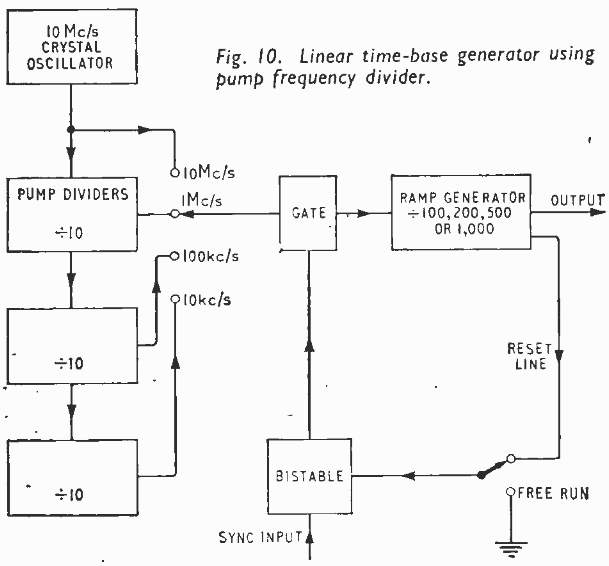


Fig. 10. Linear time-base generator using pump frequency divider.

the input frequency is more than 1/20 of the step rate, i.e., the highest usable frequency in this case will be about 500 kc/s, although higher frequency may be displayed if desired. The advantage of this method of time-base generation is that it is a true " time " base and may thus be used for making precise measurements. By expanding the sweep width sufficiently to permit individual steps to be seen and counted, it becomes a very simple matter to measure both rise time and period.

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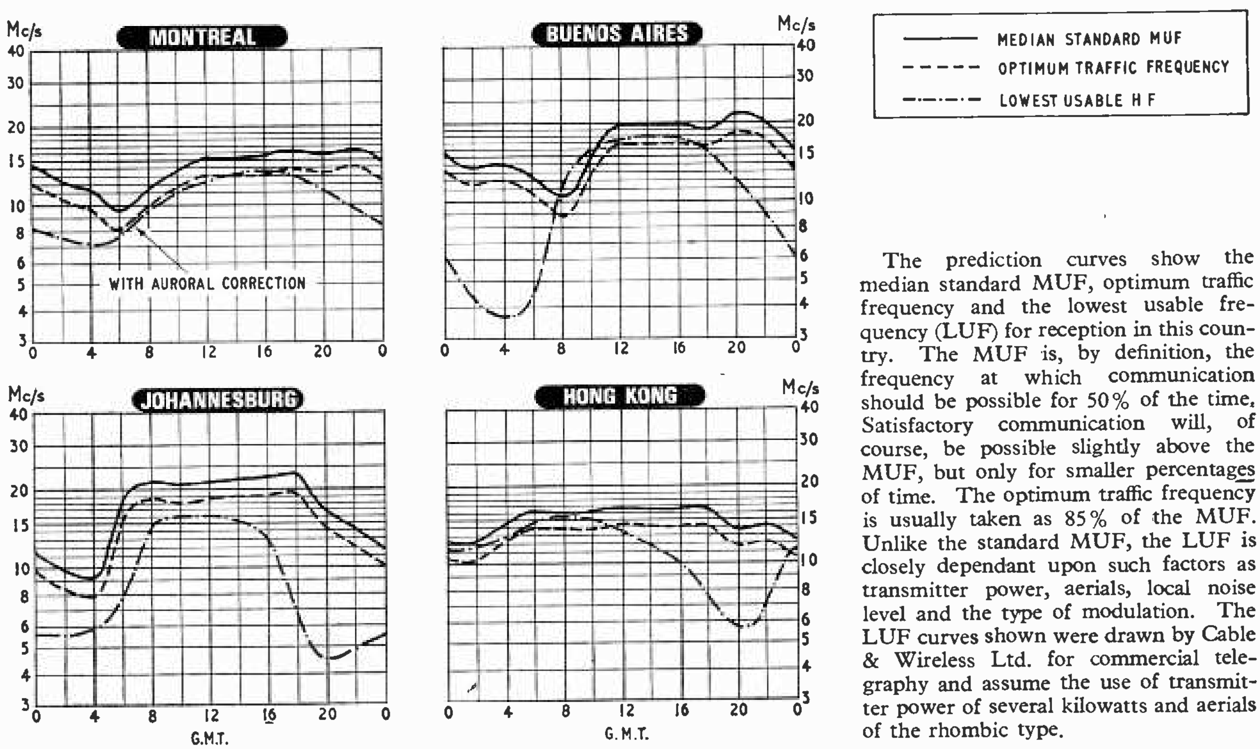
H. F. PREDICTIONS—JULY



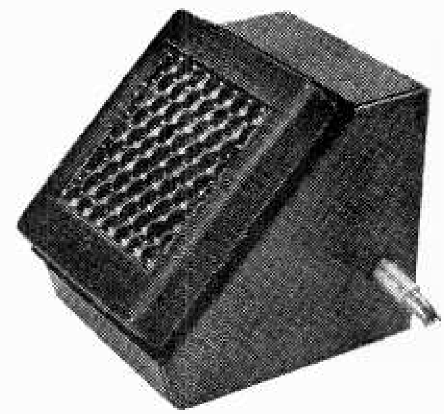
The prediction curves show the median standard MUF, optimum traffic frequency and the lowest usable frequency (LUF) for reception in this country. The MUF is, by definition, the frequency at which communication should be possible for 50% of the time. Satisfactory communication will, of course, be possible slightly above the MUF, but only for smaller percentages of time. The optimum traffic frequency is usually taken as 85% of the MUF. Unlike the standard MUF, the LUF is closely dependant upon such factors as transmitter power, aerials, local noise level and the type of modulation. The LUF curves shown were drawn by Cable & Wireless Ltd. for commercial telegraphy and assume the use of transmitter power of several kilowatts and aerials of the rhombic type.

A Solar Battery Charger

By D. BOLLEN

The ability of solar cells to convert sunlight directly into useful electrical energy has been well demonstrated in satellite applications. An advantage of the solar battery is that it allows true, unattended operation in locations remote from a power supply and, even more important, promises an outstanding degree of reliability. If a solar battery can be arranged, economically, to trickle charge an accumulator, it will then power apparatus which has a low, long-term current demand, such as electric doorbells, alarm systems, and clocks. With a NiCd accumulator, the apparatus could function for many years without any maintenance.

The purpose of this article is to outline some of the problems involved, and describe a solution, in the form of a low cost, solar powered, transistor trickle charger.



The solar battery charger.

THE two main types of solar cell normally encountered are selenium and silicon; both give a maximum open-circuit output voltage of about 0.5 V per cell. Obviously, if an accumulator is to be charged by solar cells then their output voltage must exceed the accumulator voltage. Ordinarily, a bank of at least four solar cells, giving 2 V maximum, is required to charge a 1.2 V NiCd accumulator, in bright sunlight. A dull day will not furnish sufficient energy to keep the solar battery potential above that of the accumulator, unless more cells are wired in series.

Simple circuit

The circuit of a simple charger is given in Fig. 1. The base-emitter junction of a germanium transistor is employed as a diode, to prevent the day's charge leaking back through the solar battery during hours of dull light and darkness. It was found that the junction diode reverse current, under dark conditions with this circuit, was somewhat less than 2 μA, too small to be significant. If a sealed type of NiCd accumulator is charged, such as the Varta Deac, this will give a predicted working life of perhaps 15 years. Even after the accumulator has been replaced, the solar battery will continue to function until its lens becomes darkened by the action of ultra-violet light, and ingrained surface dirt. With a four-cell silicon solar unit, the circuit of Fig. 1 will supply enough energy to operate a low-current doorbell for nearly one minute every day of every year.

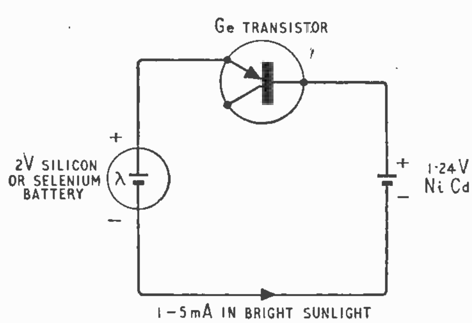


Fig. 1. Circuit of a simple charger.

Sunlight

Fig. 2 gives the rounded curves of average bright sunlight per month, recorded in three places in England over the period 1921-1950. Ventnor and Manchester may be take to represent extremes for the whole of the British Isles. In passing, it is interesting to note that the curves correspond closely to a sine wave. The reader might feel inclined to calculate r.m.s. and peak-to-peak sunlight values for his own particular area. Taking the yearly averages, we can expect from 1,000 to 1,800 hours

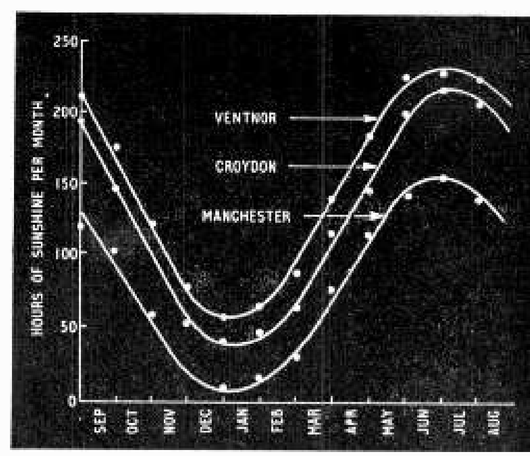


Fig. 2. The graph depicts the yearly average over the period 1921-1950 of hours of bright sunshine. The figures are 1,792 hr for Ventnor, 1,525 hr for Croydon and 967 hr for Manchester.

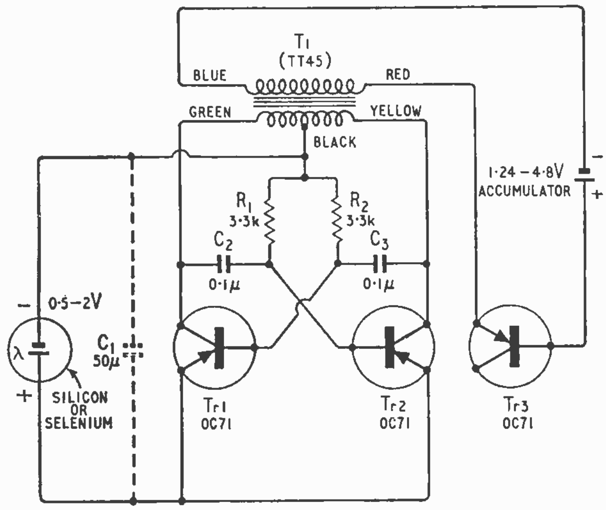


Fig. 3. Circuit of the converter charger. Suppliers of some of the components are listed in the panel on this page.

COMPONENT SUPPLIERS

Varta Deac NiCd accumulators.	G. A. Stanley Palmer Ltd., West Molesey Trading Estate, Island Farm Avenue, East Molesey.
Assorted selenium wafers.	B. W. Cursons, 78 Broad St., Canterbury.
Assorted selenium and silicon single cells.	International Rectifier Co. (Gt. Britain) Ltd. (Display Stands), Hurst Green, Oxted, Surrey.
4-cell silicon solar battery.	Service Trading Co., 47 High St., Kingston-on-Thames.
Repanco TT45 transformer	Henry's Radio Ltd., 303 Edgware Rd., London W.2.

of bright sun. Therefore, allowing for accumulator inefficiency—a Deac for example needs a charge of 1.4 times the drain, to maintain equilibrium—to realize a capacity of 1,000 mAh per year the charge rate should be at least 1.4 mA per bright sunlight hour. The "dull day" performance of the charger must also be reasonable, to offset accumulator leakage and unexpectedly heavy demands during the winter, or in a year of bad weather. To achieve a good all-round performance, without resorting to large numbers of series connected solar cells, a converter is, therefore, needed to step up the voltage.

Converter circuit

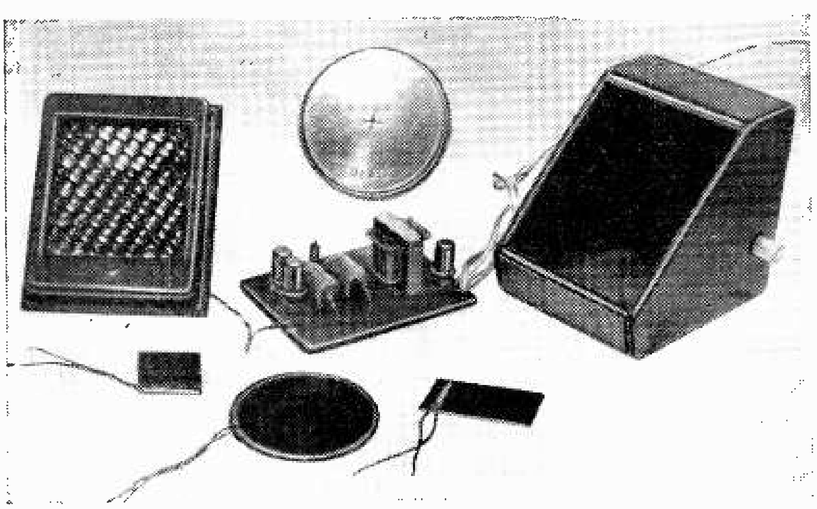
With the converter circuit of Fig. 3, a useful output can be obtained from a single selenium cell. With two selenium cells, the output can be as much as 500 mAh/year, and two NiCd accumulators may be charged in series. Using a readily obtainable silicon four-cell solar battery, a capacity of more than 1,000 mAh/year, from accumulators of up to 4 V, is possible, and the "dull day" performance is exceptionally good.

In the circuit of Fig. 3, the d.c. output from the solar cell is "chopped" by a multivibrator and the resulting square wave is fed into a step-up transformer, to give the required higher voltage. With the prototype, oscillation commenced when the supply voltage reached a mere 0.075 V.

Transistors type OC71 are specified for Tr1 and Tr2, because of their low cost, but transistors with a higher switching speed will give an improved performance. As the dissipation is unusually low, almost any type of p-n-p transistor will work in this circuit with no danger of its maximum ratings being exceeded.

The transformer T1 is a standard push-pull driver giving a voltage multiplication of 4, measured with no load. The charge current is about 1/5th the input current at normal levels.

Once again, a transistor base-emitter junction is used as a charging diode, and also for rectification. C_1 is wired across the solar battery to slightly improve efficiency. If it is thought that an electrolytic might suffer from a short life, due to slow deterioration, then this component may be omitted, and no great loss of output will result. The circuit is not at all critical, but for longevity, some care is needed with its construction.



Details of the solar battery charger. In the foreground selenium wafers. Left to right: four-cell silicon sun battery, converter and box. In the background: 1,000 DKZ Deac cell.

Construction

An etched circuit was employed for the prototype. It was considered that this would give greater strength and durability compared to the "wired underneath" form of assembly. Etched circuit plan and component placement diagram are given in Fig. 4. During assembly, cleanliness and good quality soldering are essential. When all components are finally mounted, together with the input and output leads to the etched circuit panel, the underside of the panel should be scrubbed with a clean suede brush, dipped in methylated spirits, until the surplus flux is removed and the copper and solder shines. Finally, the entire assembly may be coated with polyurethane varnish, to inhibit corrosion.

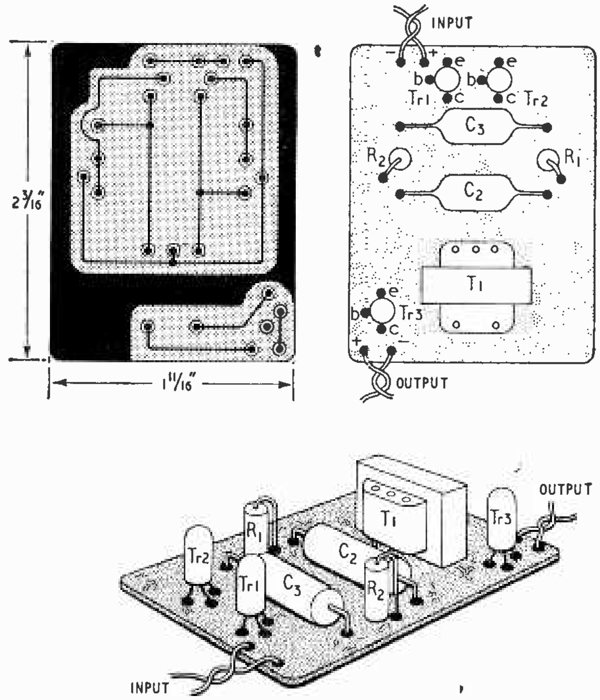


Fig. 4. Etched circuit and disposition of components.

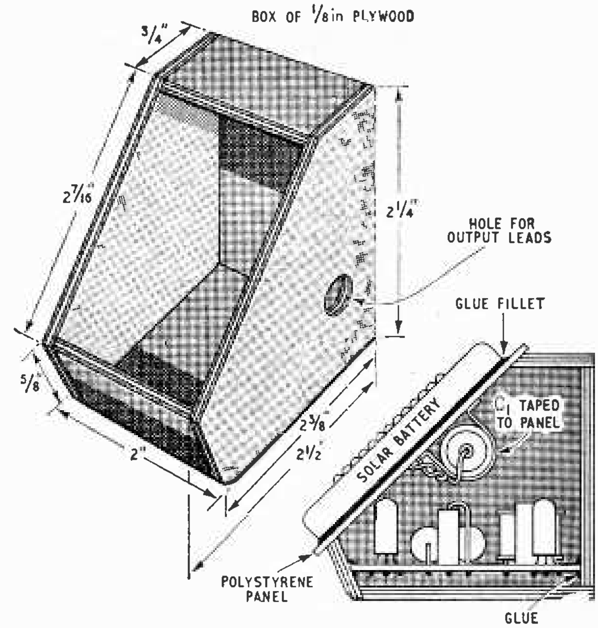


Fig. 5. Details of the housing of the charger. All joints are glued with epoxy resin and finished with polyurethane varnish.

The original intention was to enclose the circuit panel and solar cells inside a box with a glass front, but it was discovered later that a layer of ordinary glass, interposed between the cells and the light, reduced output by about 25%. It was decided, therefore, to dismantle the solar battery, and waterproof it, so that it could be mounted on the outside of the box, with its polystyrene diffuser lens exposed to the weather. The method of waterproofing depends on the solar cell or battery. Selenium wafers may be coated with several layers of polystyrene cement, and can be stuck to a sheet of polystyrene cut from a lunch-box. Some solar batteries have cases and lenses made of incompatible plastics, and here the simplest method is to waterproof with an epoxy glue, ensuring an even layer of glue at all joints. The leads from the cells must be rearranged, if necessary, and brought through the mounting panel. Silicon batteries are delicate and should be dismantled with care. The diffuser lens is sometimes lightly glued to one cell and an attempt to separate them could have disastrous results. Details of the plywood box and final assembly are given in Fig. 5.

Tests and performance

Artificial light tends to give misleading results so tests must be carried out in daylight. Fig. 6 shows the output obtained with the original charger, and light-meter readings are included for the photographically minded reader. The light-meter was set for a film speed of 100 ASA for all measurements. The curves indicate the amount of charge to be expected under varying light conditions with different accumulators and solar cells. There is little point in using more than two selenium cells as their current output would be too low to make a corresponding improvement in converter output. The equivalent input resistance of the converter is around 200 Ω, being a good match for two selenium or four silicon cells.

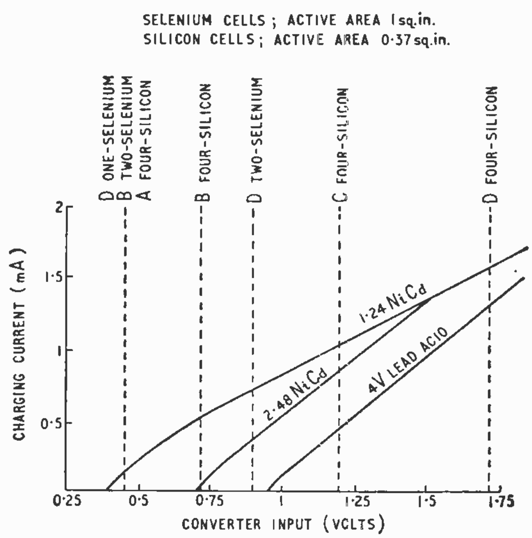


Fig. 6. Charging characteristics of the converter. An indication of the light conditions is given by the letters against the vertical lines on the graph. With the light meter pointed at the sky and set to a film speed of 100 ASA, the exposure values (E.V.), f number and shutter speed for various conditions are as follows. (A) E.V.14, f11 at 1/125, bright total overcast. (B) E.V.16, f11 at 1/500, part overcast, sun behind cloud. (C) E.V.18, f11 at 1/2000, sunlight through thin cloud. (D) E.V.20 plus (light meter off scale), winter sunlight.

Less than four silicon cells may be employed, and their performance will be slightly better than the same number of selenium. The converter will tolerate a maximum input of 6 V at about 20 mA, but it is hardly likely that this level of operation will be required. Although a single selenium cell will only produce a 100 μA charge in bright sunlight, this will be adequate for a low capacity NiCd 1.24 V accumulator, such as the Deac 100DK, and will offer a 100 mAh/year supply, enough for a small alarm bell or warning light.

When measuring solar cell and converter outputs, the readings given by even a good quality testmeter must be regarded with some suspicion, remembering that a full-scale deflection on low current ranges might produce a voltage drop of perhaps 0.5V. Shunt the testmeter leads with a high value electrolytic for voltage readings of the converter's output, this will give a reading slightly below the peak voltage supplied. A more reliable indication of performance is obtained when an accumulator is actually placed on charge, under different lighting conditions, and the current fed to it is monitored.

Solar cells and converter should be left in a warm place for a few hours before sealing, to remove any moisture. The solar battery panel can then be glued to the box. Functioning of the multivibrator may later be checked at any time, by placing the ferrite aerial of a transistor radio close to the converter output leads, to pick up the feeble radiation of square wave harmonics.

Installation

Mount the charger, with its solar battery facing south at an elevation angle of 45°, preferably high up and away from obstructions, with no trees in the foreground to overshadow it. The accumulator, bells, and other equipment, can be placed under cover somewhere near. The accumulator should be kept dry. Either the side of a house or a tall pole will make a good mount for the charger.

Applications

The possible uses of the charger are almost too numerous to list, but a few suggestions are outlined here. In Table 1 which is based on the calculated output of a 1,000 mAh NiCd cell, coupled to the charger, there is given a range of loads at differing time intervals. This data will be of assistance to the reader who may want to assess the possibility of using a solar device for various applications. The figures given in the table are a conservative estimate, based on bright sunlight only. The surplus charge of a good "dull day" performance will therefore cover bad years, unexpected loads, and keep the accumulator well topped up. In practice, with a good year, the capacity could almost be doubled. The short period discharges, such as 1 A for 9.8 sec/day, indicate that the unit might be used for intermittent switching of power relays and the triggering of other equipment.

TABLE I

Current	Once per day	Once per week	Once per month	Once per year
1mA	2.74 hr	19 hr	83 hr	1,000 hr
10mA	16 min	1.9 hr	8.3 hr	100 hr
100mA	1.6 min	11.4 min	50 min	10 hr
1A	9.8 s	1.1 min	5 min	48 min
10A	1 s	6.8 s	30 s	—

The intermittent discharge rate of a 1000 DKZ cell (obtainable from G. A. Stanley Palmer Ltd.), when connected to a 4-cell silicon charger, is shown in the above table. The continuous discharge rate is 110μA. The manufacturer quotes a maximum admissible discharge current for 10 seconds as 15A at a cell potential of 0.2 to 0.3V.

AERIAL PROFILE AUTOMATICALLY CONTROLLED

THE large, steerable paraboloid aerials used for satellite communications and radio astronomy must be designed to give the highest possible gains, and this demands bowl diameters of 1,000 or more times the working wavelength. With such large diameters it is extremely difficult to make the bowl support structure sufficiently rigid to maintain the correct reflecting profile when the aerial is subject to loading forces resulting from wind, water, ice, gravity and steering acceleration, and to distortions due to heat, ageing and structural resonances. A new approach to this problem being tried by the Royal Radar Establishment is to build a relatively light and compliant structure but give it high effective rigidity against disturbing forces by applying closed-loop position control to individual elements of the bowl surface.

At an I.E.E. conference on the design and construction of large steerable aerials, D. W. Burr of R.R.E. described a 23-ft experimental aerial constructed on this principle (actually a scale model of a 170-ft aerial for use in the X band). The bowl surface is formed from 54 glass fibre honeycomb panels and these are mounted on a light and flexible aluminium back frame by 36 hydraulic jacks—each jack supporting the corners of a group of adjacent panels. At any such support point, a disturbing force (e.g. wind) applied to the bowl is transmitted through the jack to the back frame, which yields. The resulting positional error in the reflector is detected by the movement of an optical transducer, mounted on the bowl surface at that point, relative to a fixed reference light beam, and the resulting error signal—10mV per 0.001 inch displacement—is used to control electro-hydraulically the flow of oil into the jack. Thus the jack extends or retracts to adjust the distance between the bowl surface and the frame so that the surface is restored to its correct position. The response—up to 25 c/s—is fast enough to deal with turbulent wind forces.

Each of the 36 control loops limits excursions of the bowl surface relative to the reference light beam to 0.005in, and in this way the true paraboloidal shape of the reflector is maintained. Positional errors due to permanent manufacturing inaccuracies are also automatically corrected.

Each jack can move up to 6in, and when the control system is energized a 1-c/s oscillation is applied to the oil valves so that the jacks and optical transducers search for the reference light beams.

The 36 reference light beams are formed from a common light source consisting of an iodine quartz lamp, a set of lenses and a light beam chopper. This unit is mounted near the front feed of the aerial and directs a beam on to a pyramid of 36 mirrors mounted in the centre of the bowl. Each of these mirrors reflects an image of the light source on to an associated optical transducer on the bowl surface. Thus the true paraboloidal reference shape is defined by the various angles of the 36 reflected beams relative to the central incident beam and by the corresponding beam lengths (mirror-to-transducer). The light chopper breaks the incident beam at 400 c/s and the transducer amplifiers are tuned to this frequency so that the control loops are made immune to ambient light.

The total weight of the aerial is 2,000lb. It has been estimated that a comparable aerial of conventional construction would weigh at least 20 tons. Development is not yet complete but there is confidence that the project will be successful. Aerial steering will require a special approach because of the profile control system, but there is a possibility of making use of the profile control facility for fine adjustment of aerial beam direction.

WORLD OF WIRELESS

The U.K. Space Programme

ACCORDING to a report recently published by the National Industrial Space Committee entitled "The Case for a U.K. Space Programme," members of the British aerospace industry are concerned about the lack of a clear policy definition or of any significant national programme of work in the space field. It was because of the importance of this subject that the N.I.S.C. was recently formed by the following associations—Society of British Aerospace Companies, Electronic Engineering Association, and Telecommunication Engineering and Manufacturing Association.

The sectors of space technology singled out as being of particular importance to the U.K. are defence (reconnaissance and military communications), navigation, meteorological, commercial communications, domestic applications of communications satellites, rescue surveillance, and scientific research in space. The committee consider that these aspects of space technology are of immediate importance to Britain and her economy, and calls for the most urgent and serious consideration by the Government.

Of particular interest is the recommendation for using satellites for direct television broadcasting. With the increase in the size of satellites that is now practicable, improvements in electrical power supplies and light-weight amplifiers it is stated that it will be possible within the next few years to radiate sufficient power to enable sound radio and television broadcasts to be received directly by small domestic aerials of similar size to the paraboloids used for terrestial relay of television programmes.

For 99% coverage of the U.K., with four television services 64 major stations, 250 minor stations and 1,000 fill-in stations would be required, costing £120M against £50M by satellite relay.

The main theme of the note is summed up in the suggestion that international collaboration should be an extension of the national effort and not a substitute for it. The document outlines possible courses of action to achieve a more balanced participation in space technology at moderate cost.

The cost of the programme outlined by the committee is estimated at less than £40M p.a.; little more than double the present gross British expenditure on all space activities.

Tropospheric Propagation

SEVERAL contributors to the recent I.E.E. colloquium on tropospheric propagation described efforts to correlate transmission loss with meteorological measurements—especially refractivity of the surface atmosphere which can be obtained from published data. Although this parameter was shown to be of little use it was equally clear that radiosonde measurements tracing the change of refractive index with height gave good correlation with received field strength.

The work described was exclusively concerned with frequencies above 100 Mc/s at which propagation is controlled by the atmosphere rather than by properties of the ground. All the measuring techniques of the meteorologist are relevant to studies in this field. If any meteorologist had been present, which was not evident, he would have been surprised to find a radio engineer such as Dr. D. T. Gjessing, from Norway, having progressed to the point of using an instrument that measures changes in atmospheric temperature during a 1 μsec interval.

Mr. M. W. Gough (Marconi) presented an elegant examination of the factors causing a drop out which is sometimes observed between terminals apparently in line-of-sight. Microwave circuits of only 25 miles in length have been found to fail under certain conditions when the terminals are at widely different heights. Mr. Gough explained how this was caused by total internal reflection at an atmospheric layer at a height intermediate between transmitter and receiver.

Another paper of vital interest to those planning trunk routes was that by G. C. Rider and D. J. Palmer, of Marconi, who gave data indicating that fading on two tropospheric scatter links connected end-to-end is virtually independent. This means that present planning methods are too cautious since they assume that in the worst conditions one must allow for both links to be fading simultaneously.

With modern high-capacity systems operating at 6 and even 11 Gc/s it is certain that a great deal of effort will continue to be deployed on examination of the fine structure of the troposphere and its influence on propagation.

Computer Designs Computer

A METHOD has been devised by International Computers and Tabulators Ltd. by which an existing computer is made to behave like one being designed. In this way, the performance of the new computer can then be assessed and the system perfected without the use of a new physical layout, but once the system design is finalized, the existing computer

Ancient and modern *techniques are sharply contrasted in this illustration of an operative measuring the contents of a storage tank at a Shell refinery. Information is reported to the refinery's central control room by use of a modern two-way radio-telephone but absence of automatic electronic (or mechanical) level reading equipment (highly developed during recent years) is emphasized by the dip stick used by the operative. The radio-telephone is a Lancon I.S. manufactured by G.E.C. (Electronics) Ltd., and is the first compact lightweight v.h.f. transmitter-receiver to be issued with an Intrinsic Safety Certificate by the Ministry of Fuel and Power permitting its use in hazardous atmospheres.*

can be used to optimize the layout of the new computer. One of the advantages of design simulation is the elimination of manual mistakes. This is of particular significance when developing a computer comprising several thousand logic circuit elements and their associated interconnections. In fact, this complexity has been the major problem encountered in previous attempts to achieve design simulation with a computer. Owing to the time period and storage capacity involved, the part-by-part testing of a simulated model was necessary. I.C.T. have evolved a method by which the system to be simulated is described in a new specialized language known within I.C.T. as SIMBOL. The new language offers facilities for simulating complete systems, or individual parts of systems in greater detail, or both simultaneously. To imitate the operation of a new computer, the power of a large existing computer is required and a SIMBOL compiler has been developed for the I.C.T. Atlas and is currently under test.

Local Radio Plan

A MEMORANDUM, issued by the Local Radio Association of 35 Connaught Square, London, W.2, has been submitted to the Postmaster General outlining a plan for the introduction of local radio stations in the U.K. This follows an earlier recommendation, submitted in January 1965, putting forward reasons for proposing that local broadcasting be financed by advertising.

Among the questions discussed are frequency allocations, the number of stations and field strengths. On the assumption that a population of 50,000 is the smallest community for which it is economically possible to operate a local radio station, the Association considers, in the light of technical advice from the Marconi Company, that there would be a need for 276 stations. Assuming that station coverage extends to a 20-mile radius it is estimated that 98.5% of the population of the U.K. would be covered. The L.R.A. recommends that all stations should be equipped with both low-power medium-wave and v.h.f. transmitters.

The medium-wave transmissions would be restricted to daylight hours and during the day the v.h.f. transmissions might offer an alternative programme. The memorandum states that "*The introduction of local broadcasting would necessitate using many of the channels in the band which are not allocated to the U.K. and hence a depature from present policy would be involved.*" It would appear, therefore, that the scheme could not be introduced until a new European wavelength plan had been agreed.

Suggested field strengths are: city service 10 mV/m, town service 4 mV/m, and rural service, 1.5 mV/m. The protection ratio for co-channel stations (the level of the wanted signal compared with an unwanted signal) may have to be as low as 20:1 and some degradation at the edges of rural service areas may be experienced. Transmitter radiated powers to give a rural-grade service at a distance of between 20 and 30 miles are between 25 and 200 W depending on the frequency. On the v.h.f. band necessary field strengths, according to the C.C.I.R., are city service 3 mV/m, town service 1 mV/m, rural service 0.25 mV/m. A maximum radiated power of about 250 W is envisaged.

An expedition organized by Imperial College is to go to Malta this year to study **underwater communications.** Existing systems have been limited to wires which have serious attendant disadvantages, and the use of ultrasonic carrier waves which not only limit communications to one way but also need complex equipment. Both types of system have been tested at Imperial College with the conclusion that future research and development will be directed towards a form of voice frequency link. Investigations will be made of intelligibility, microphone and transducer sensitivity, power requirements and threshold and directional measurements. A film will be made of the expedition and equipment will include two surface ciné cameras and a camera for operating more than 200ft below the surface.

The **Standard Time and Frequency** transmissions from MSF Rugby on 60 kc/s have been extended from the daily one hour period of 1430-1530 G.M.T. to 24 hrs a day, but for an interim period the one hour schedule of A2 modulation pulses consisting of 5 cycles of a 1 kc/s tone for the seconds pulse and 100 cycles of 1 kc/s tone for the minute pulses will be retained. The new extension to the service for the remaining 23 hours of the day will operate with a modulation of interrupted carrier pulses of 100 ms duration for the seconds pulses and 500 ms duration at the minute, the epoch of the pulses in each case will be at the start of the break in the carrier signal. The estimated decay time of the pulses is 0.5 ms. A shutdown period for maintenance will be observed on the first Sunday of every month between 1000 and 1400 hrs.

More programme time for channel 6.—For many years the frequency band 176-180 Mc/s which falls in channel 6 has been used in this country for radio astronomy observations and, to enable an important part of this work to be completed, it was necessary for television stations using this channel to share it on a time basis with radio astronomers. This restricted the times of operation of the BBC-1 stations at Sandale and Moel-y-Parc to the period midday to midnight. The radio astronomical survey has been completed and the restrictions withdrawn so that the stations now operate from the start of trade test transmissions at 09.00, or from the start of programmes if earlier.

Improved I.T.A. Service.—The Independent Television Authority's new transmitting station at Belmont, Lincolnshire, recently began transmitting a full programme service. The programmes from this station will be available to nearly a million people. Trade transmissions, however, will be liable to interruption for some time, particularly during the period of installation and testing of the u.h.f. aerial for BBC-2 which is mounted on the same mast as the I.T.A. aerial.

The 1966 edition of the **British Standards Yearbook,** which has just been published, contains a complete numerical list of all the five thousand British Standards and Codes of Practice, with a brief summary of each one, and a subject index. The publications of international standards organizations, which were covered in previous editions of the Yearbook, are now dealt with in a separate Supplement. The first edition of this Supplement, published last November, is complete up to June 30th, 1965, and contains a complete numerical list of all recommendations by the International Organization for Standardization and similar bodies. The Yearbook (15s) and the Supplement (7s 6d) are available from the B.S.I. Sales Office, 2 Park Street, London, W.1.

From America, the Electronic Industries Association announce that the first national **Consumer Electronics Show** will be held during June 25th -28th, 1967, at the New York Hilton and Americana Hotels. On display in an exhibition space of over 200,000 square feet will be monochrome and colour television receivers, record players, tape recorders and electronic organs; it will be the largest trade show ever held in New York using hotel facilities. The second annual show will be held at the same location during the fourth week of June, 1968.

A one week course of lectures entitled **Digital Circuit Techniques** is to be held from June 20th-24th at the Borough Polythechnic, Borough Road, London, S.E.1. The fee is 7gn and further details are available from the college secretary.

I.E.E. Membership.—The annual report of the Institution of Electrical Engineers gave the figure of 55,578 for total membership as at April 1st, 1966. This represents an increase of 1,428 on the figures for the previous year. Corporate members numbered 27,768, i.e., 49.96% of the total.

PERSONALITIES

Earl Mountbatten of Burma, chairman of the National Electronics Research Council, has been elected a Fellow of the Royal Society. Lord Mountbatten, who is this year's president of the British Computer Society, has been the prime mover in the Selective Dissemination of Information project being conducted by the N.E.R.C. in an endeavour to find a solution to the problem of information retrieval.

C. L. G. Fairfield, M.A. (Cantab.), M.I.E.E., has been appointed managing director of Submarine Cables Ltd., of Greenwich, in succession to **F. W. H. Shaw** who has retired after more than 50 years' service with the A.E.I. Group which together with B.I.C.C. are joint owners of Submarine Cables. Mr. Fairfield, who has been assistant managing director of the company for the past year, joined the Telegraph Construction and Maintenance Company (a subsidiary of B.I.C.C.) in 1953 as manager of the overseas division. Mr. Fairfield,

C. L. G. Fairfield

who is 54 and is a barrister-at-law, was with Mullard from 1947 to 1953 first as assistant to the directors on technical matters and later as manager of the valve division.

E. V. D. Glazier, Ph.D., B.Sc., M.I.E.E., head of the Physics & Electronics Department at the Royal Radar Establishment, Malvern, has had the title of honorary professor in the Department of Electronic & Electrical Engineering conferred on him by Birmingham University. Dr. Glazier, who is 53, was director of scientific research (electronics and guided weapons) in the Ministry of Aviation from 1957 to 1963. He received his early training in electronic and mechanical engineering in industry and joined the Post Office in 1933. He transferred to the Signals Research and Development Establishment at Christchurch in 1942 and in 1950 took charge of the research division.

C. O. Stanley, C.B.E., LL.D., F.C.G.I., chairman of Pye of Cambridge Ltd., has relinquished his responsibilities as chief executive of the Group and has tendered his resignation as a director of the company and its subsidiaries. He has been invited to become honorary president of the Company "in recognition of the invaluable services which he has rendered during a period of over forty years and as a tribute to his great contribution to the growth and development of the Group during his chairmanship." Mr. Stanley, who became chairman of the board in 1946, joined the organization in 1928 when W. G. Pye & Co., the Cambridge instrument-making firm, became interested in radio receiver production and formed Pye Radio Ltd.

Frank B. Duncan, chairman of Ether Controls and deputy chairman of British Relay Wireless & Television Ltd., who joined the board of Pye in February and a fortnight later was appointed deputy chairman, has become chairman and chief executive of the Pye Group. The executive management of the group has been reorganized and there is now a managing director for each of four divisions. **J. R. Brinkley,** M.I.E.R.E., who joined the group in 1948 after six years in the Home Office Communications Directorate and has been managing director of Pye Telecommunications Ltd. since 1956, is appointed managing director of the telecommunications division. **R. M. A. Jones,** a director of Pye Ltd., and managing director of E. K. Cole Ltd. since 1962, becomes managing director of the radio and television division. **C. A. W. Harmer,** O.B.E., who has been a director of several of the Pye subsidiaries for some years, is appointed managing director of the overseas companies. Mr. Harmer is this year's chairman of VASCA (the Electronic Valve and Semi-Conductor Manufacturers' Association). The managing director responsible for the instrumentation and controls division is **F. W. Coulling** who is on the board of several companies including Ether Langham Thompson Ltd., Electro Methods Ltd., and Ether Ltd.

James H. Bonnett is appointed editor of *Computer Weekly*—the new newspaper for the computer world, to be launched this autumn by Iliffe Electrical Publications. He was previously industrial and components editor of *Electronics Weekly*, and was also for 2½ years the group European editor for the Heywood-Temple electronics publications. Prior to taking up journalism Mr. Bonnett spent ten years as a design engineer in the electronics industry. **Tony J. Higgins** is appointed news editor of *Computer Weekly*.

J. Stuart Sansom, A.M.I.E.R.E., is the new chief engineer of ABC Television Ltd. in succession to **Howard Steele,** who (as stated in our April issue) has joined the Independent Television Authority as chief engineer. Mr. Sansom joined ABC in 1959 as head of

J. Stuart Sansom

maintenance at Teddington and in 1960 was appointed head of development (electronics). Since 1963, he has been head of the equipment and installation group of the Engineering Department. Prior to joining ABC Mr. Sansom was for two years with T.W.W. (Television Wales and the West) as head of maintenance having previously been with High Definition Films Ltd. for four years.

W. D. H. Gregson, D.F.H., M.I.E.E., assistant general manager of the Ferranti Group in Scotland, has been elected chairman of the Industrial Control and Electronics Board of the British Electrical & Allied Manufacturers' Association. He succeeds **G. S. Lucas,** group director and general manager of AEI Electronics, Leicester. The new vice-chairman is **L. E. Thompson,** B.Sc., A.R.C.S., managing director of West-

W. D. H. Gregson

inghouse Brake and Signal Company. **Mr. Gregson,** who is a member of the Government Electronics Economic Development Committee ("little Neddy") and a member of the Scottish Economic Planning Council set up by the Secretary of State for Scotland, received his technical training at Faraday House. At the beginning of the war he was with the Admiralty Signals and Research Establishment at Portsmouth, followed by service with the R.A.F. He joined Ferranti Ltd. after the war and has been in his present position since 1960. Mr. Thompson received his technical education at the Royal College of Science where he took a degree in physics. In 1931 he joined Westinghouse and in 1944 became assistant chief engineer and three years later chief electrical engineer. He has been group managing director since 1965.

L. E. Thompson

Raymond F. Brown, O.B.E., has had to resign from the position of chairman and managing director of Racal Electronics Ltd. on his appointment by Her Majesty's Government as Head of Defence Sales. He is succeeded by **E. T. Harrison** who joined the company in 1951 as secretary and chief accountant at the age of 25 and since 1961 has been deputy managing director. Mr. Brown, who is 45, started his career as an engineering apprentice with Redifon in 1934. He left that company in 1948 and joined the Communications Division of Plessey as sales manager. He founded Racal with G. Calder Cunningham in 1950.

E. R. Laithwaite, Ph.D., M.Sc., Professor of Heavy Electrical Engineering at Imperial College, has received the Royal Society's S. G. Brown Award and Medal for 1966 for his work on the linear induction motor. Professor Laithwaite, after war-time service in the R.A.F., graduated at Manchester University in 1949, obtaining his M.Sc. in 1950 following a year's full-time postgraduate research on electronic computer design, and his Ph.D. in 1956 for a thesis on induction motor development. He became a lecturer at Manchester in 1953 and a senior lecturer in 1956, and has occupied his present Chair in London since 1964.

F. T. Christmas and **J. Ayres,** M.I.E.E., have been appointed executive directors of Standard Telephones and Cables Ltd. Mr. Christmas, who is to be responsible for special projects,

F. T. Christmas

covering the co-ordination of major contracts involving several divisions of the company, and the establishment of new plants, has for the past five years been general manager of S.T.C's Transmission Systems Group. He joined the company in 1928 as a telecommunication engineer in the central laboratories and four years later went into the transmission division. In 1936 he became chief production engineer for the Woolwich factory, moving in 1942 to New Southgate as deputy chief production engineer. Between 1957 and 1960 he was company chief production engineer. Mr. Christmas is succeeded at Basildon by Mr. Ayres, who becomes executive director of the Transmission Systems Group. He recently joined S.T.C.—as a special assistant to the managing direc-

J. Ayres

tor—from G.E.C. (Telecommunications) Ltd., Coventry, where he had been managing director since 1963. From 1953 to 1962 he was managing director of Simms Motor Units.

In the note in our last issue (p. 281) on appointments in the S.T.C. Components Group the position to which **G. Thornton** has been promoted was inadvertently omitted. He has become product sales manager of the Capacitor Division.

J. H. Mitchell, Ph.D., B.Sc., M.I.E.E., F.Inst.P., who has been for some years technical director of research with Ericsson Telephones Ltd., and also, since 1960, chairman of Associated Transistors Ltd., has joined the board of Astaron-Bird Ltd., of Poole, Dorset, with special responsibilities for radar and telecommunications. Dr. Mitchell, who joined Ericsson in 1947, was at the Bawdsey radar research station in 1936 and later at the Royal Aircraft Establishment, Farnborough, where in 1939 he took charge of radio aids to navigation. For his "contribution to the development of radar installations" he received in 1952 an award from the Royal Commission on Awards to Inventors.

OBITUARY

Vice-Admiral James W. S. Dorling, C.B., M.I.E.E., M.I.E.R.E., director of the Radio Industry Council from its formation in 1946 until 1958, died on May 12th at the age of 77. He entered the Navy as a cadet in 1904 and throughout his naval career was a signals specialist. During the First World War he was for a time assistant to the Fleet Wireless Officer, Grand Fleet, and in 1919 became Fleet Wireless Officer, Atlantic Fleet. He was later successively director of the Admiralty Signal Dept. and Captain of H.M. Signal School, Portsmouth. Admiral Dorling was responsible for the setting up in 1932 of the Royal Naval Wireless Auxiliary Reserve. Among the positions Admiral Dorling held during the second war was that of deputy controller, Admiralty, Bath, and head of the British Admiralty Supply Mission in the U.S.A.

Air Commodore W. E. G. Mann, C.B., C.B.E., M.I.E.E., director-general of navigational services in the Ministry of Transport and Civil Aviation from 1950 to 1959, died on May 4th aged 67. During the early part of the war he was Chief Signals Officer, R.A.F., Middle East, and on retiring from the R.A.F. in 1945 joined the Ministry as Senior Signals Officer and U.K. representative, Middle East. *The Times* obituary recalls that it was while in Egypt immediately prior to the war that "he evolved the first truly mobile radio communications unit on which designs were based all the R.A.F. mobile signals and radar units which performed such vital work with the Tactical Air Forces." When Air Comdre. Mann retired from the Civil Service in 1959 he became Middle East representative of the Decca Navigator Company.

Horace Freeman, who died on May 14th aged 84, organized the first all-British Wireless Exhibition which was held at the Royal Horticultural Society's Hall, Westminster, in 1922. He retired in 1960 after nearly 40 years in radio and electrical advertising. He was elected in 1960 the first and only honorary vice-president of the Radio Society of Great Britain with which he had been associated for 35 years.

Transistor Electronic Organ—3

Simple Electronic Organ for the Amateur Constructor

By T. D. TOWERS*, M.B.E.

THE first two articles in this series examined electronic organs generally (May 1966 issue) and their use of semiconductors (June 1966.) The present article sets out the basic design of a simple instrument capable of being built by an amateur with a moderate knowledge of electronics, carpentry and music.

The transistor organ to be described is a single-manual, divider-type instrument with twelve "speaking" stops, and vibrato provision. It does not include some features conventionally standard in some commercial instruments, such as pedals, a second manual, sustain, reverberation and percussion. The reason for the restricted specification is that anyone setting about building it has a better chance of finishing it than if he tries something more ambitious. (The "project-mortality" rate is probably higher in electronic organ building than in any other branch of amateur electronics!) However, the design is such that the extra facilties mentioned can be covered by a separate article later if the demand arises (and the Editor agrees!).

COMPLETE ORGAN SYSTEM

Fig. 1 gives a block schematic of the various parts of the design, and is largely self-explanatory. In it you can easily follow the course of the electrical signals from the tone generators to the loudspeaker.

Tone generator assembly.—This comprises a set of twelve tone-"boards", a vibrato oscillator, and a stabilized d.c. supply.

The set of twelve tone boards are the source of tone signals. There is a separate board for each note of the chromatic scale, C, C♯, . . . A♯, B. Each board gives six octave-related square wave outputs in the standard equal-tempered scale, taken off from an LC master oscillator and five synchronized divide-by-two circuits. For example, the "C" board gives C6 (2093.0 c/s), C5 (1046.5 c/s), C4 (523.3 c/s), C3 (261.6 c/s = "Middle C"), C2 (130.8 c/s), and C1 (65.4 c/s).

The vibrato oscillator provides a sinusoidal output at around 6 c/s which can be switched in at will to frequency-modulate the set of twelve tone-board master oscillators simultaneously and thus provide a vibrato effect in the sound output from the organ.

The regulated supply ensures that the master oscillators in the tone boards do not vary in frequency with mains voltage variation. This helps to prevent the organ going out-of-tune.

Keyboard switching.—From the tone generator, the square wave signals pass via isolating or "anti-robbing" resistors (not shown in Fig. 1) to the keyboard switches. Each playing key actuates a 5-pole change-over switch. When the key is at rest, the tone generator outputs are shunted to earth. When the key is depressed, the generator outputs are fed into five busbars, one for each of the pitches—16 ft, 8 ft, 4 ft, $2\frac{2}{3}$ ft, and 2 ft. (For the newcomer, 8 ft is "unison" or normal pitch, 16 ft is an octave lower, 4 ft an octave higher, $2\frac{2}{3}$ ft an octave-plus-a-fifth higher, and 2 ft two octaves higher than the key being played.)

The output from the five busbars are each amplified at the keyboard by identical busbar pre-amplifiers, and the amplified outputs are fed onwards on five busbars to the tone shaper.

Tone shaper.—In the tone shaper you will see from Fig. 1 that the five busbars feed directly into tone shaping filters. There are twelve of these filters—two 16 ft, five 8 ft, three 4 ft, one $2\frac{2}{3}$ ft and one 2 ft. Individually, each provides a different sound or "stop" in the organ output, when a playing key is depressed, and they can be used together to give various combinations of stop sounds.

The switches controlling the stop filters are mounted on the separate stop panel, which is usually sited handily immediately above the keyboard. In its off position, each stop switch shunts to earth the square wave signal being handled by the corresponding filter and there is no output from that filter. When the stop is "pulled", i.e. switched in by depressing the stop tab, the switch open-circuits

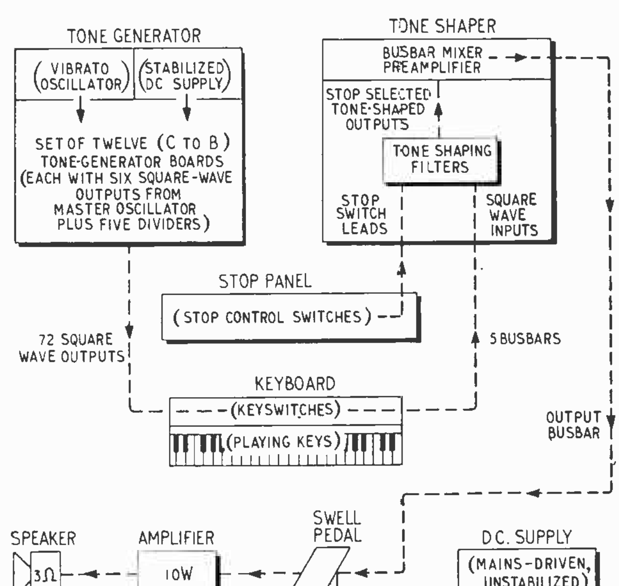


Fig. 1. System block diagram of home-constructor's simple single-manual, polyphonic, divider-type transistor electronic organ.

* Newmarket Transistors Ltd.

and ceases to shunt the input signal to earth. This allows the signal to pass through the filter where it is appropriately shaped. The outputs of all twelve filters are permanently commoned into a single mixer pre-amplifier.

Swell pedal, amplifier, and d.c. supply.—The output from the mixer pre-amplifier passes to the swell pedal, which in this design is a potentiometer volume control operated by a foot pedal. From the swell pedal, the signal is transferred to an amplifier feeding a loudspeaker. Any standard commercial amplifier can be used, but it should be noted that the "voicing" of the stops (i.e. the design of the tone filter circuits to get the desired timbre or tone colour of sound) depends quite critically on the frequency response characteristics of this amplifier and the loudspeaker system it drives. The design given, therefore, gives details of the 10 W, 3-ohm power amplifier that was specifically used in developing the instrument.

The d.c. supply, shown as a separate section of Fig. 1, is a mains-driven unit designed to give an an unregulated 12 V d.c. supply at 0.5 A to the 9 V stabilized supply in the tone generator section. Any power amplifier used should incorporate its own d.c. supply, and the on/off switches of the power amplifier and the organ d.c. supply can be ganged together for convenience of operation.

GENERATING SQUARE WAVE TONES

Going into more detail on the individual parts of the system, Fig. 2 sets out full circuits of the items grouped in the tone generator assembly.

Tone board details.—One tone board circuit is shown in detail at Fig. 2(c), the others being identical except for the *LC* tank components in the master oscillator.

The master oscillator (Tr1, Tr2, Tr3) is a "long-tailed-pair" oscillator of my own design which gives a sinusoid across the *LC* tank circuit and a square wave final output from the collectors of Tr2, Tr3.

The oscillator tank circuit inductance, *L*, uses an adjustable ferrite high-Q pot core (LA2517, MM484 or

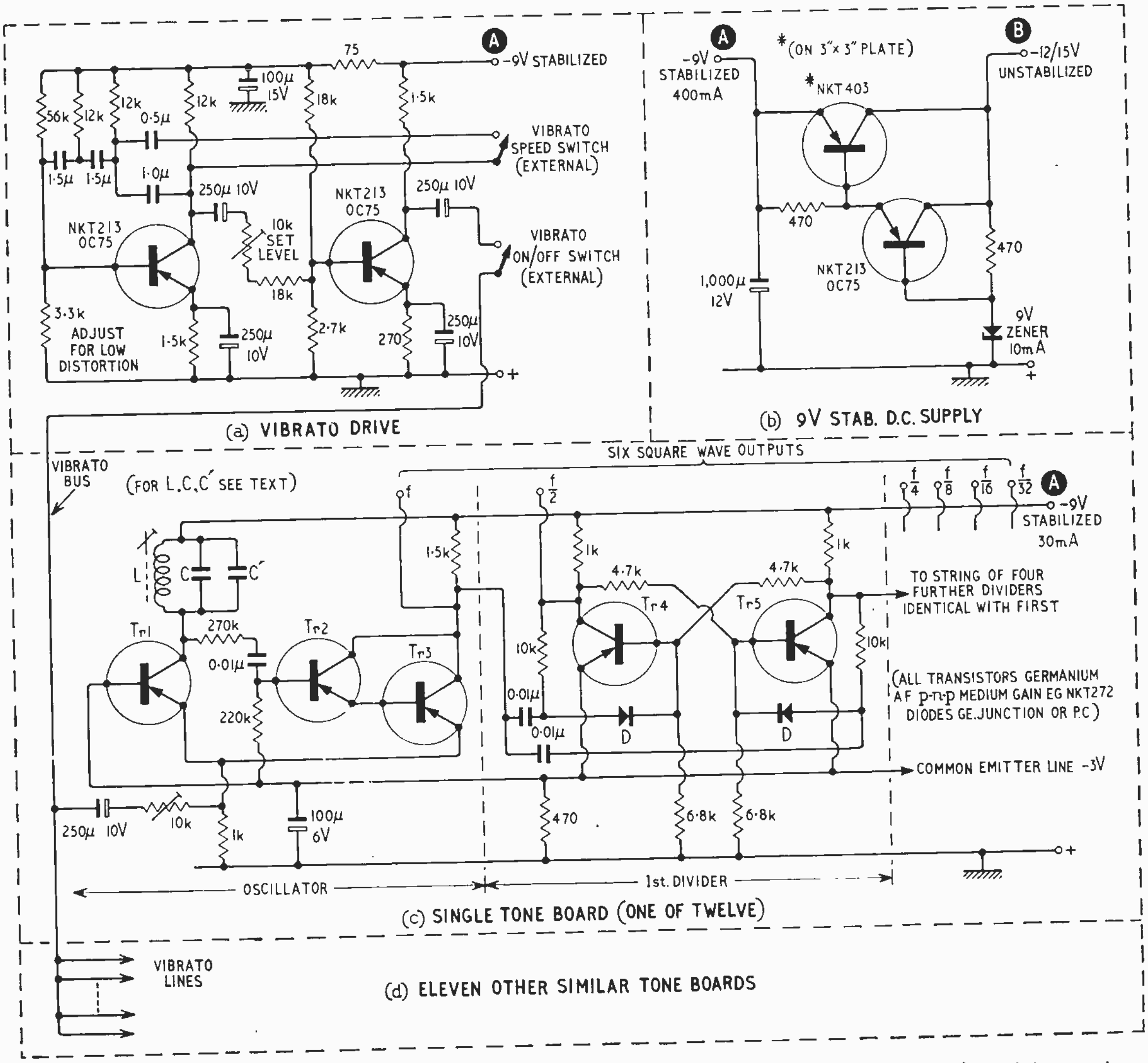


Fig. 2. Circuits grouped in tone generator assembly, including (a) vibrato oscillator and driver, (b) 9 V, 400 mA stabilized d.c. supply, each of which is ancillary to (c) and (d), the twelve tone boards, each with an oscillator and five dividers, together giving square wave outputs at six octave-related pitches.

similar). The tank capacitors, C and C′, are polystyrene with a negative temperature coefficient of around 120 p.p.m./°C which offsets the positive temperature coefficient of the pot core inductor. The main capacitor C is 0·035 µF and the "padder" C′, is selected between 0·001 and 0·007 µF to set up the frequency during assembly so that the pot core adjuster slug is in the middle of its travel. The inductance values are selected approximately as in Table 1 for the different oscillators. The string of five dividers on each tone board are identical with the bistable multivibrator, Tr4, Tr5, which is a conventional "diode-steered" circuit.

TABLE 1

Note	Freq. (c/s)	Inductance (mH)
C6	2093.0	160
C#6	2217.5	145
D6	2349.3	130
D#6	2489.0	115
E6	2637.0	100
F6	2793.8	90
F#6	2960.0	80
G6	3136.0	70
G#6	3322.4	63
A6	3520.0	56
A#6	3729.3	50
B6	3951.0	45

Vibrato circuit details.—The vibrato drive circuit at Fig. 2(a) is an *RC* feedback oscillator with a buffer driver stage which feeds a sine-wave signal into the vibrato busbar to provide vibrato drive to all twelve tone boards together. The oscillator has provision for varying the output amplitude level by a preset "set-level" 10 kΩ variable resistance, and is switched for fast/slow vibrato speed, and vibrato output on/off. (The two control switches for these functions will be mounted separately away from the tone generator assembly with the stop switches on the stop panel.) The drive from the common vibrato bus to the individual tone board oscillators is controlled by a separate preset 10 kΩ on each board feeding into the top end of the 1 kΩ emitter resistor in the master oscillator.

The 9 V stabilized power supply at Fig. 2(b) is a conventional emitter-follower cir-

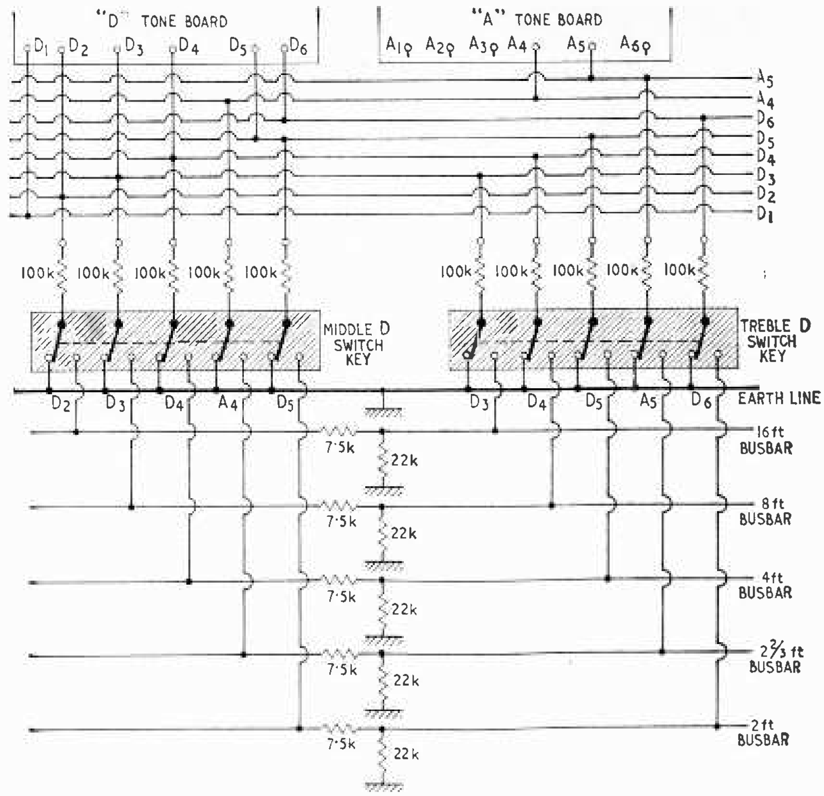
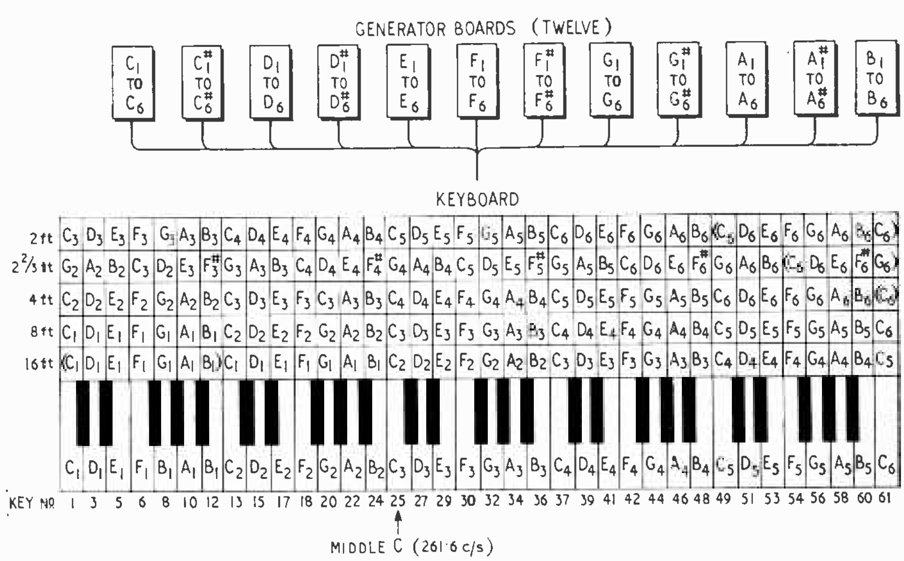


Fig. 3. Square-wave signal paths from tone generator boards via 100 k isolating resistors to key switches and thence to five separate busbars for different pitches. The distribution system is illustrated for the middle and treble D keys. (The 7.5 k and 22 k resistors in the busbars are equalizing networks inserted at intervals along the bars to attenuate notes progressively towards the low-frequency end to prevent bass notes from overpowering treble. For details of networks for a complete single busbar see Fig. 5.)

Fig. 4. Key contacts connection chart; with black note connections omitted for clarity. Observe "doubling back" of pitches in brackets at top of 2 ft, 2⅔ ft and 4 ft ranks and bottom of 16 ft rank; six outputs in octaves from each generator board; five change-over switches per playing key; standard 61 note, 5 octave organ manual keyboard, C to C.



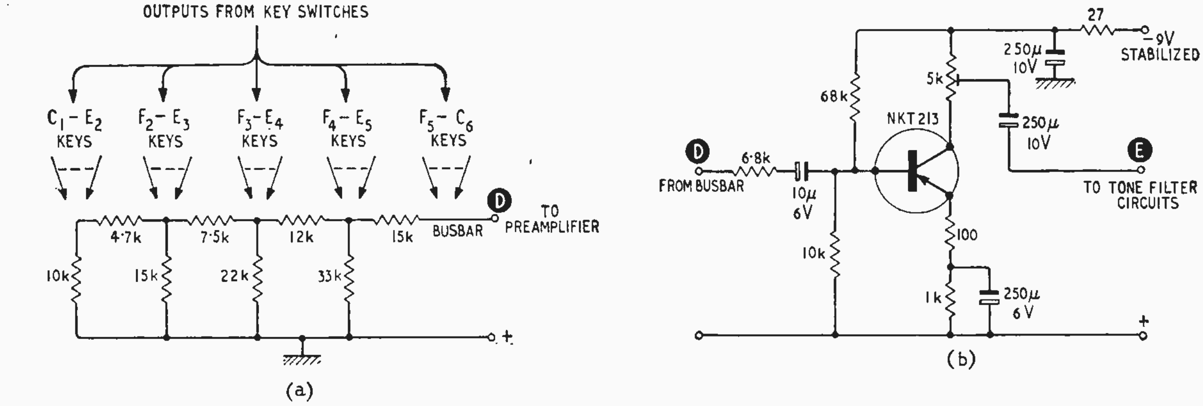


Fig. 5. Bus equalization and amplification provision; identical for each of five busbars (16 ft, 8 ft, 4 ft, 2⅔ ft, 2 ft); (a) attenuation network elements inserted between notes E and F in every octave except lowest; (b) bus pre-amplifier with output level setting provided by preset potentiometer in transistor collector circuit.

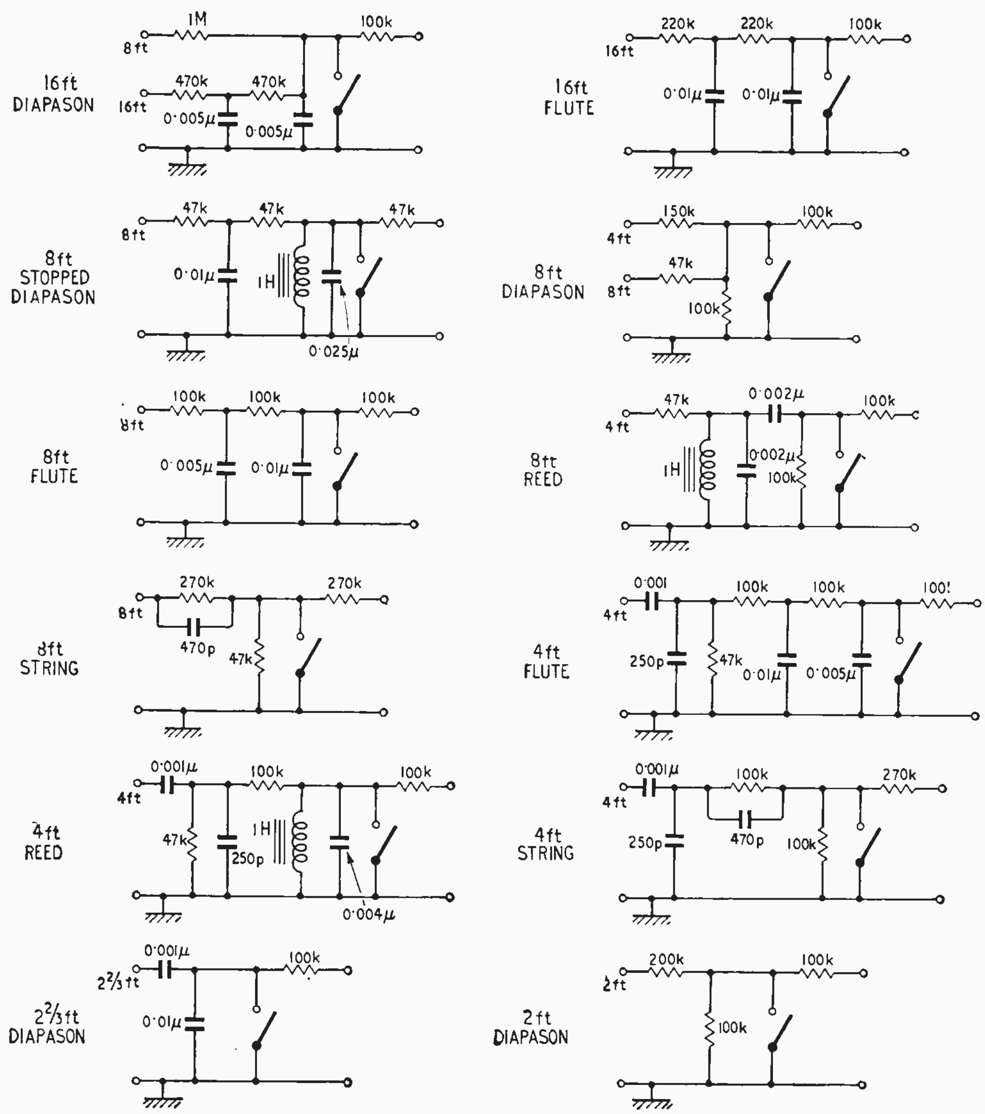


Fig. 6. Stop (tone filter) circuits; square wave input from left, out of corresponding bus pre-amplifier 5k output resistance; shaped outputs commoned to right into single bus mixer-amplifier input of approximately 10k resistance with same circuit as bus pre-amplifier, Fig. 5 (b).

cuit deriving its unstabilized input from a separate 12 V d.c. power supply unit which is described later (Fig. 8).

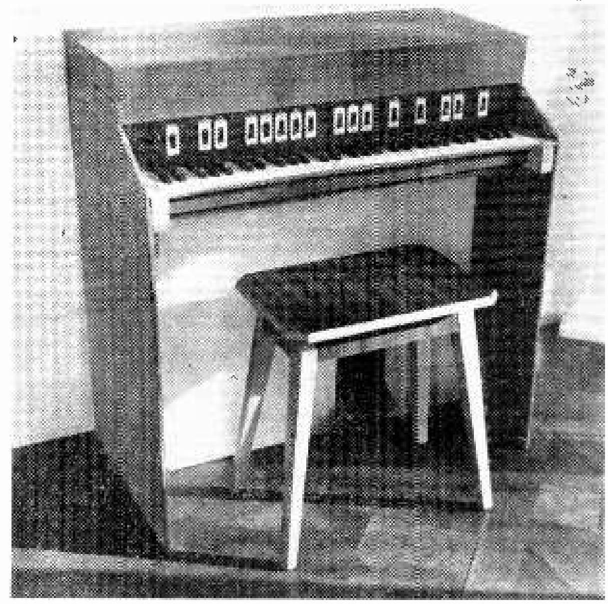
SELECTING SQUARE WAVE TONES BY PLAYING KEY SWITCHING

The square wave output signals pass from the tone generator board outputs via 100kΩ isolating resistances to the key switches and thence to five separate common busbars for different pitches. This is illustrated in detail in Fig. 3 for two typical notes an octave apart. The key switches are shown in the "off" position, short-circuiting the generator outputs to earth. When actuated, they feed the square waves to the appropriate busbars. The purpose of the 7.5 kΩ, 22 kΩ resistor networks in the busbars is explained below.

The full routeing of the square-wave signals through the complete key switch assemblies is set out in simplified chart form omitting black notes in Fig. 4 for use when it comes to wiring up the keyboard.

Busbar equalization.—It is necessary to insert progressive attenuating networks in the busbars following the key switches to scale down the lower frequency notes which would otherwise tend to overpower higher notes. In each busbar, breaks are made between the notes E and F (except in the lowest octave), and attenuator pads inserted. The provisions are the same in each busbar and the arrangement for one busbar is given in Fig. 5(a). Conventionally the break is usually made between the notes B and C, but in this design between E and F. This is because, if it is decided to use a split-keyboard with the notes from middle F upwards on one set of busbars, and from middle E downwards on another (to be able to vary the balance of output between the two halves), this is possible without much rewiring of the busbars.

Busbar pre-amplifiers.—From the busbar output (D) in Fig. 5(a) the signals, still square wave, are amplified in the busbar pre-amplifier (one for each busbar) shown in Fig. 5(b). The preset 5 kΩ potentiometer which serves



The completed electronic organ showing cabinet construction and mounting of keyboard. Further constructional details will be given in the final article.

as a collector load enables the output level of each busbar to be set up independently or "scaled." The output from each pre-amplifier busbar is connected to the corresponding tone filter circuits.

SHAPING BUSBAR SQUARE WAVE OUTPUTS IN STOP FILTER CIRCUITS

The filter circuits that shape the square-wave signals into complex waveforms to simulate various "voices" in the organ are set out in detail in Fig. 6. As noted

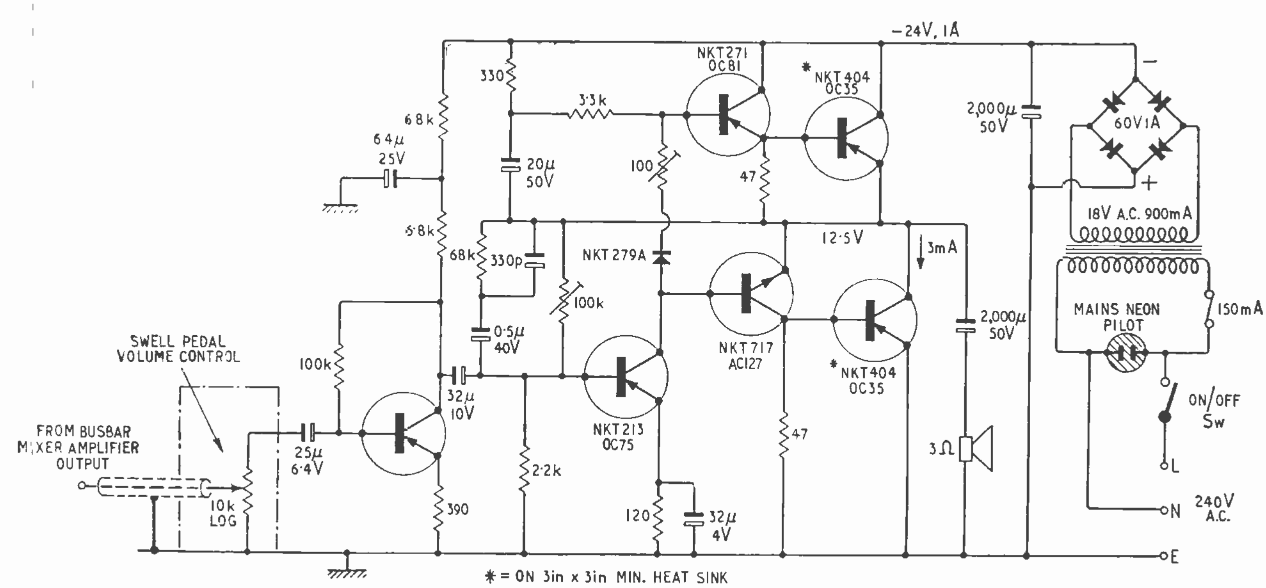


Fig. 7. 10 W power amplifier; mains driven; 3 ohm load, 100 mV input sensitivity; 10 k input resistance; swell pedal volume control at input

earlier there are two 16 ft, five 8 ft, three 4 ft, one 2⅔ ft, and one 2 ft filters. The square wave output busbars from which the filters collect their inputs are indicated on the left hand. All the outputs, on the right-hand side, are fed in parallel into a single mixer pre-amplifier with the same circuit as Fig. 5(b).

The filter circuits given are fairly typical. Diapasons have no great accentuation of any frequencies, strings use high frequency accentuation, reeds use "formant" tuned-circuit accentuation of a specific band of medium-high frequencies, while flutes feature attenuation of higher frequencies. These are, of course, brutal generalizations, but if you examine each filter in turn you will see that they conform generally to this. Tone filters are the ideal area for amateur experimentation. By varying component values around the values given, you can modify the tone colours steadily to suit your own "aural palate."

The stop switches controlling the filters operate by short- and open-circuiting the middle of the filter to earth. This arrangement has several advantages. Cheap single-pole switches can be used. The large resistances between the stop switch and the input to the following amplifier reduce the key-clicks which arise when the stop switch is operated. Finally the actuating of a stop switch does not substantially change the loading on the busbars at the inputs or the amplifier at the output.

AMPLIFYING MIXED COMPLEX TONE SIGNALS AFTER TONE FILTERS

From the output of the mixer pre-amplifier, the complex signals are fed via a screened coaxial cable to the swell control. This is a 10kΩ logarithmic potentiometer controlled by the swell or expression pedal as shown at the left of Fig. 7.

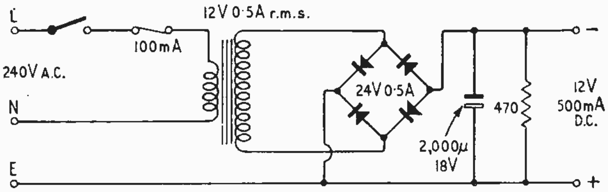


Fig. 8. 12 V, 500 mA d.c. unstabilized supply for oscillators, dividers and bus pre-amplifiers and mixer-amplifiers.

The remainder of Fig. 7 is the power amplifier proper. This is a typical transformerless, Class B push-pull circuit, which is able to provide 10 W into a 3-ohm load, such as four or five 15-ohm speakers in parallel, or four 3-ohm speakers in series parallel.

POWER SUPPLIES

The amplifier in Fig. 7 has its own power supply, but Fig. 8 gives the detailed circuit of the 12 V, 0.5 A, power supply used to provide the unregulated d.c. for the 9 V voltage regulator described earlier (Fig. 2(b)) which supplies the tone generator boards. The busbar pre-amplifiers and mixer amplifier also derive their d.c. from this same 9 V regulated supply.

BUILDING THE ORGAN

In the next article, it is proposed to give practical information on how to assemble the various circuit sections described above.

British Acoustical Society Formed

THE British Acoustical Society has been founded to provide persons having acoustical and allied interests with a single society to promote and disseminate knowledge of acoustics in all its aspects—scientific, technological and medical. The need for such a society has been apparent for some time now and in December 1963 the Royal Society set up an *ad hoc* committee to explore the possibilities.

The committee, headed by Sir Gordon Sutherland (chairman of the British National Committee for Physics), reported in March 1965 and a provisional council was established to launch the society. The chairman of the society is Dr. A. J. King (Manchester University); vice-chairman is Professor E. J. Richards (Southampton University) and the joint hon. secretaries are Dr. P. Lord (Royal College of Advanced Technology, Salford) and Dr. R. W. B. Stephens (Imperial College, London).

Members of the council are: W. A. Allen (Associated Architects and Consultants), Professor R. E. D. Bishop (University College, London), D. E. Broadbent (Applied Psychology Research Unit, M.R.C.), Professor W. Burns (Charing Cross Hospital Medical School), C. T. Chapman (Derritron Ultrasonics Ltd.), Professor C. Cherry (Imperial College), H. Creighton (consultant), P. E. Doak (Southampton University), F. B. Greatrex (Rolls-Royce Ltd.), Dr. P. Grootenhuis (Imperial College), Professor G. M. Lilley (Southampton University), Dr. H. D. Parbrook (Liverpool University), A. T. Pickles (Building Research Station), Dr. L. H. A. Pilkington (Pilkington Brothers Ltd.), Dr. D. W. Robinson (National Physical Laboratory), T. Somerville (B.B.C. Research Dept.), Dr. W. Taylor (St. Andrews University), Professor D. G. Tucker (Birmingham University), Dr. J. Dunstead (Admiralty Underwater Weapons Establishment), and F. E. Williams (G.P.O.).

The proposed constitution and rules have been issued and are subject to an Extraordinary General Meeting to be held in October this year. Applications for membership should be made to Dr. R. W. B. Stephens, Department of Physics, Imperial College, Prince Consort Road, London, S.W.7.

The inaugural meeting was held in May at Imperial College when papers on the subject of aircraft noise were presented by invited speakers from Britain, the U.S.A., Switzerland and the Netherlands. In July there will be a four-day meeting (12th-15th) on "Numerical methods for vibrational problems" and a two-day meeting (20th-21st) on "Impulsive noise and sonic bangs," both being held at the Institute of Sound and Vibration, Southampton. On the 19th there is a meeting on "Non-linear underwater acoustics" at the Dept. of Electronics & Electrical Engineering, Birmingham University.

"The Field-effect Transistor at V.H.F."

WE have been asked by Texas Instruments Ltd., of Bedford, to point out that they were not in any way associated with the circuit design work described in U. L. Rohde's article "The Field-effect Transistor at V.H.F." (January 1966 issue) and therefore regret that they cannot deal with readers' enquiries about the article. The f.e.t. types referred to in the article were erroneously described as insulated gate m.o.s. transistors, whereas in fact they are junction gate f.e.ts (see subsequent correspondence, April 1966 issue, p. 197).

Transistor 2-Metre Converters

F.E.T. design with valve-like performance and a low-cost design using germanium epitaxial planar transistors

By U. L. ROHDE

TWO years ago the author published a transistor circuit for a 144-Mc/s converter in a German journal[1] and in this design the low noise figure of 1.8 dB was obtained at the expense of image rejection and cross modulation. Now that field-effect transistors are available which are even better than some of the valves used in this type of application, it has been possible to produce a new converter with a superior large-signal performance to that of valve designs. The author has also developed a low-cost converter using germanium transistors, and the circuit of this will be given in the latter part of the article.

F.E.T. circuit.—Fig. 1 is the circuit of the converter using field-effect transistors. It can be seen that the input circuit has a junction f.e.t. with a series resonance circuit between gate and source electrodes. The 2N3823/T1S34 junction f.e.t. made by Texas Instruments has following two-port parameters.

Input resistance	2 kΩ
Input capacitance..	6 pF
Transconductance	6 milli-mhos
Feedback capacitance	1.5 pF
Output resistance	10 kΩ
Output capacitance	2 pF

The capacitive voltage divider across the secondary of the input transformer, together with the output circuit of the transistor, transforms the input admittance so that power matching with simultaneous noise minimum is obtained at the input. As a result of the much smaller increase of noise from the noise minimum with the same noise factor at the band edges, a considerably wider transmission bandwidth is obtained. The bandwidth, to the -3 dB points, is 3 Mc/s.

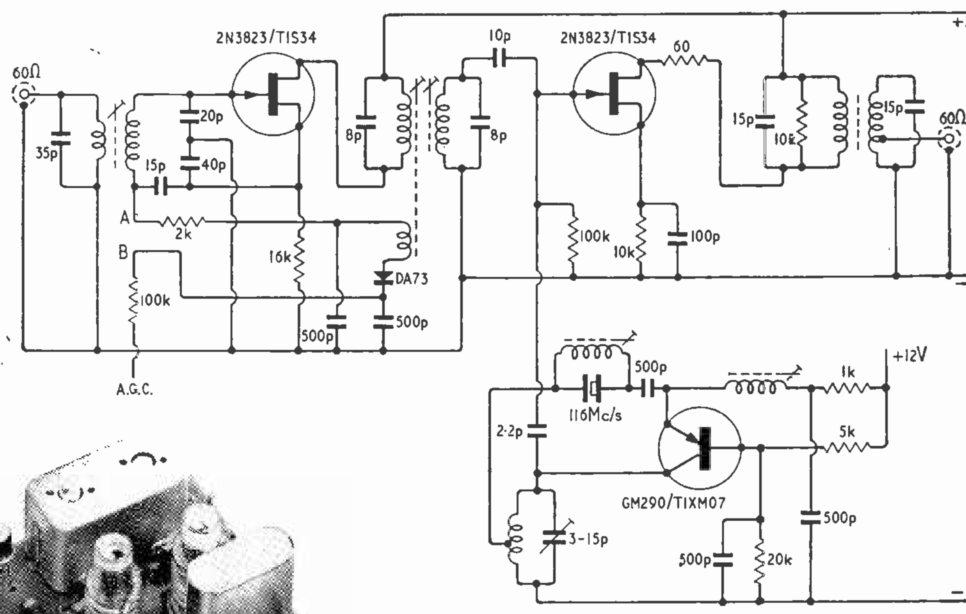
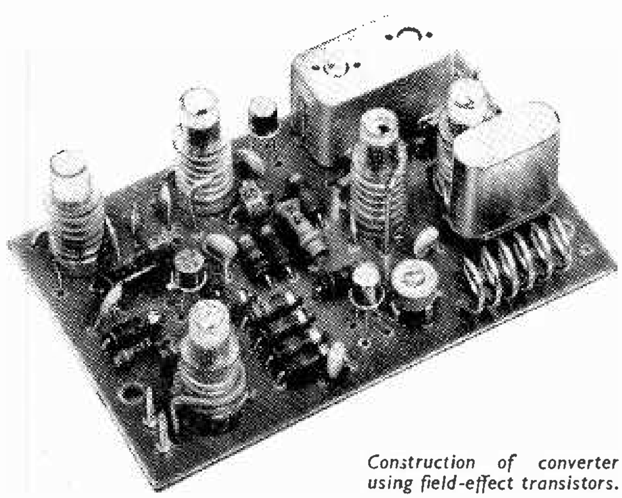


Fig. 1. Converter circuit using field effect transistors.



Construction of converter using field-effect transistors.

In order to obtain the highest possible image rejection, a high-Q bandpass filter circuit is used between the r.f. amplifier and mixer at 144 Mc/s. The lower part of the r.f. amplifier section in Fig. 1 is concerned with the correction of waveform deformation. A small fraction of the signal power is taken from the output of the r.f. amplifier and fed to a diode circuit, which is assumed to have a quadratic charactertistic. The voltage developed by this circuit, between points A and B, can be considered as a variable-voltage battery. From Fig. 2 (a) it can be

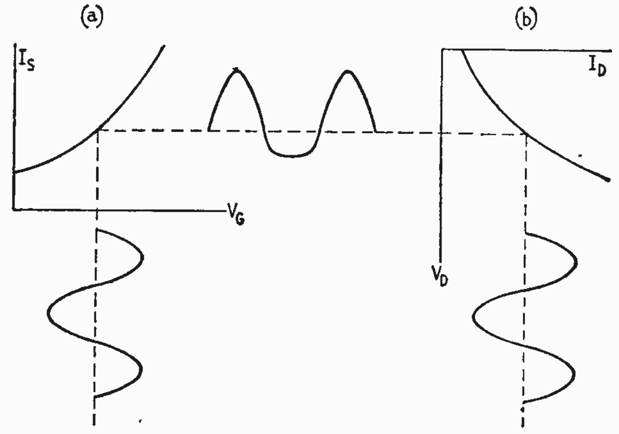


Fig. 2. Illustrating the "double deformation" process: (a) deformation caused by square-law characteristic of r.f. amplifier; (b) cancellation of distortion by "variable battery" effect.

seen that the square-law characteristic of the r.f. amplifier transistor would normally cause a deformation of the input waveform. Owing to the 90° phase shift within the transistor, however, the effect of the "variable battery" is to cancel this distortion (which is predominantly 2nd order) as shown in (b). Because of this "double-deformation" all mixing products resulting from unwanted stations are cancelled and the mixer receives a substantially distortion-free signal.

The signal from the bandpass filter is applied to the gate electrode of the additive mixer, which also uses a junction f.e.t. Since the junction f.e.t., because of its structure, has an exact square-law mixing characteristic, under no circumstances can ambiguous signals appear, not even with overloading at the input. Thus the problem of overloading by nearly 100-watt amateur transmitters in the band is solved. The mixing transconductance has been found to be 3.3 milli-mhos. Since the gate electrode is "hot" with respect to i.f., the output resistance will be increased (at an oscillator voltage of 1.8 V_{eff}).

The oscillator uses a crystal operating at 116 Mc/s, but a modified version for 172 Mc/s is currently being examined. This will avoid the image coming in the 88 to 108 Mc/s broadcasting band with an i.f. of 30 Mc/s. The oscillator has a distortion of 1 %, which is substantially better than in the earlier version of the converter.

Measurements:

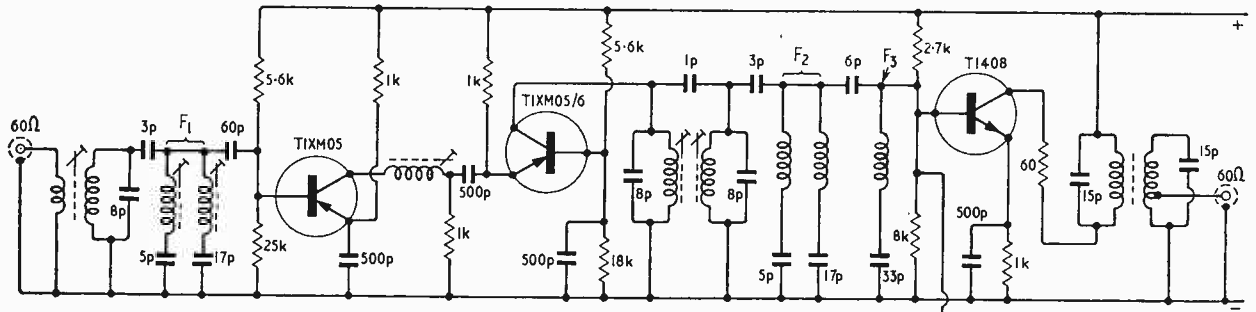
Power gain of pre-amplifier	10 dB
Power gain of mixer	15 dB
Image rejection	80 dB
Gain control	35 dB
Noise figure	2 dB
Input voltage for 1% intermodulation	800 mV
Wipe-out effect for 3 dB loss of gain	300 mV

Cross-modulation of 1 % will be generated between one signal of 2 mV, unmodulated, and another of 300 mV, 40 % modulated, spaced in frequency by 500 kc/s.

Low-cost converter.—Using germanium epitaxial planar transistors type TIXMO5/7 (made by Texas Instruments), a spot-noise figure of 2.2 dB can be achieved with the circuit shown in Fig. 3. For the mixer a silicon epitaxial planar transistor type TI408 by the same manufacturer has been chosen, giving 10 dB better cross-modulation than a germanium type.

The converter uses a rather sophisticated filter design providing high image rejection and low harmonic mixing. The transistors, because of the relatively high operating emitter current of 2.5 mA, offer a more linear characteristic than is commonly obtained. The bandpass filter has relatively high losses, but these are offset by the high gain of the input amplifier. The crystal-controlled oscillator uses a 5th overtone crystal providing a stability of better than ± 50 c/s for large changes of temperature and supply voltage.

From the input, the r.f. signal is applied to a bandpass filter, which suppresses unwanted image frequencies and harmonic mixing. This filter, F_1, is a parallel arrangement of two series resonance circuits, one resonating at 97 Mc/s and the other at 203 Mc/s, and the values of the capacitors have been chosen so that a parallel resonance occurs at 145 Mc/s.



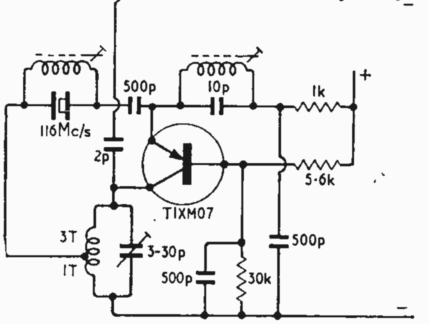


Fig. 3. Converter using germanium transistors. ($F_1 = F_2$ = series resonance at 97 Mc/s and at 203 Mc/s with parallel resonance at 145 Mc/s. F_3 = series resonance at 29 Mc/s with Q = 10).

Mixing amplification is then identical to that of straightforward amplification. Because the oscillator employs a crystal (using the 3rd overtone) no bridge arrangement is necessary to isolate the input voltage and the oscillator signal. Since the i.f. bandpass circuit requires a 2 Mc/s bandwidth, it must be damped at both ends, and this is done by matching in the secondary circuit of the transformer.

In the amplifier use is made of the well-known cascade arrangement, which is very rarely used with transistors, since this configuration allows high gain with the best possible stability. In fact, it was found extremely difficult to make this stage oscillate, and only with heavy external feedback could this be achieved. A second bandpass filter, using three 145-Mc/s circuits, one as already described, is used to suppress unwanted heterodyned signals. The amplified signal is then applied to the silicon transistor mixer, which, because of the high base-emitter voltage of the transistor and the high oscillator voltage of about 700 mV, offers an improvement of 10 dB in linearity. The mixer output is tuned to 28-30 Mc/s.

The oscillator requires zero phase shift between the emitter and collector currents. This is provided by the input tuned circuit consisting of a 10-pF capacitor and a variable inductor. In the feedback loop the 5th overtone crystal (made by Quarzkeramik of W. Germany) operates at 116 Mc/s. Several crystals made by other companies were tested, but they failed to give the high stability of ±50 c/s over the temperature range −10° to +85°C provided by this type. No frequency change greater than 50 c/s can be made in the tuned circuit, for after detuning by 50 c/s the oscillator rapidly stops working. A sampling oscilloscope (Tektronix) was used to control the harmonics of the oscillator, and with the spectrum analyser adaptor for the 'scope a distortion of 0.5% was measured. This was about the same as with the f.e.t. circuit.

Measurements:

Power gain	28 dB
Spot noise figure	2.2 dB
Image rejection..	90 dB
Suppression of harmonic mixing	65 dB
Crossmodulation will start with an input signal of	100 mV into 60Ω

Intermodulation will start with one signal of 5 mV, and another of 70 mV. Fig. 4 shows the spot noise figure of the TIXM05 transistor at 200 Mc/s, the value at 150 Mc/s being 1.9 dB.

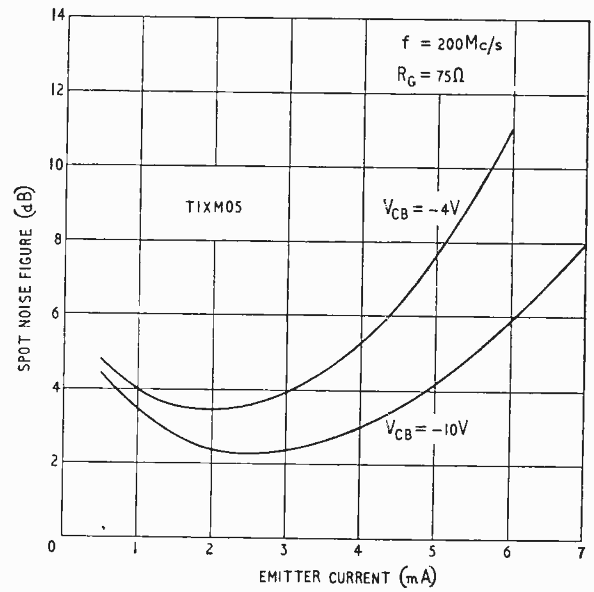


Fig. 4. Spot noise figure vs. collector current of TIXM05 transistor.

REFERENCES

1. 2-m converter with transistors, by U. L. Rohde. *Funktechnik*, vol. 11, 1964, pp. 412-414.

2. Design of v.h.f. cascaded stages with u.h.f. silicon transistors and u.h.f. m.o.s. f.e.ts, by U. L. Rohde. *Elektronische Rundshau*, vol. 11, pp. 633-640.

3. The field-effect transistor at v.h.f., by U. L. Rohde. *Wireless World*, January, 1966, pp. 2-6.

Literature Received

"**Microcircuits Planar Selector**" gives brief details of the wide range of microcircuits currently available from SGS-Fairchild Ltd., 23 Storefield Way, Ruislip, Middlesex. The range is divided into three groups; military, professional, and industrial.
WW 338 for further details

"**Designers' Digest 4,**" issued by the Standard Telephones and Cables Ltd., Components Group, Footscray, Kent, is intended as a quick 47-page reference to components manufactured and marketed by the Group.
WW 339 for further details

"**Solid-state video switching and mixing equipment**" (B/VSE issue 3) has been received from the Broadcast and Recording Equipment Division of E.M.I. Electronics Ltd. This 19-page publication is concerned with E.M.I. solid-state equipment designed to replace electromechanical switching and mixing equipment.
WW 340 for further details

Four **application reports** produced by Brookdeal Electronics Ltd., Myron Place, Lewisham, S.E.13, describe (1) optical spectrometer measurements with the phase sensitive detector; (2) measurement of Hall effect using a phase sensitive detector; (3) measurement of the edge shift in gallium arsenide using a phase sensitive dectector; and (4) the a.c. operation of thermistor bridges.
WW 341 for further details

"**Induction Brazing,**" a new technical data sheet on low-temperature silver brazing, explains why high-frequency induction can provide the most rapid form of heating and is particularly useful in the brazing of large runs of ferrous components of relatively simple shape. Uniform and reproducible results can be obtained at high speed and heating cycles can be controlled by automatic timing devices. This data sheet 110;143 is one of a series on low-temperature silver brazing issued by Johnson, Matthey & Co. Ltd., 73-83 Hatton Garden, London, E.C.1.
WW 342 for further details

"**Loctite Single Components Structural Adhesives**" is a general description 4-page leaflet No. S155 covering most of the Loctite self-curing resins. Full technical data on any one of six new adhesives is available from Douglas Kane (Sealants) Ltd., Swallowfields, Welwyn Garden City, Herts.
WW 343 for further details

"**Silicon & Germanium Transistor Selection.**"—Considerations that must be made when designing equipment around either silicon or germanium devices are discussed, together with advice on making the choice between the two types in the 31-page booklet by Newmarket Transistors Ltd., Esening Road, Newmarket, Suffolk. Tables are included, indicating the more commonly used silicon and germanium devices both industrially and professionally.
WW 344 for further details

NEW PRODUCTS SEEN AT THE I.E.A.

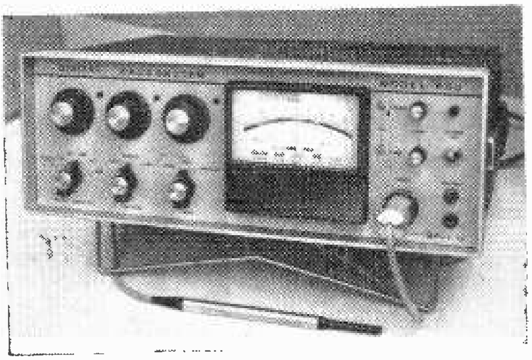
BECAUSE of the vastness of the range of instruments, components and equipment shown by the 800 exhibitors at the recent Instruments, Electronics & Automation Exhibition held at Olympia we have not attempted a review of the Show but have chosen the following items for our New Products Section.

INSTRUMENTS

Digital Gaussmeter

A Hall-effect probe with linear flux response, good thermal stability and temperature compensation is one of the main features of the F. W. Bell (American) Model 660 gaussmeter just introduced into the U.K. by Livingston Laboratories Ltd., North Watford, Herts. Furthermore, in the four higher ranges (0-100 G to 0-100 kG) the instrument gives its read-out in digital form on three manually operated dials. On the two lowest ranges (0-1 G and 0-10 G) the indication is presented in conventional analogue form on a meter.

In the digital mode of operation the three dials are operated to give a null-balance with the signal from the Hall probe, and this is shown by a centre-zero indication on the meter. Further resolution is obtained by using the meter scale for interpolation between digits on the last (least-significant) dial. Analogue measurements 0.1 at G full scale can be made using the 0-100 G digital range.



The temperature dependence of probe sensitivity (compensated, digital mode percentage of reading, $-20°C$ to $+65°C$) is -0.005% per °C nominal.

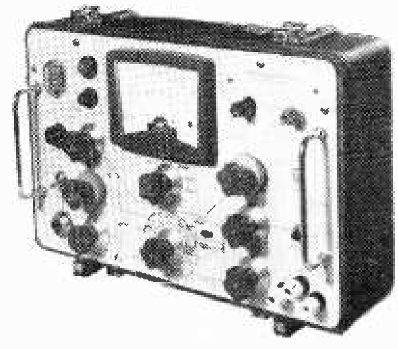
WW 301 for further details

TRANSISTOR AND DIODE TESTER

A transistor and diode tester, type TT 537, is announced by Avo. Provision is made for measurement of transistor h_{FE} up to 1500 at a frequency of 1 kc/s and the measurement of leakage current down to 1 μA. Collector currents up to 1 A can be measured and base currents from 100 nA to 50 mA.

Both forward and reverse characteristics of diodes can be measured. Reverse characteristic up to 1000 V can be measured (at 200 μA) and to 100 V at 3 mA. (Avo Ltd., Vauxhall Bridge Road, London, S.W.1.)

WW 302 for further details



Selective Null Detector

A tunable null detector for the range 25 c/s to 100 kc/s is introduced by S.T.C. The selective detector, type 26 16-A, has a sensitivity of 1 μV for full-scale deflection. It can be used as a bridge balance detector and as a low-noise pre-amplifier for oscilloscopes and electronic voltmeters.

Either a linear or a logarithmic response can be obtained from the output amplifier by operating a switch, thus simplifying the search for a null point by widening the scale in the logarithmic condition. Provision is made for using external filters to extend the scope of the instrument, which is suitable for field use since it operates from two 6 V internal dry batteries.

The instrument has an input impedance of 25-kΩ-1 MΩ depending on gain control setting and output impedance is about 300 Ω in series with 5 pF Maximum output is about 1 V r.m.s.

WW 303 for further details

DIGITAL TACHOMETER

Speeds of rotating parts are indicated digitally on a four-numeral indicator in a digital tachometer introduced by Smiths Industries, Industrial Instrument Division, Wembley, Middx. The instrument operates from pulses received from, say, an inductive pick-up, and the standard instrument is calibrated on the basis of 60 pulses/rev. (though other ratios can be provided for). The pulse rate is sampled at intervals of either 1 or 5 sec, as selected by a switch on the front panel, and the speed indication, in r.p.m., is held steady during these intervals. Any input pulse frequency up to 100 kc/s can be accepted and the pulse amplitude can be anything from 200 mV peak to 175 V peak. The minimum input pulse width permissible is 5 μsec.

WW 304 for further details

PRE-SET COUNTER-TIMER

A pre-set counter-timer (model 805R) using silicon transistors, is offered by Racal Instruments Ltd., Dukes Ride, Crowthorne, Berks.

It is intended primarily for industrial application. The digital timebase is variable between 1 ms and 100 s, and the five-digit readout will display such units as gallons per hour, or revolutions per second, etc. The instrument may be used as a frequency meter, ratiometer, chronometer for time interval measurement or as a delay generator (1 μs-100 s). Optional features available include serial output for a digital printer, remote display and supplementary switching modules.

The crystal standard has a stability of ± 1 part in 10^6 long and short term. Sensitivity is 100 mV and input impedance is either 10 or 100 kΩ.

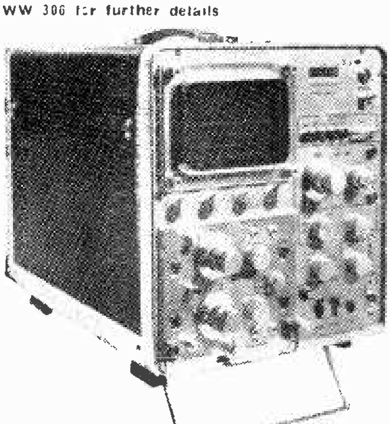
WW 305 for further details

Transistor scope with Plug-in Units

One of a new range of instruments from Cossor Instruments, of Harlow, is the CDU110 general purpose oscilloscope, priced at about £330. The timebase sweep range extends from 0·2 μs cm^{-1} to 0·5 s cm^{-1} and a 5× magnification control extends the fastest sweep speed to 40 ns cm^{-1}. Single sweep and sweep delay facilities are provided.

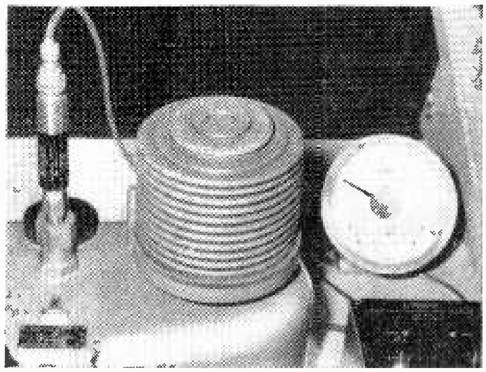
The vertical deflection system incorporates a 180 ns signal delay so that the leading edge of the sweep triggering waveform can be observed. Three plug-in y amplifiers are available: a single trace unit (CAM 110) with a sensitivity of 5 mV cm^{-1} and a bandwidth of 20 Mc/s; a double trace unit (CAM 111); and a differential unit (CAM 112) with a sensitivity of 500 μV cm^{-1}, a 1 Mc/s bandwidth and a common mode rejection of 10,000 to 1.

WW 306 for further details



HIGH-OUTPUT PRESSURE TRANSDUCERS

Pressure transducers with integral solid-state d.c. amplifiers giving a full-range output of 1 V d.c. (at up to 1 mA) have been introduced by Intersonde Ltd., The Forum, High Street, Edgware, Middx. Available for liquid or gas pressure ranges from 0-100 p.s.i.g. to 0-10,000 p.s.i.g., these devices, because of their large outputs, give signals which can be directly indicated on 0-1 mA meters calibrated in p.s.i. or other units.

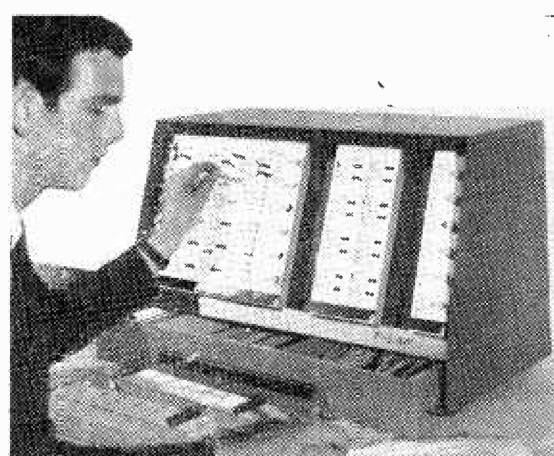


The tubular beryllium-copper pressure sensitive element has bonded to it resistance strain gauges wired into a four-arm bridge circuit, which is energized from a 24 V d.c. supply (a separate unit available from the company). Applied pressure unbalances the bridge, and the unbalance signal is amplified in the d.c. amplifier—a Ferranti ZLD2S integrated circuit. Static or varying pressures can be measured, and the operational temperature range of the transducers is −40°C to +120°C. Electrical connections are flying leads or Plessey plugs and sockets. (Transducer seen on left of picture.)

WW 307 for further details

Logic Trainer

A logic training unit for demonstration, experiment and teaching of modern control and computer techniques was shown by Allen West Automation Ltd., of Brighton, and utilizes the industrial range of static switching modules produced by the parent company Allen West & Co. Ltd. The equipment comprises a cabinet, containing a power supply unit, with an inclined face to which 10 modules covering up to 60 logic elements can be fitted. Functions of modules currently available are AND, OR, NOT, NAND, FLIP-FLOP, INPUT, DISPLAY, STEPPING UNIT and MISCELLANEOUS COMPONENTS. The logic elements within the module are arranged in groups of 6 or 4 and are of the resistor-transistor logic type except for AND and NAND which are diode-transistor logic. Power supplies are made to the elements via a connector mounted at the bottom of the module; fitting the module in position makes the connections. The positions of the modules on the cabinet are interchangeable. Interconnection of logic signals is made with jumper leads, which have colour coded plugs, into socket positions on the faces of the modules. The input module has switches which give a "1" and "0" output; presence of a 1 output is indicated by an energized lamp. Logic levels are 0 (false) between 0 and 1·1 V, 1 (true) between 8·2 and 12·9 V.



The power unit built in the cabinet operates from 230-250 V a.c. and supplies the ten modules with a stabilized operating voltage of ± 12 V. The power unit will also supply an extension cabinet which can be used to increase the number of logic elements to 120.

WW 308 for further details

Low-cost Digital Voltmeter

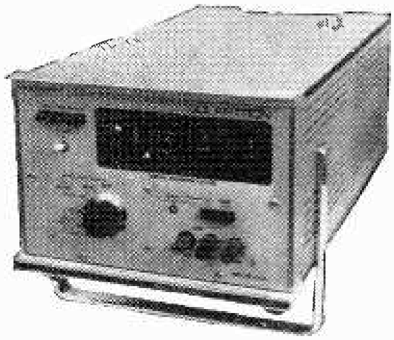
Only one switch, the range selector, is involved for most measurements on the LM 1450 digital voltmeter, manufactured by Solartron, of Farnborough.

Range maxima are from 20 mV to 1,000 V, with a resolution of 10 V on the lowest range. Accuracy is ±0·05% of reading ±0·05% of range for a ±5% variation of mains voltage. Input resistance is 100 MΩ on ranges less than 2 V and 10 MΩ otherwise. Internal calibration is provided by a low temperature coefficient Zener diode. Common mode rejection at 50 c/s can be as high as 140 dB with a filter which has a 60 dB rejection from 50-120 c/s.

Three modes of operation are commanded by front panel pushbuttons: an auto mode, when the instrument samples at 50 readings per second; a slow mode, providing repetitive sampling at approximately one reading every two seconds and single shot sampling.

In operation the LM 1450 converts the unknown voltage into a proportional time interval, this time interval then being measured and displayed using conventional counter circuitry with an internal crystal clock. The initial conversion depends upon charging a capacitor to a voltage derived from the input signal and then discharging the capacitor with a constant defined current. The time taken is then a direct measure of the unknown voltage.

WW 309 for further details



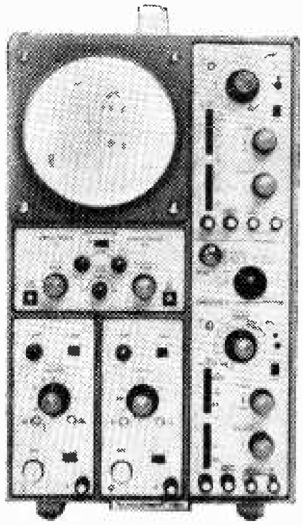
DOUBLE-BEAM OSCILLOSCOPE

The D56 special purpose oscilloscope, manufactured by Telequipment Ltd., Chase Road, London N.14, is designed for applications involving twin timebase techniques. Two independent timebases are provided, each variable between 0·5 μs cm⁻¹ and 5 s cm⁻¹. The B timebase can be used to delay the A timebase, allowing a selected portion of the lower trace to be expanded and shown on the upper trace.

Two marker facilities are provided. One, a television line marker, uses a 0·5 V pulse from the A timebase which may be fed to a video monitor for line identification of video waveforms. An internal 10 Mc/s generator produces marker pips on the upper beam for rise time measurement.

The two identical *y* amplifiers have bandwidths of 15 Mc/s and sensitivities of 10 mV cm⁻¹. Price is about £300.

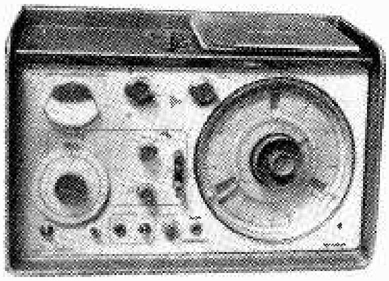
WW 311 for further details



0·1 per cent Universal Bridge

One of the most recent instruments to be announced by Marconi Instruments, of St. Albans, is the TF 1313A general purpose impedance bridge with a measurement accuracy of ± 0·1%.

At balance, the *L*, *C* or *R* value is read from two concentric dials of the coarse and fine balance controls. The coarse control is 110-position switch and the reading from this is added to that from the continuously variable fine control. There are eight resistance ranges with maxima from 11 Ω to 110 MΩ and permitting measurement down to 0·003 Ω. Inductance and capacitance ranges cover 0·1 μH to 110 H and 0·1 pF to 110 μF with lowest range maxima of 110 μH and 110 pF respectively. On the resistance ranges, the bridge is energized with d.c. and a photoelectric chopper is used to provide a.c. for the amplifier preceding the balance indicator. The internal a.c. bridge source operates at 1 or 10 k/cs, but measurement can be made at any frequency with the use of an external source. An output is provided for use with an external balance indicator. A polarizing voltage of up to 350 V is provided for measurement of electrolytic capacitors.



The *Q* range extends to 310 and *D* (=1/*Q*) range to 0·0005. Accuracy on these ranges is about ± 5% of reading and ± 5% of reading plus respectively ± 3% f.s.d.

WW 310 for further details

Portable Weighing Equipment

Maximum loads between 200 lb and 2,000 tons can be measured by a new portable weighing equipment consisting of a load cell and an electronic indicator unit measuring only 8 in × 6 in × 10 in. Made by Ekco Electronics Ltd., Southend-on-Sea, Essex, the equipment uses either a single load-cell or a flat weighing platform containing a number of small cells. Weight is sensed by the resistance change of the strain gauge elements in the load cell and indicated by a null-balance method using a ten-turn 3-digit dial and a centre-zero meter. Accuracy is claimed to be ±0.25% of full load and the temperature coefficient 0.0002% of full load per °C.

WW 312 for further details

INFORMATION SERVICE FOR PROFESSIONAL READERS

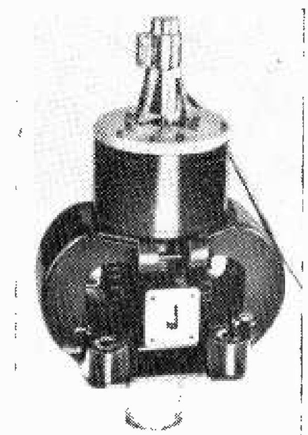
To expedite requests for further information on products appearing in the editorial and advertisement pages of *Wireless World* each month, a sheet of reader service cards is included in this issue. The cards will be found between advertisement pages 16 and 19.

We invite professional readers to make use of these cards for all inquiries dealing with specific products. Many editorial items and all advertisements are coded with a number, prefixed by WW, and it is then necessary only to enter the number on the card.

Postage is free in the U.K. but cards must be stamped if posted overseas. This service will enable professional readers to obtain the additional information they require quickly and easily.

J-band "Agile" Magnetron

A J-band coaxial pulse magnetron, the L-4500, capable of high-speed random tuning in the range 15.5-17.5 Gc/s, and rapid dithering about a given frequency to improve radar resolution by reduction of clutter and glint, has been developed by the Litton Industries Electron Tube Division of California. It is also capable of precise electronic setting to any fixed frequency within the range. The unique feature of this magnetron is the electro-magnetic actuator that works on the same principle as a loudspeaker, except that it employs a servo feedback. The tuner follows any signal—sine, triangular, or square wave —and provides an output voltage for monitoring the frequency to an accuracy of 0.3 %, under all environmental conditions. There is also a low voltage cooker magnetron, the Microtron, which is a permanent magnet, air cooled tube, operating at 3.6 kV. Power output is 1 kW at 2,450 Mc/s. Warm-up time is

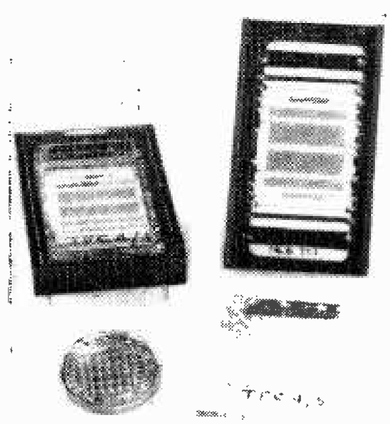


3 seconds. Available in the U.K. from Litton Precision Products, 503 Uxbridge Road, Hayes, Middlesex.

WW 313 for further details

Tantalum Film Resistors

Sample arrays of 12 fixed resistor elements having a common substrate are now available from A.E.I. These sample arrays (TFC 4/1 and 4/5) are typical in every aspect of those elements used in tantalum film hybrid circuits. Since these sample resistors are not internally connected, any combination of the 12 elements with each other, or with any



other device or component may be made by the use of external connections. The leads which are gold-plated nickel tapes may be soldered or welded. The resistor elements are etched and anodised sputtered tantalum films on a substrate of borosilicate glass, the contacts are gold/chrome evaporated films, the whole array being inside a moulded polystyrene package 2.4×1.3×0.28 in. The elements consist of two each of the following values 100Ω, 1k, 5k, 10k, 25k, 50k, while the recommended power ratings at 20°C ambient are 100, 100, 100, 100, 200 and 500 mW respectively. The tolerance on nominal value for TFC 4/1=±1% and for TFC 4/5=±5%. Temperature coefficient of resistance: less than ± 50 p.p.m./°C. From Associated Electrical Industries, Research Laboratory, West Road, Temple Fields, Harlow, Essex.

WW 314 for further details

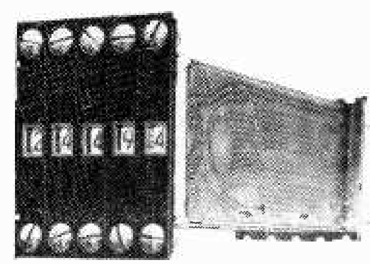
Solid-state Gas Igniter

This Brush-Clevite Mark 1 gas igniter employs a patented method of mechanically distorting two piezoelectric ceramic elements to produce a series of sparks. Appliances such as fires, cookers, heaters and lighting equipment can have their gas fuel ignited by this solid-state device. It does not require batteries or power supply. The energy produced by the Mark 1 will ignite the following gases: acetylene, butane, hydrogen, methane, pentane, petrol, propane and natural gas. Brush-Clevite Co. Ltd., Hythe, Southampton.

WW 315 for further details

High Speed Counting Module

The E.N.M. high-speed electro-mechanical counting module with electrical read-out, is described as the Series 444 UNIDEC. A single decade counter, in modular design, it can be arranged in groups as a high-speed counter with any number of digits and it is fitted with internal contacts to enable groups to be driven in either serial or parallel form. These contacts will permit remote re-setting to zero, and provide an electrical read-out. The count frequency is 60 c/s, with minimum pulse length of 8.5 ms at 10% below rated voltage. Maximum pulse length is continuous duty at 25 ° C ambient and 10 % above rated voltage. Nominal count voltage 12 V d.c. or 24 V d.c.; coil resistance (nominal) 52 or 210 ohms. The reset pulse length is 200 ms. The figure size is 0.14 in high by 0.09 in wide and is black on a white background. The front panel is 1.68 in high



by 0.25 in wide. A printing wheel is available in addition, for printed read-out. Overall length is 4.216 in, and body height 1.125 in. English Numbering Machines Ltd., Queensway, Enfield, Middlesex.

WW 316 for further details

SILICON PHOTO SENSOR

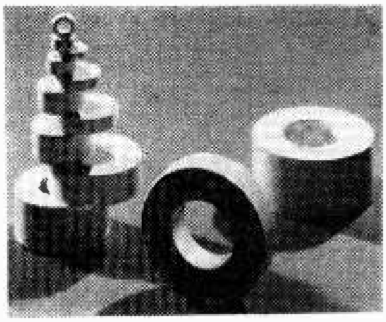
The MSP/3 and MSP/6 are composite silicon photo-electric sensors that can operate relays directly in optical links that utilise gallium arsenide light sources. With a peak spectral response of 9500 Å, they have an output current intensity of 100 mA, and a maximum voltage rating of 25 V. These sensors can also be used in photo-electric systems employing visible light sources. They are 25.4 mm long and have a diameter of 6.4 mm Sensitive area is 2 mm diameter. The MSP/3 has a frequency response of −3 dB at 10 kc/s, and a dark current of 0.003 mA at 25°C. The MSP/6 has a frequency response of −3 dB at 3 kc/s, and a dark current of 0.02 mA at 50°C. Manufactured by M.C.P. Electronics Ltd., Station Wharf Works, Alperton, Middlesex.

WW 317 for further details

Magnetic Materials

Among the magnetic materials shown by Standard Telephones and Cables Ltd. was a range of high permeability ferrite ring cores which although designed especially for pulse and wide-band transformers are suitable for other applications. The cores are available in two grades (SA503 and SA601) of high stability manganese-zinc ferrites with low losses. The main differences in the properties of these materials are listed in the following table.

Property	SA503	SA601
Initial permeability	2250±20%	3500±20%
Maximum permeability	3750	5800
Coercivity Bmax = 4000 (Oe)	0.14	0.12
Temperature coefficient of permeability from 20°C to 70°C (% per 0°C)	0.2±0.1	0.35±0.35
Typical loss factor at 300 kc/s	10	12



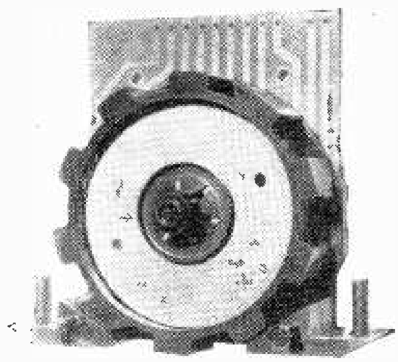
The proportions of the cores ensure maximum inductance per turn and the range of dimensions is such that for a given value of A_e or A_e/l_e, the designer always has a choice of two sizes. Twelve core sizes ranging from an o.d. of 4 mm and i.d. of 2 mm to an o.d. of 24 mm and i.d. of 12 mm are available. Cores are normally available with a tolerance of ±25% on the specific inductance value. This tolerance allows for variations of material permeability and core size. Closer tolerances are available. Cores are finished with two coats of stoved enamel so that self-fluxing wire can be wound directly on the core without danger of insulation breakdown.

WW 318 for further details

Thumbwheel Rotary Switch

A thumbwheel or edge control rotary switch by Nucleonic Accessories Ltd. of Lee Green, Mirfield, Yorks., is produced in a wide variety of output codes, that include decimal, binary coded decimal (with and without complementary codes) or zero and parity contacts. The switch has 10 positions and is available with or without detent. Rotation may be continuous (360°) or stops may be provided to limit the rotation to any position from any two adjacent ones (36°) up to the full ten positions (324°). The printed circuit is gold plated, and a life expectancy of at least 1 million revolutions is claimed for it. Maximum current rating is 0.5 A, with an insulation resistance greater than 1000 MΩ. Width 0.5 in, height 2.3 in (overall), and fixing is by two studs. Connections may be made by direct soldering or edge connectors. Models available:—Type A 1-pole 10-way break before make; Type B 10-position for binary coded decimal. Also available is a mains version (250 V a.c. 5 A; 110 V a.c. 10 A) with micro-switch for instrument on/off control operated by a thumbwheel.

WW 321 for further details



NEW GRADES OF INDUSTRIAL LAMINATES

Bakelite Limited, London, S.W.1, have introduced new paper-based and epoxide-glass based laminates. Grade "EW 54943 natural" copper-clad laminate is paper based and can be guillotined and punched at room temperatures, thus obviating heat shrinkage problems. This grade, intended to comply with the relevant British Standards, has all the characteristics of the American National Electrical Manufacturer's Association (NEMA) standard for XXXPC laminates and is suitable for many applications in the electronics industry. The Bakelite range of epoxide glass fabric laminates has been extended with new grades which have fire retardant and cold punching properties combined with excellent mechanical and electrical characteristics. "DH 138 Natural," in standard form and "DH 90/E Natural," the copper-clad version, are intended to comply with relevant British Standards and with the fire retarding requirements of NEMA FR4. The copper-clad version employs an adhesive system specially formulated to provide additional resistance to electroplating conditions and translucency of the substrate is such as to allow the circuit pattern to be visible from the opposite side of the board in daylight.

WW 319 for further details

MINIATURE MERCURY CELL

Claimed to be the world's smallest primary dry battery the Mallory RM-212 is 0.22 in wide, 0.13 in high and weighs 0.3 gram. This new mercury oxide battery has been specifically designed for a new type of hearing aid that fits inside the ear duct. Its size, and stability of power output will make it suitable as a power source for "radio pills" and the diagnostic probe techniques now being developed. The capacity of the RM-212 is rated at 0.5 mA 16 mAh. Mallory Batteries Ltd., Gatwick Road, Crawley, Sussex.

WW 320 for further details

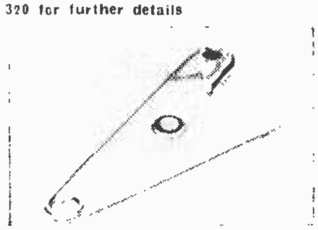


Diagram Preparation

Until recently Chart-Pak pre-printed tapes and symbols have been imported from America but now a British Company Chart-Pak Ltd., Weybridge, Surrey, has been formed to manufacture and market the product in the U.K. Basically, Chart-Pak is the use of pre-printed self-adhesive tapes and symbols to prepare diagrams but one interesting aspect is its use with respect to printed circuits. If a prototype circuit is required the tape—available in widths from 1/64 in to 2 in and cut to a slitting accuracy of ±0·002 in—can be placed directly on the copper clad sheet and immersed in the acid bath to protect the copper during circuit formation.

WW 322 for further details

STANDEE TYPE RESISTOR

The Vitrohm UBT standee-type carbon composition resistor has been developed for printed circuits and conforms to DEF-5115-1, and MIL-R11-E specifications. The resistance range available is from 22 Ω to 22 MΩ, power rating 0.3 W at 70 ° C derated to no load at 130 ° C. Tolerance ± 10 %, ± 5 %, and a 250 V maximum rated continuous voltage. Body dimensions 8.5 × 5 × 3.5 mm. The sole U.K. distributors of this Danish product are Dubilier Condenser Co., Ducon Works, Victoria Road, North Acton, London.

WW 323 for further details

Ceramic i.f. Filters

These filters by Brush-Clevite are now available for use in military and commercial equipment. Designed for the i.f. stages of superheterodyne radio receivers, they possess advantages over the i.f. stages in common use. Fixed-tuned, they require no alignment, and possess a centre frequency stability of within + 0.2 % for 5 years, and within 0.2 % from − 40 ° C to + 85 ° C (their operating temperature range). Five standard models are available, TL10D9-20A, TL16D9-32A, TL20D9-38A, TL30D9-57A, and TL40D9-72A; the minimum bandwidths at 27° C at 6 dB are 10 kc/s, 16 kc/s, 20 kc/s, 30 kc/s, 40 kc/s respectively, while the maximum bandwidths at 27° C/60 dB are 20 kc/s, 32 kc/s, 38 kc/s, 57 kc/s and 72 kc/s respectively. These five models are available with centre frequencies of 455 kc/s and 500 kc/s. Input and output impedances at 27 ° C are 2 kilohms for a 10 kc/s bandwidth and 1 kilohm for a bandwidth of 16 kc/s and above. Stop band rejection is 50 dB and the tolerance on the centre frequency at 27° C is ± 3 kc/s, although filters can be supplied with a tolerance of ± 2 kc/s at 27 ° C.

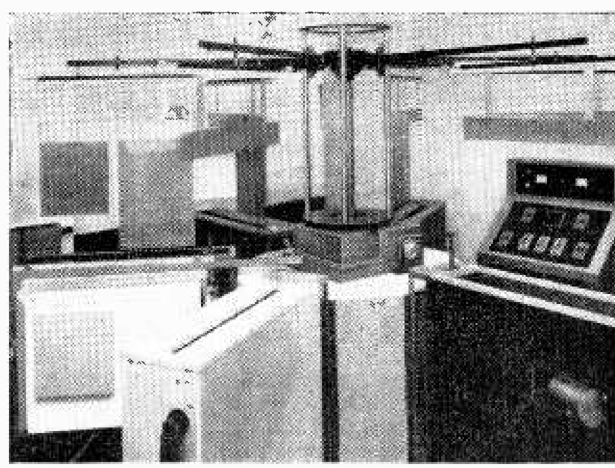
Brush-Clevite Co., Ltd., Hythe, Southampton.

WW 324 for further details

Printed Circuit Production

On the stand run jointly by Kodak and MPC of Milan was shown the first commercially available fully automatic production unit for printed circuits. Three separate units are used: the MPC UNI 63 for cleaning the copper laminate; the MPC Photomat E for printing; the MPC UNI 100 for etching and rinsing the final printed circuit. Other versions are available but only the three types mentioned will be discussed. In addition, the units have other uses besides those briefly mentioned. For example, the MPC UNI 63 can be used for cleaning and deoxidizing copper-clad material before photoprinting, but it can also be used for deoxidizing of printed circuits after the application of solder resist with subsequent fluxing. Material for the printed circuits is placed on a flat conveyor and subjected to a spray of cleaning or deoxidizing liquid which is automatically maintained at the desired temperature. The material is then burnished and cleaned.

After this stage, the material, for example, copper laminate board, is passed to the printing unit. The MPC Photomat E has six radial arms which rotate through 360° and go through a six-stage process.



After the completion of each stage, the arms rise, rotate, stop and then descend for the next process. The first stage entails manual loading and subsequent unloading (at the end of the cycle) of the boards which are prepunched to enable them to be clipped on the arm. During the succeeding five automatic stages, the boards are (2) coated with a photosensitive resist (3) dried (4) printed on one side (double sided printing is possible with a larger model) (5) first stage developed (6) second stage developed.

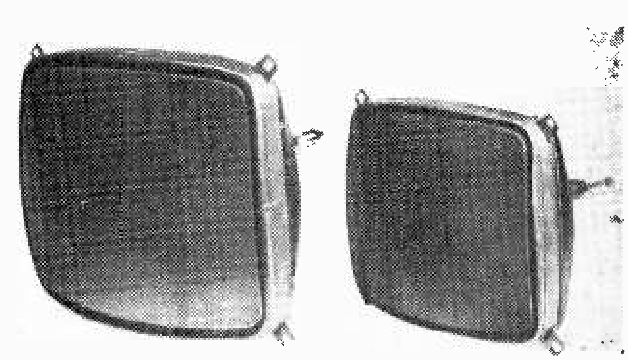
Etching and rinsing of the boards can be done by the MPC UNI 100. The boards are placed on a horizontal conveyor, then pass into an etching section, where an etchant is sprayed on to them. Two rinsing sections are provided.

WW 325 for further details

Colour Tubes

A 19-in Mazda rectangular shadow-mask tube has been introduced and pilot production of this and the 25 in size has started at the Thorn-AEI factory at Brimsdown, North London. These 90° deflection tubes have a neck diameter of 36.5 mm and a heater rating of 6.3 V. The three electrostatic focusing anodes, connected in parallel, run at about 5 kV and the final anode operates at 25 kV.

The grey tinted glass screens are aluminized and have integral metal suspension lugs. Rare earth red phosphor is used resulting in a higher overall brilliance without desaturation of reds and giving the unlit screen a less yellow appearance.

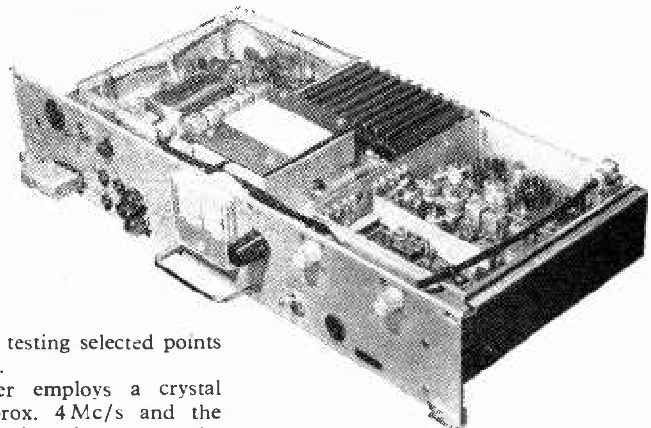


WW 326 for further details

COMMUNICATIONS EQUIPMENT

Point-to-point Tx/Rx

Designed to meet the British Post Office specification for point-to-point communications equipment the Cossor CC-RTR4A transmitter-receiver operates in the 450-470 Mc/s band allocated to fixed and mobile radio services. The complete equipment, including the power unit, is mounted in a 19 in chassis, 9 in deep, and has a $3\frac{1}{2}$ in front panel. Silicon planar transistors are used throughout, and there are versions for d.c. operation (12 or 24 V) and a.c. mains 90-120 V or 180-240 V (50 or 60 c/s). A front panel meter can be switched to monitor the transmitter power output, the receiver r.f. input level or for testing selected points in the equipment.



The transmitter employs a crystal oscillator of approx. 4 Mc/s and the second harmonic is selected by the tuned circuit in the collector of the oscillator transistor. Part of the tuning capacitance of the tuned circuit is formed by a variable capacitance diode, the capacitance of which is varied according to the amplitude of the modulation signal applied across it from the modulation pre-amplifier. The 2-W transmitter operates on one crystal-controlled frequency between 450 and 470 Mc/s and has a frequency stability of ± 5 parts in 10^6 from $-10°$ to $+40°$C.

The receiver, which is also crystal controlled, has a signal/noise ratio of 42 dB for ± 5 kc/s deviation in the range 300-3,400 c/s for an r.f. input of 5 μV p.d. and 1 kc/s modulation.

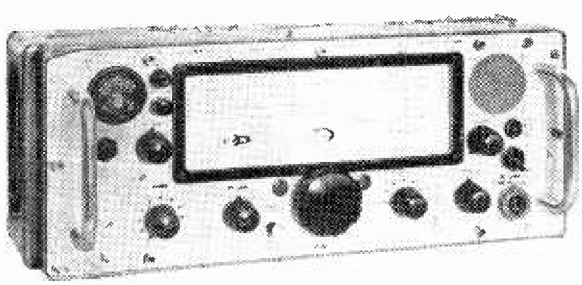
This is the first point-to-point equipment to be produced by Cossor Communications Co., Ltd., of Elizabeth Way, Harlow, Essex. It is designed to provide one or two speech channels with or without supervisory control tones.

WW 327 for further details

H.F. Communications Receiver

Continuously tunable over the frequency range 600 kc/s to 32 Mc/s in eleven 3 Mc/s bands, the R7020 receiver, recently introduced by C. & N. (Electrical) Ltd., of The Green, Gosport, Hants, employs a 6 ft scale "folded" in 7-in bands. Detector outputs are provided for a.m., p.m.., s.s.b., f.s.k. and c.w. Sensitivity on a.m. with 30% modulation at 1 kc/s is 6 μV for 20 dB S+N/N ratio. On c.w. it is 3 μV and on p.m. (deviated 1 kc/s at 1 kc/s) it is 4 μV. The receiver employs a 100 kc/s crystal controlled 1st local oscillator and frequency stability is quoted as within 3 kc/s from $-10°$ to $+40°$C.

The R7020 has a built-in $2\frac{1}{4}$ in monitor speaker and an "S" meter. The receiver has an integral voltage regulator and will operate on input voltages of between 12 and 50 V d.c.



WW 328 for further details

Pocket Transmitter-receiver

Code-named MITRE (Miniature Individual Transmitter-Receiver Equipment) this pocket set covering the 68-100 Mc/s or 145-174 Mc/s bands provides four f.m. channels with a 25 kc/s separation. Produced by Rank Bush Murphy at Welwyn Garden City, Herts, the set has been designed specifically to slip into a uniform pocket. It is a little over $\frac{3}{4}$ in thick, is $5\frac{1}{4}$ in high and $3\frac{3}{4}$ in wide including the clip-on rechargeable sealed nickel-cadmium battery. The miniature loudspeaker-microphone can be clipped on to a lapel enabling the wearer readily to hear incoming calls. The set is muted until an in-coming signal is received.

WW 329 for further details

H.F. Pack Set

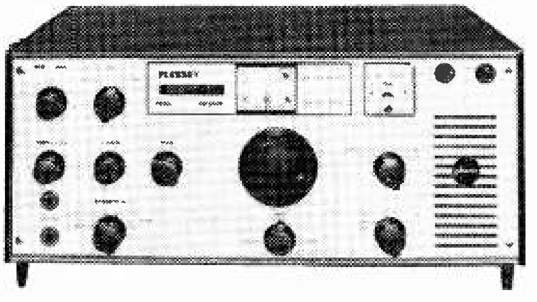
Weighing only 18 lb, complete with battery and carrying harness, the Racal "Squadcal" pack set transmitter-receiver has an output of 5 W p.e.p. and operates in the band 2-7 Mc/s. It can be operated on any of 29 crystal-controlled channels which are pre-selected. The channel crystals can readily be changed in the field. Speech communication over a distance of up to 12 miles is possible with a whip aerial.

WW 330 for further details

M.F./H.F. Receiver

A short-term frequency stability of better than 5 c/s and over a long term better than ± 30 c/s is claimed for the Plessey PR155 communications receiver which covers 60 kc/s to 30·1 Mc/s. It is continuously tunable over this range in thirty 1 Mc/s bands. The linear scale provides 70 inches per megacycle giving a frequency setting resolution of better than 100 c/s. The incoming signal is fed to one of eight sub-octave bandpass filters which are automatically selected by the "megacycles" switch. An on-off calibration switch injects 100 kc/s crystal markers for the adjustment of the zero setting cursor on the tuning scale. A reception mode switch provides for u.s.b., l.s.b., c.w. and a.m. with two spare positions for other modes. Typical sensitivity figures quoted by the manufacturers are:— s.s.b., measured at 15 Mc/s with 3 kc/s filter, carrier-on/carrier-off ratio >20 dB for 1 μV; a.m. (measured at 150 kc/s with 6 kc/s filter) 4 μV for 10 dB s+n/n ratio; and c.w. (as for s.s.b. but with 300 c/s filter) carrier-on/carrier-off ratio 26 dB for 1 μV.

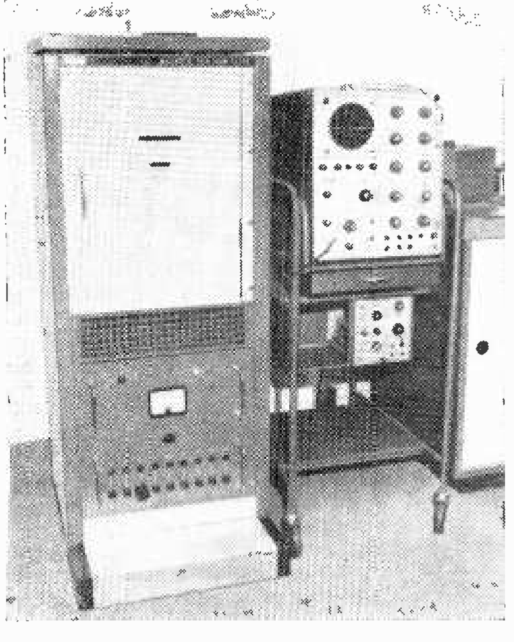
WW 331 for further details



INFORMATION SYSTEMS

Magnetic Thin-film Store

A digital information store with the short read/write cycle time of 0·33 μsec and access time of 0·2 μsec is the latest in a series of magnetic thin-film stores being developed by E.M.I. Electronics Ltd., Hayes, Middx. It stores 128 words, each of 16 bits. The storage elements of one plane are formed by evaporation of 80/20 nickel-iron alloy through a mask on to a glass substrate, and this is done in the presence of a magnetic field so that the elements have a preferred direction of magnetization, thereby providing two stable magnetic states. A matrix of printed wires, formed by two identical two-layer printed circuits, wraps the magnetic elements, providing address drive, digit drive and sense conductors. A number of such storage planes are stacked and connected together by printed circuits to form a complete storage module.



WW 332 for further details

ACOUSTIC TRAFFIC SENSOR

An echo sounding principle is used in an ultrasonic traffic sensor introduced by The Marconi Company Ltd., of Chelmsford, Essex, for counting or measuring the speed of vehicles on roads. The advantage of the system over conventional switch pads in the road is claimed to be lower capital cost and lower installation cost (since no work on the road is required).

The unit is mounted above the road on a bridge or standard, and transmits 2 msec bursts of ultrasonic energy downwards so that they are reflected from the tops of vehicles passing beneath. The return times of the echoes are measured. In the absence of vehicles the echo return time corresponds to the distance of the road surface, and this is used as a reference. When a vehicle enters the acoustic beam the echo return time is shorter than the reference value because of the shorter path length; this indicates the presence of a vehicle and is used to operate a counter or other recording device. By means of an electronic gating circuit the device can discriminate between vehicles of different heights (different path lengths), signifying cars, lorries, buses, etc., so that traffic analyses may be made. Speed may be measured by the use of two spaced sensors and a common signal processing unit.

The ultrasonic pulses are transmitted and received at a p.r.f. of 20-25 per second by barium titanate transducers working into beam forming horns, which give fan-shaped beams. Beam width is variable from 10° to 60°.

WW 333 for further details

PROCESS CONTROL COMPUTER

Latest addition to the Elliott-Automation range of ARCH process control digital computers is the ARCH 102. This new silicon diode/transistor computer is suited to direct digital control duties, but it has greater flexibility in application than the earlier ARCH 101 fixed-programme machine and can work in conjunction with other computers and accept programme alterations.

The ARCH 102 is a binary, parallel (synchronous) machine with a word length of 13 bits, a speed of approximately 40,000 operations per second, an add time (with access) of 23·4 μs, and a multiply time of 76·5 μs. A small store version (4096 words) and a large store version (8192 words) are available. Inputs may be scanned at either 10 or 128 points per second.

Elliott-Automation Ltd., 34 Portland Place, London, W.1.

WW 334 for further details

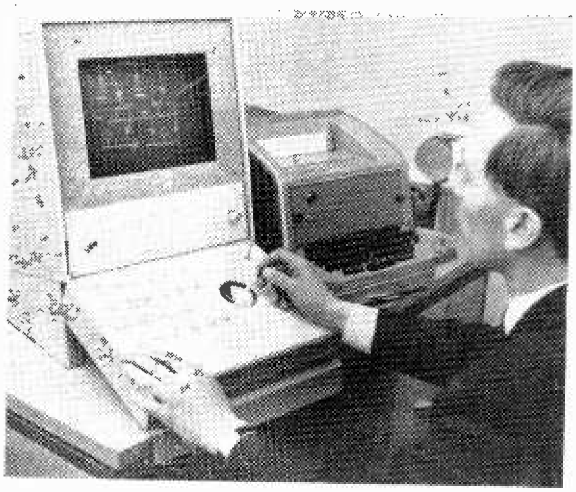
VERSATILE C.R.T. DISPLAY SYSTEM

The distinguishing feature of a c.r.t. computer-output display system just introduced by Ferranti is that it is not restricted to a standard list of symbols. New symbols may be created as required by "drawing" them on the screen with the aid of a joystick control, after which they are stored in the associated computer. Types of display mode available include letters and numerals (two sizes) with random or tabular positioning, graphical symbols as in circuit or mimic diagrams, straight lines of any length and angle starting at any required point, circles of any radius and any centre position, and graphs. The equipment does not use the raster bright-up principle but forms all characters out of straight-line sections and circles, from positional information supplied by the associated computer. Lines are specified by their resolved *x* and *y* components expressed in numerical terms. Circles, once their radius and position have been determined, are generated on the screen by the Lissajous figure technique.

The equipment comprises a c.r.t. display console, a control panel for generation or modification of spatial information, a teleprinter keyboard for writing letters and numerals, and a logic unit for format control, character extraction and selection of display mode (this unit includes the hardware for line and circle drawing). Up to 12 displays can be driven from the such logic unit. Digital data referring to the display need not be kept in a particular part of the associated computer store but can be dispersed according to programming requirements.

Ferranti Ltd., Hollinwood, Lancs.

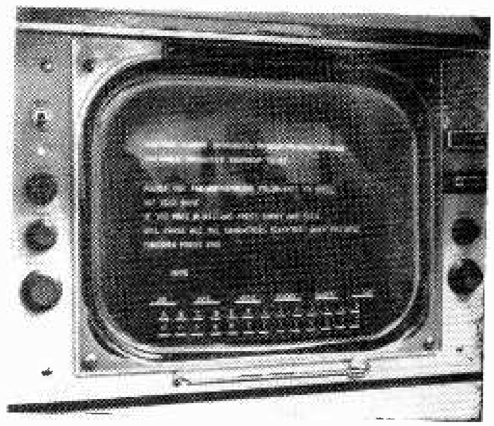
WW 335 for further details



"Touchwire" Manual Input to Computers

A new manual method for giving instructions to computer-controlled or data processing systems has been introduced by The Plessey Company Ltd., of Ilford, Essex. Originally developed for air traffic control, the equipment comprises an array of 32 short wire electrodes set in a transparent screen mounted in front of a c.r.t. display unit. Against each of these "touch wires" the c.r.t. displays a code group of characters signifying an available control decision.

The wires are electrically sampled in turn by a scanning system controlled by a binary clock. When the operator touches one of the wires his hand capacitance unbalances an a.c. energized circuit, and this is detected by a phase detector. The output of the phase detector passes into a logic circuit which stops the scanning system, erases the corresponding control code sequence from the c.r.t. screen and sends a binary number to the computer identifying which wire has been touched. When the computer has recorded this number it sends a re-set pulse to the logic circuit which



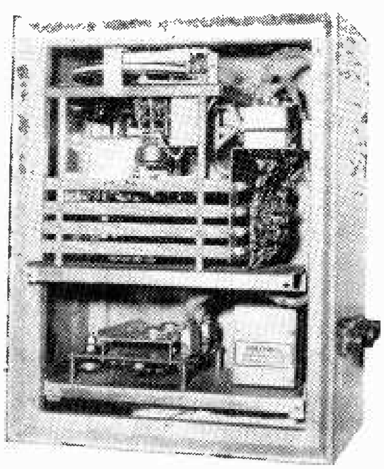
re-starts the scanning system. This causes the next control decision (in some pre-arranged sequence) to be displayed on the c.r.t. If the operator touches the wires in a sequence which is illogical for the system concerned, a warning indication is displayed on the c.r.t. The number of control sequences which can be performed is limited only by the work capacity of the associated computer, and can be varied by modifying the computer programme.

The advantages of the equipment over keyboard input devices are claimed to be that it is simpler to operate, has no moving parts to wear and requires very little operator training.

WW 337 for further details

Automatic Alarm Unit

Intended for use at unmanned stations, such as remote oil storage tanks, the Parkinson Cowan Ltd. "Dialarm" automatically rings a pre-arranged telephone number or numbers when an out-of-limits condition is detected in the plant (e.g. high or low level in the storage tank) and gives a 12-second recorded verbal message to this effect to the person who answers the phone.



Four alarm conditions can be accommodated, the appropriate messages being recorded on four magnetic discs in the unit. An alarm is initiated by the closing of a pair of normally open contacts. The Dialarm is allocated a telephone number like an ordinary subscriber and can be interrogated by ringing that number; if at that time the plant is operating correctly an "all conditions normal" message is sent. The equipment uses solid-state circuits and can be operated from the mains, from a primary battery or from a secondary battery with a trickle charger.

Parkinson Cowan Ltd., Stretford, Manchester, Lancs.

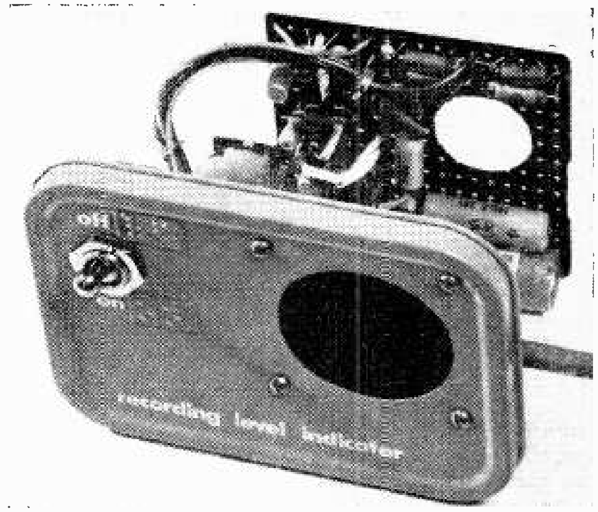
WW 336 for further details

Recording Level Indicator

AN AUDIBLE WARNING DEVICE

By MURRAY WARD, B.Sc.

THIS circuit was designed primarily to give aural indication to a blind person of the recording level on a tape recorder. When the recording level is set too high an audio tone is given out. Other possible applications are as an aid to the amateur ciné enthusiast during the recording of sound on film, or a simple industrial level-warning device.



The illustration shows the mounting of the components in a 2 oz tobacco tin. The on-off positions of the switch are marked in Braille.

Circuit

The circuit is shown in Fig. 1. An audio signal taken from the monitor socket of the tape recorder is fed to an emitter follower, Tr1, which acts as a buffer stage, reducing the loading at the monitor point and preventing any of the audio tone produced by the indicator feeding back into the recorder.

Transistors Tr2 and Tr3 are cross coupled in a monostable multivibrator circuit with Tr3 normally bottomed and Tr2 cut off.

Tr4 and Tr5 form an astable multivibrator, with the emitter of Tr5 directly coupled to the audio output stage Tr6. In the quiescent condition Tr5 is non-conducting due to its base being kept near earth potential by a connection via D1 from the collector of the bottomed Tr3.

Operation

When an audio signal is fed to the input stage Tr1, a proportion of the output voltage, determined by the pre-set potentiometer RV1 is applied to the base of Tr3. This voltage switches Tr3 off and triggers the monostable multivibrator to its unstable state in which Tr2 is bottomed and Tr3 cut off.

The collector voltage of Tr3 is now negative and reverse biases D1, thus allowing the astable multivibrator to operate and produce an audio tone from the loudspeaker.

After a short time, C2 in the monostable multivibrator discharges and the circuit reverts to its stable state, causing the astable multivibrator to become non-operative, thus cutting off the tone in the loudspeaker.

Further audio peaks from the tape recorder cause the sequence to be repeated, the pre-set potentiometer RV1 being adjusted so that the indicator works when the meter or magic eye on the tape recorder shows maximum recording level.

Power supply

6·3 V a.c. from the tape recorder is fed to a bridge rectifier, D2 to D5, and smoothing circuit to give the neces-

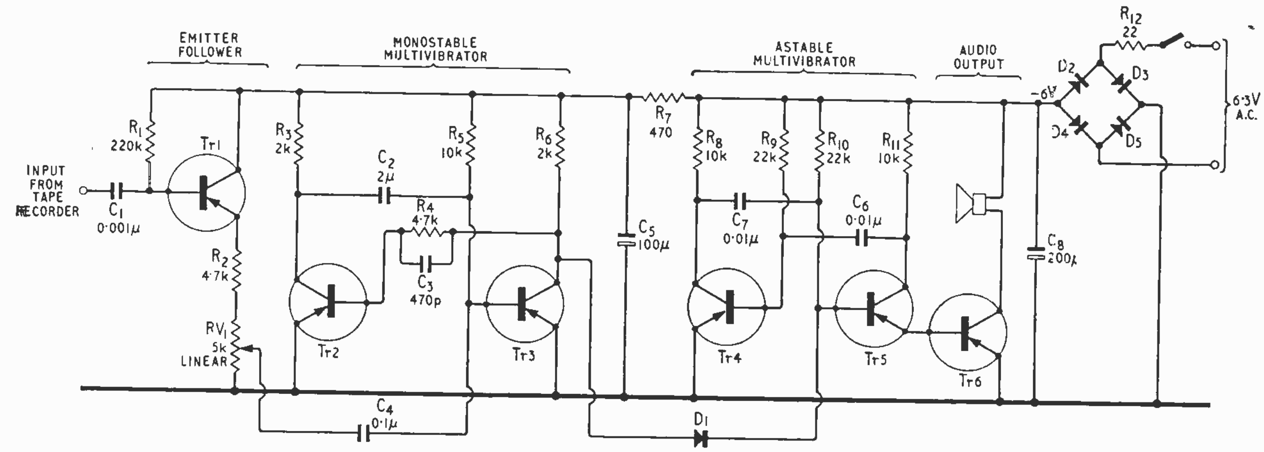


Fig. 1. Circuit diagram of the recording level indicator.

sary power. A small battery would be equally suitable.

Quiescent current is about 2 mA, rising to 12 mA when operating.

Construction

The components were mounted on a piece of Veroboard and the author housed the unit in a 2 oz tobacco tin. An illustration of the finished unit is shown on the previous page.

The recovery time of the monostable multivibrator (and hence the length of output tone) is determined by the time constant C2R5. The frequency of the tone depends on the time constants in the multivibrator cross-coupling networks, i.e. C6R9 and C7R10.

Other component values are not critical. Practically any small-signal p-n-p transistors may be used for Tr1 to Tr5, e.g. OC71. Tr6 is a low power p-n-p output transistor; an OC81 was used in the original unit. By connecting a 75Ω loudspeaker directly in the emitter lead of Tr6, no output transformer is needed.

Acknowledgement

I am indebted to Mr. B. E. A. Vigers for his guidance during the construction of this device.

LETTERS TO THE EDITOR

The Editor does not necessarily endorse opinions expressed by his correspondents

The Future of Television in the U.K.

IT will be obvious by now to all interested parties that this country's 625-line u.h.f. television service is a flop. There is evidence that many viewers with *properly* installed receivers get a poorer picture on 625 lines (u.h.f.) than they do on 405 lines from v.h.f. stations of BBC-1 and I.T.A.; and TAM ratings for BBC-2 vary from unmeasurable to an audience of about 10% of the possible.

Yet it is this same 625-line u.h.f. service which is expected to revive the flagging receiver industry in some magical way by the addition of colour. We are asking to repeat the long slow drag which marked the first years of colour in the U.S.A.

If we look back a few years, all the high hopes of the Pilkington Committee and others about the technical future of British television can be seen now to be so much hot air. For the facts are that

(1) the viewer considers the improvement in picture quality with 625-line u.h.f. to be marginal, and

(2) that four years after the Pilkington report, no plan has yet emerged to change-over the existing 405 line services to 625 lines.

I think it will be accepted by all but the colour blind that the addition of colour to a monochrome television service is a far more worthwhile improvement than the addition of 50% more scanning lines. Therefore it makes commercial, political and engineering sense to add colour to our national (98% coverage) 405-line services rather than to the almost moribund 625-line BBC-2 service. If this is done, a case can be made for putting BBC-2 back to 405 lines, which is easier than might be thought, or it can be left as a monochrome 625-line service, with no detriment to any one. Several B.R.E.M.A. members admit privately that they would far rather have colour on 405 lines than on both standards, and they are becoming painfully aware of the small market for a receiver that has to show 405-line monochrome and 625-line monochrome and colour.

Recently, a B.R.E.M.A. and T.A.C. spokesman gave it as his opinion that it would be disastrous for the country and the industry if colour were transmitted on 405 lines for BBC-1 and I.T.A. This has been the opinion of the T.A.C. for some years, but one cannot help thinking that if asked to reconsider and in the light of subsequent developments reverse their decision, they would earn the gratitude of the industry and the public for the magnanimity of such a gesture.

The cost to the country of introducing colour on the existing 405-line service would be small, as it involves only some relatively minor engineering work on the transmitters and inter-city links, whereas the cost of introducing one 625-line national coverage u.h.f. service is now estimated to be about £130M for the 2,000, or more, transmitters which are now known to be necessary.

It only remains to look briefly at the reasons given for the change to 625 lines. The first is that of parity with Europe; but the T.A.C. fixed different sound-vision carrier spacings. The second reason was that by going to 625 lines, we could exchange programmes with the Continent but the B.B.C. has nullified that point by introducing the line store standards converter. The only major remaining point is that of making the export of receivers easier. However, since the Continental market has different standards of performance for d.c. maintenance, sound quality and scanning linearity, it is understood export receivers are developed in different laboratories to receivers for the home market. Last year about 3—4% of the U.K. receiver production was exported, which is hardly reason to change our entire system.

I look forward to at least two competing colour programmes next year, and I am sure that your readers do too.

Richmond, Surrey. MICHAEL COX

PAL Co-channel Interference?

I THINK it advisable to draw attention to a shortcoming of the PAL colour television system which does not appear to have been considered carefully, if at all.

It is a fundamental characteristic of the PAL system that while the phase of the *B-Y* colour vector is held constant that of the *R-Y* vector is switched 180° on alternate lines of the same field. To a first approximation this is mathematically analogous to having two sub-carriers whose frequencies are separated by exactly one half the line scanning frequency.

It has been necessary in the past to allocate to co-channel transmitters carrier frequencies whose difference is a multiple of one third of the line frequency. By this means the visibility of co-channel interference is reduced some 14 dB.

The presence of two colour subcarriers separated by one half line and the need to allocate co-channel luminance carriers separated by one third line are incompatible and it can be shown that the visibility of interference will be increased by at least 8 dB compared to monochrome or N.T.S.C.

If PAL *is* adopted in this country, as the P.M.G. has intimated, are we going to be troubled by co-channel interference? There can be little doubt of this. If this is so are we right in adopting a largely untried system for the sake of partial European unity?

It is being argued that it is too late to reconsider systems. Is it not remarkable that after years of indecision it now becomes imperative to settle promptly for what may prove to be an inferior system?

Morden, Surrey. D. SMART

Electronic Organs

IN the present series of articles on electronic organs Mr. Towers suggests in the May issue that random mistunings can add to the true organ effect. I would like to suggest that permanent maladjustment of the "bearing" (or more scientifically, the relationship between the notes of the scale and their reference) is most unmusical. The point that Mr. Towers should make, surely, is that the "chorus" effect experienced when listening to a pipe organ consists of random changes in frequency due to minute variations in wind pressure and low "Q" factor of the organ pipe, the free phase effect and tone of individual pipes, and the different characteristic starting transients of each pipe sounded in each register or stop.

Clearly, if we are going to design an electronic instrument to meet the above requirements we are letting ourselves get involved with considerable financial and technical complications.

In a divider organ there are only 12 basic generators and an attempt to mistune say 3 or 4 of these would mean that all the divided frequencies from these generators would be out of tune and this would be painfully obvious even for small errors.

To summarize, if we are unfortunate enough to have separate generators for each note and indeed for every note on all stops, minute variations in frequency could be tolerated and would enhance the sound of the instrument especially if random changes in frequency could be introduced (not to be confused with vibrato, where considerable frequency change is produced in a cyclic manner). The divider organ is a reasonably cheap and simple instrument, and very useful because of this. Consequently, the divider organ must be treated as a single scale organ and no attempt should be made (by accident or design) to alter the tempered scale to produce pseudo chorus effects.

Axminster, Devon. B. W. DANIELS

The author replies:—

With my "purist's" hat on, I agree completely with Mr. Daniels. His exposition of the scientific aspect of the problem reflects well the views widely expressed in the literature on the subject. There can be no doubt that the "lifeless, dull, dead, hooty, tubby quantity" (Peabody, 1936) of the electronic organ is due to the use of too few and too non-disonant partials, its lack of pitch fringe and its lack of temporal (or agogic) fringe.

Accepting this, when I put my "practitioner's" hat on, I find that part of the charm of pitch fringe and agogic fringe (which both stem from the aesthetic principle of uncertainty) can be achieved simply by deliberate random mistuning as I indicated. My own proof of this in the practice tests carried out with a crystal controlled divider organ I built which held equal temper to 0.01% with a corresponding coldness of sound. This my critic friends found less sympathetic than a conventional *LC*-oscillator-controlled divider organ with imperfect tuning.

Cambridge. T. D. TOWERS

Matrix Algebra

ON reading Mr. Hina's letter in the April issue of *Wireless World* we too were "shaken to fragments." So much so we have had to read and re-read the letter to discover the cleverly concealed criticism amid the myriads of irrelevant data such as the state of Stevenage and Hatfield libraries, the poor perspiring, aspiring H.N.C. candidates, their exam trials, etc., *ad nauseam*.

Like Mr. Hina we have discovered the power of the matrix in circuit analysis, particularly phase shift networks and we have constantly referred to last year's excellent articles by Mr. Olsen.

The crux of the criticism is that he requires a derivation of the matrices for the shunt impedance and the ideal transformer. We indicate how by similar methods we reapplied Mr. Olsen's argument.

With reference to the articles in the March and April issues of last year and using the same nomenclature, the defining equations of the A-matrix are

$$v_1 = a_{11}v_2 - a_{12}i_2$$
$$i_1 = a_{21}v_2 - a_{22}i_2$$

Therefore

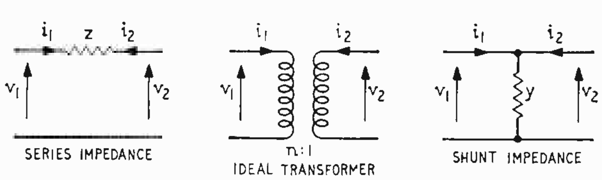
$a_{11} = \left\{\frac{v_1}{v_2}\right\}_{i_2=0}$ which is for the output open-circuited.

$a_{12} = \left\{\frac{v_1}{-i_2}\right\}_{v_2=0}$ which is for the output short-circuited.

$a_{21} = \left\{\frac{i_1}{v_2}\right\}_{i_2=0}$ which is for the output open-circuited.

$a_{22} = \left\{\frac{i_1}{-i_2}\right\}_{v_2=0}$ which is for the output short circuited.

By applying these equations to the four terminal networks shown and remembering Ohm's Law and the voltage ratio for the ideal transformer we obtain these matrices:—



$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} = \begin{bmatrix} 1 & z \\ 0 & 1 \end{bmatrix} \qquad \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} = \begin{bmatrix} n & 0 \\ 0 & \frac{1}{n} \end{bmatrix} \qquad \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ y & 1 \end{bmatrix}$$

Difficulty may be experienced on Mr. Hina's part in explaining the a_{22} element in the ideal transformer case but it will be remembered from elementary transformer theory that the current ratios are inversely proportional to the turns ratio with the output short-circuited.

In deducing the above we make no claim to be latter-day Sylvanus P. Thompsons nor for providing a method of passing H.N.C. " standing on one hand." A full exposition in two short articles is expecting too much and we hold little faith in the comprehendability of a full treatise in three eloquent pages.

Finally may we point out a trivial mistake in Table I. In converting from y-parameters to z-parameters the z_{21} has been printed as z_{12}.

Framwellgate Moor, Durham. NEVILLE HOGARTH, CHARLES LEWIS

Automatic Car Parking Light

READERS of the May 1966 issue who try to use an OC71 minus paint as suggested by Mr. S. K. Chawla as a phototransistor may be disappointed by the results. Some while ago, Mullard stopped putting a translucent jelly in the OC71, and substituted an opaque type. The solution is to use an OCP71, although a cadmium sulphide cell is likely to work out cheaper. The ORP12 would suit. Should the OCP71 be chosen, better results will be obtained by connecting the base to the emitter with a 4.7 kΩ resistor. This improves the ratio of light to dark impedance of the transistor.

Stroud, Glos. JOHN WEBSTER

Amplifier Noise Level

I READ with interest Mr. Driscoll's letter (June issue) regarding signal-to-noise ratio (or to be more academic signal+noise-to-noise ratio) in transistor amplifiers.

First, with regard to maximum settings of volume and tone controls this would in itself result in clipping of transient peaks even if the average modulation were low. In addition the effect of the tone controls would be nullified by clipping and considerable distortion result by overload of the earlier stages of the pre-amplifier due to poor positioning of these controls in several popular transistor amplifiers.

Secondly, regarding specifying a minimum acceptable noise power delivered to the loudspeaker, surely this is in itself meaningless considering the widely varying efficiencies of loudspeakers currently available. In any event the manufacturer has already stated the noise power delivered by his amplifier, since this is always (or should be) measured with volume controls at maximum and expressed as signal-to-noise ratio in decibels with reference to maximum power output. The very definition of the decibel (10 log P_1/P_2) means that it is a measure of the ratio of two powers. Hence, a 30-watt amplifier with a 70 dB signal-to-noise ratio delivers a noise power of 30×10^{-7} watts or 3 microwatts to the loudspeaker system.

SGS-Fairchild Ltd., Applications Laboratory, Ruislip, Middx. C. ARTUS

Collision Avoidance Systems

I HAVE read with interest Flight Officer Perry's letter in your May issue, and would agree with him that an active bearing measuring scheme would be most satisfactory, provided that sufficient range and accuracy could be achieved at a sufficiently low weight penalty. Unfortunately, however, this is not the case at the present state of the art. This is not the place to go into detailed calculations, but a radar such as he envisages would be likely to weigh at least 50 lb, and to require an exposed radome, which would increase drag, in order to obtain an all-round look. My system, on the other hand (April issue), uses equipment that will have to be carried and maintained by law in the near future, and the additional weight penalty attached need not be more than, say, 10 lb. Although, therefore, my system is less attractive operationally than that of Flt. Officer Perry, I feel that it presents at present a more useful solution to the problem of avoiding collisions in areas without ground surveillance. Later, when more is known of the behaviour of active laser systems, a scheme such as Flt. Officer Perry's may well have considerable merit.

EMI Electronics Ltd., Wells, Somerset. W. D. GILMOUR

Pick-up Arms

I HAVE followed with interest the correspondence subsequent to Mr. Bickerstaffe's articles on Unipivot pick-up arms, and I should like to add that I have never experienced any trouble with either rumble or torsional modes of vibration. My problem, to the exclusion of nearly all others, has been the h.f. resonance of the arm. The present model, my third, is excellent in all respects bar this one, and although I have managed to damp the resonance considerably by filling the tube with a soft silicone potting-compound and rubber-mounting the counterweight the resonance still shows up on extreme orchestral peaks as a tendency for the sound to "break up." This admittedly only occurs on one or two records, but is, as any hi-fi man knows to his cost (!), disturbing. I was surprised therefore, to see almost no mention of how to avoid this trouble in the aforementioned article, and I would suggest that anyone building Mr. Bickerstaffe's arm should try filling the tube with various substances to see which is the most effective—two suggestions are Rawlplugs, or tight-fitting p.v.c. sleeving, but I would be intrigued to hear of any other methods used successfully.

Langford, Beds. ANTHONY H. KING

Tailpiece!

THE more observant of your readers will have no doubt noticed that I.T.A. has been carrying out colour television tests for the past two years or so during the natural breaks occupied by advertising.

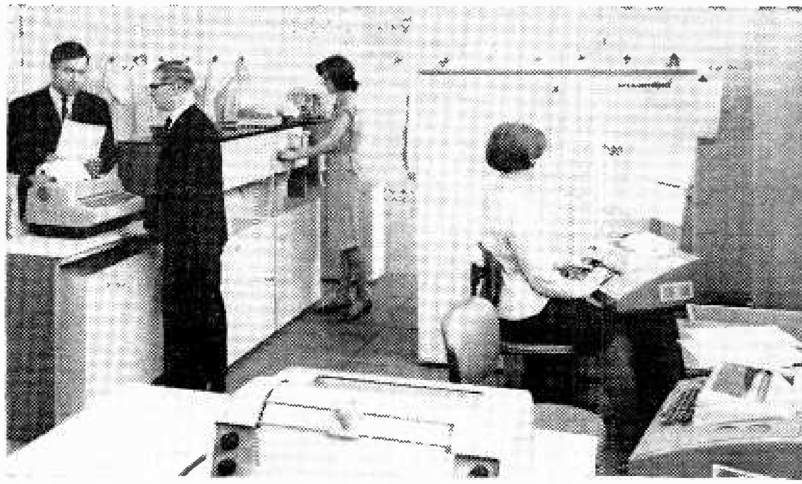
Tests on P.A.L. have been going on for some time and the enriching experience gained has now led to tests on Colour Harmonic Unit Modulation (C.H.U.M.) which is similar to P.A.L. in as much as a long tailed pair is used to produce a vector resultant which wags either side of the B-Y Leg. This system is German and is attributed to Hr. Dr. Ing. D. A. Chshundt whose original idea of the quadruped colour vector diagram gave the lead (after much vetting) to the British System—Black Unit Line by Line (B.U.L.L.).

Dogged by the inability to produce a colour bar, the B.U.L.L. system which suffered with degraded whites, has been superseded by the British Entirely Alternating Gamma Line Experiment (B.E.A.G.L.E.). This experimental system has had some small success in the aviation world and has bred some interesting colour displays for flight simulators.

Apart from this, British Television, both monochrome and colour, has been lying doggo for sufficiently long to be considered thoroughly up the (Barking) Creek.

Backwell, Glos. J. J. BELASCO

Computer room at the new premises of Racal Research Ltd. at Tewkesbury, Glos.



Computer-"designed" Circuitry

WHEN Sir Walter Cawood, chief scientist in the Ministry of Aviation, officially opened the new premises at Tewkesbury, Glos., for Racal Research Ltd., the highlight was the use of a computer in the design of electronic equipment. Racal established this company a few months ago as a central research organization for the group under the direction of Eric Wolfendale. Design problems from the subsidiary companies throughout the world will be sent to this new establishment for investigation.

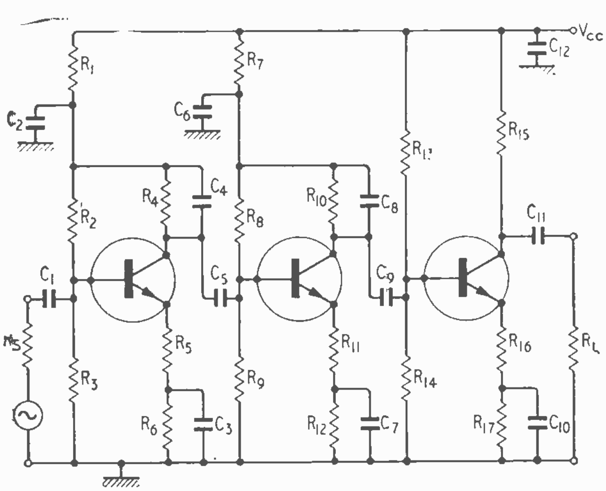
The computer, an Elliott 4120, is being used for trial designs and visitors were invited to specify requirements (bandwidth, voltage gain, gain stability, source resistance and ambient temperature) for a wideband r.f. amplifier. The basic circuit, shown below, had been prepared and the computer programme stored on punched tape. The parameters prescribed by *Wireless World* were fed into the computer, followed by the first part of the programme, from which the computer then calculated the values of the bias resistors, the decoupling capacitors and the load and emitter resistors to give the gain and the gain stability. As the total component list has to be printed out as input data for the next part of the programme, the remaining capacitors, also, have to be given values, hence the series capacitors are given large values of 1,000 μF and the shunt capacitors very small values of 0.1 pF. The values of these capacitors do then not affect the calculation of the mid-band gain.

The second part of the programme calculates the values of the series and shunt capacitors which determine the bandwidth of the amplifier. In each case, they are adjusted to be within 10% of the actual value required to give the bandwidth in the specification. The complete component list is then printed and is reproduced below. The nearest preferred values are used except for the components which determine the gain, gain stability and frequency response. These are printed out to greater accuracy to enable 1% components to be used, where the bandwidth is required to be specified accurately and/or the gain stability required is very small.

The third part of the programme then calculates the gain frequency response of the designed amplifier and shows where the amplifier differs from the bandwidth called for.

Initially the computer is using paper tape input, but with the aid of a random access backing store a much more sophisticated programme could be prepared.

The specification prescribed by the guest of honour on his arrival was programmed, the amplifier made and graphs prepared showing the measured performance against the calculated frequency response before he left the establishment three hours later with the equipment and the data.



AMPLIFIER DESIGN

SUPPLY VOLTAGE 12V

AMBIENT TEMPERATURE FROM 0 TO 30 DEGREES CENTIGRADE

BANDWIDTH FROM 40 KILOCYCLES TO [illegible] MEGACYCLES

VOLTAGE GAIN= 750 [illegible] STABILITY= 80 PERCENT

SOURCE RESISTANCE= 70 OHMS

R	1	1000.0	OHMS
R	2	27.0	KILOHMS
R	3	[illegible]	KILOHMS
R	4	3[illegible]3.0	OHMS
R	5	4.1	[illegible]
R	6	600.0	OHMS
R	7	680.0	OHMS
R	8	1[illegible].0	KILOHMS
R	9	[illegible].0	KILOHMS
R	10	93[illegible].8	OHMS
R	11	57.7	OHMS
R	12	390.0	OHMS
R	13	1[illegible].0	KILOHMS
R	14	3.9	KILOHMS
R	15	850.0	OHMS
R	16	1[illegible].0	OHMS
R	17	150.0	OHMS

FREQUENCY RESPONSE OF THE AMPLIFIER

FREQUENCY KILOCYCLES	FALL OF GAIN FROM MID BAND IN DECIBELS
13	12.74
16	10.36
19	8.55
21	7.15
24	6.05
27	5.17
29	4.45
32	3.87

C	1	0.047	MICROFARADS
C	2	0.390	MICROFARADS
C	3	[illegible].200	MICROFARADS
C	4	10.[illegible]	PICOFARADS
C	5	2540.5	PICOFARADS
C	6	0.560	MICROFARADS
C	7	0.560	MICROFARADS
C	8	4.1	PICOFARADS
C	9	2062.5	PICOFARADS
C	10	0.330	MICROFARADS
C	11	0.022	MICROFARADS
C	12	3.900	MICROFARADS

TRANSISTORS TYPE BFY 79

The basic circuit and (right) the print-out of the list of components. Inset is part of the frequency response calculated over the range 17 kc/s to 17·351 Mc/s at which frequency the gain was −13·55dB.

2—Plotting the Root-locus

By W. TUSTING

Continuing this series of articles, the main steps in plotting the root-locus are now described in detail and illustrated by an example

THE necessary form for the equation and the meanings of the terms root, pole and zero have been explained. At this stage, therefore, we know the values of the poles and zeros with which we are concerned. We are using as an example an equation which represents the performance of a three-stage *RC* amplifier having time constants of 1, 2.5 and 10μsec. This equation is

$$0 = 1 + \frac{G_0H_0K}{(p + 1)(p + 0.4)(p + 0.1)}$$

with $K = 1/25$.

In the general case a sheet of graph paper is required with horizontal and vertical scales crossing in the middle at the zero of both. Positive is upwards and to the right, negative downwards and to the left. It is essential that both scales be the same. In practice, we are rarely concerned with the right-hand half, for this is the region of instability. It is usually permissible to omit most of this part therefore. The root-locus plot is always symmetrical about the real (horizontal) axis. Unless there are complex poles and/or zeros, it is permissible to suppress the lower half.

For the present we shall use the full diagram, but in practice where it is practical to employ little more than a quadrant it is as well to do so, since it enables a bigger scale plot to be made on a piece of paper of given size.

Having prepared the paper the following steps are taken in turn as far as they are applicable to the given case or as far as it is necessary to take them to obtain the required information.

Step 1. *Plot the values of the poles and zeros on the diagram. Indicate a pole by a cross on the point, and a zero by a circle around it. If there are two or more equal poles or zeros, the convention is to indicate this by a vertical row of crosses or circles, one for each pole or zero, placed symmetrically about the actual point.*

Fig. 1 shows the diagram appropriate to the example with the three poles plotted on it.

Step 2. *Draw that part of the root-locus which exists on the real axis. The locus exists on the real axis at every point which has to its right an odd number of poles and zeros, counting them together. Any complex poles or zeros are ignored.*

In the example of Fig. 1, there are no zeros and there

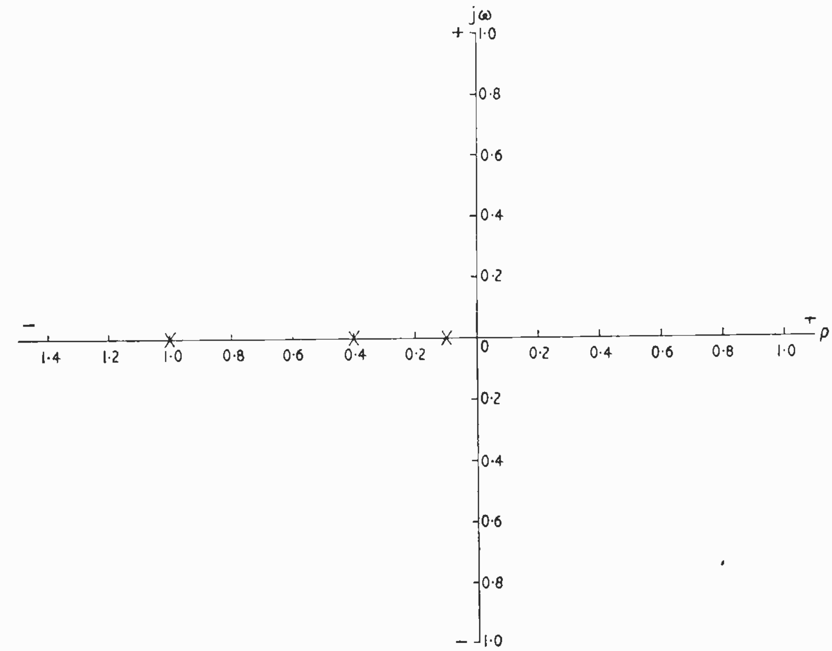


Fig. 1. For a root-locus plot the real and imaginary axes must be scaled the same. The first step is to plot the values of the poles and zeros. Here there are three real poles indicated by crosses.

are poles at −0.1, −0.4 and −1. To the right of −0.1 there are neither poles nor zeros and so the locus does not exist on the real axis. At all points between −0.1 and −0.4, there is an odd number of poles and zeros (*viz* one pole) to the right. The locus exists between −0.1 and −0.4 and is indicated by drawing a line between these two poles, as in Fig. 2.

Between −0.4 and −1, all points have an even number of poles and zeros on the right (*viz*, two poles). Consequently, the locus does not exist between these poles. All points to the left of −1 have an odd number of poles and zeros (*viz*, three poles) to their right; hence, the locus exists at all points on the real axis to the left of −1. This is indicated by drawing a line coincident with the real axis to the left from −1 to the limit of the figure; in reality it goes to infinity. This is again shown in Fig. 2.

Step 3. *Compute the value of*

$$p_a = \frac{\Sigma P - \Sigma Z}{P_n - Z_n}$$

where ΣP *and* ΣZ *are respectively the sums of the values of the poles and zeros and* P_n *and* Z_n *are respectively the numbers of poles and zeros. Plot the value of* p_a *on the diagram.*

In the example, there are poles at −0.1, −0.4 and −1 and no zeros. Hence, $\Sigma P = -0.1 -0.4 -1 = -1.5$, $\Sigma Z = 0$, $P_n = 3$, $Z_n = 0$. Consequently, $p_a = -1.5/3 = -0.5$, and this is plotted in Fig. 2.

Complex poles and zeros, if any, are included. As they always occur in conjugate pairs their imaginary parts always cancel out and so p_a is always real.

Step 4. *Compute angles from the relation*

$$\Theta = \frac{180}{P_n - Z_n}(1 + 2n)$$

for $n = 0, 1, 2, 3$, *etc. Draw lines at these angles from the real axis from the point* p_a *found in Step 3.*

In the example $P_n - Z_n = 3$, so $\Theta = 60\,(1 + 2n)$. For $n = 0$, $\Theta = 60°$; for $n = 1$, $\Theta = 180°$; and for $n = 2$, $\Theta = 300° = -60°$. Higher values of n only give angles repetitive of these. An angle of 180° is given by a line on the real axis to the left of p_a. The angles of ±60° are given by lines drawn from p_a at ±60° to the real axis on the right of p_a.

These lines are asymptotes to which the root-locus tends when G_0H_0 tends to infinity. They are shown dotted in Fig. 2.

Step 5. *Determine the breakaway point(s) on the real axis. A breakaway point* p_b *is one at which for a certain value of* G_0H_0 *two real roots become equal, so that for a further change of* G_0H_0 *they become complex. It is necessary to find a point by guessing a likely value and then checking it, repeating until it is found with the required accuracy.*

A breakaway point on the real axis is always at some point which lies on that part of the locus which exists on the real axis and which has been drawn in Step 1. It usually lies between two poles or two zeros. An even number of breakaway points can exist between a pole and a zero (which may be at infinity).

Having guessed a likely value for a breakaway p_b

(*a*) *measure the distances between this point and all the poles and zeros on the real axis, and assign negative signs to the pole distances and positive to the zero distances*

(*b*) *take the reciprocals of all these distances*

(*c*) *add all the reciprocals which refer to poles and zeros to the left of* p_b

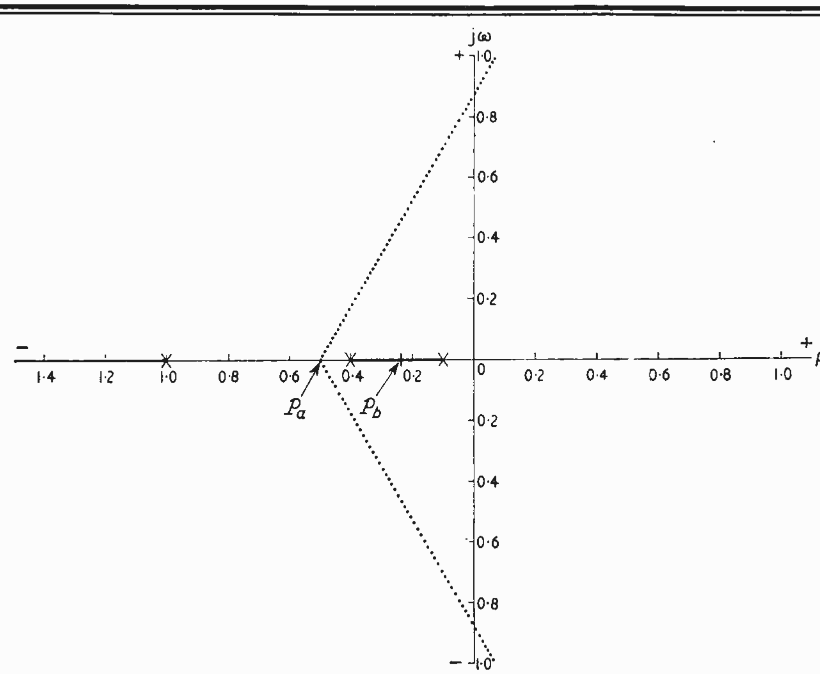
(*d*) *add all the reciprocals which refer to poles and zeros to the right of* p_b

(*e*) *subtract the right sum from the left sum. If the result is zero the guessed point is indeed the right point. If it is not zero the guessed point is wrong, so try again*

(*f*) *if there are complex poles and/or zeros, further quantities must be added to (c) and/or (d)*

(*g*) *measure the distances AC and BC, Fig. 3, and evaluate the quantity* $2\,BC/(AC)^2$. *Assign a negative sign if it*

Fig. 2. Here the diagram is shown with the part of the locus which lies on the real axis drawn in. The origin of the asymptotes p_a *and the asymptotes themselves are also shown. These are lines to which the locus tends as* G_oH_o *tends to infinity. The breakaway point* p_b *is also plotted.*



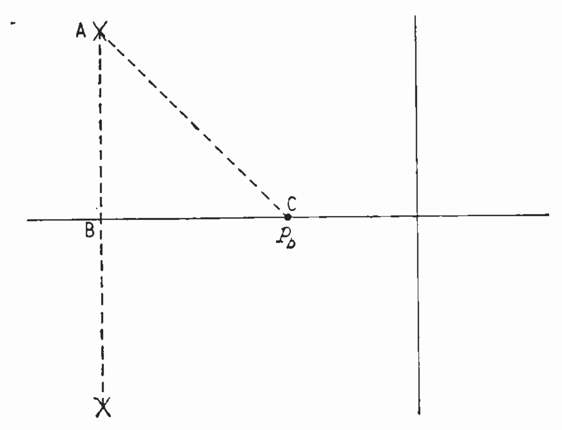


Fig. 3. This diagram shows a pair of complex poles with a trial breakaway point at C. As explained in the text the contribution of these poles (or zeros) is determined from a measurement of AC and BC.

is for a pair of complex poles and a positive if it is for a pair of complex zeros. If the poles or zeros lie to the left of a vertical through p_b (=C), add the quantity to (c); if they lie to the right add it to (d).

It is much less difficult than it would appear to determine p_b, but nevertheless doing so can be rather tedious. Fortunately, in many practical cases it is not necessary to determine it with great accuracy.

In the example, the locus exists on the real axis between poles at −0.1 and −0.4 so the breakaway point must lie between them. If it were not for the third pole at −1, it would be halfway between them, at −0.25. As the third pole is relatively far away and to the left, the breakaway point will be to the right of −0.25. A first guess for p_b is −0.24.

The pole distances are 1−0.24=0.76, 0.4−0.24=0.16 and 0.24−0.1=0.14. Assigning minus signs because they are pole distances and taking reciprocals gives us −1.317 and −6.25 on the left of p_b and −7.15 on the right. The sums on the left and right are −7.567 and −7.15. The difference left sum minus right sum is −7.567−(−7.15) = −0.417. Thus the breakaway point is not at −0.24.

Now try −0.23. The distances are 0.77, 0.17 and 0.13, giving for the reciprocals −1.3 −5.88=7.18 on the left and −7.68 on the right. The difference is −7.18+7.68=0·5. Thus the breakaway point is not at −0.23.

However, the difference found is only slightly greater in this second trial than in the first but is of opposite sign. Therefore, the true point is approximately halfway between our two trials, or at −0.235. Probably −0.236 would be nearer and we should try this if we were going to make a third check. However, when we look at the scale of our graph we can only plot clearly in steps of about 0.005, and we take p_b= −0.235 as being quite accurate enough.

Having determined p_b, we plot it in Fig. 2.

Step 6. *Sketch in freehand the complex part of the root-locus, guided by the knowledge that it passes vertically through p_b and tends towards the asymptotes.*

In the example, a freehand sketch of the locus will probably pass through the imaginary axis at ω=0.75-0.8. This may be near enough for a first rough estimation of the critical gain. However, it may be necessary to find the crossing point accurately.

Step 7. *To determine whether or not any point is on the root-locus. Draw straight lines from the point to all the the poles and zeros. Measure all the angles between these*

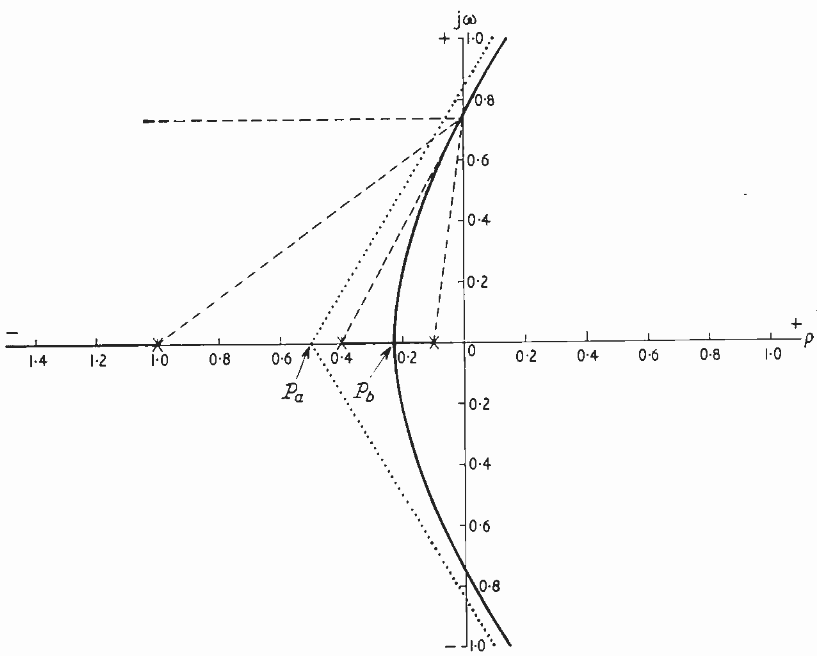


Fig. 4. In the complete root-locus diagram the curved part of the locus is drawn freehand through p_b, guided by the asymptotes. The only point which must be known at all accurately is the crossing point of the jω axis. This can be checked by drawing lines (dashed) to all the poles (and zeros) and measuring their angles from the horizontal. If the point is correct they sum to 180°. The lengths of these lines enable the critical gain to be computed.

and a horizontal to the left through the point and assign negative signs to angles to zeros and positive to angles to poles. Add all the angles with due regard to sign. If the result is an odd multiple of 180°, *the point is on the root-locus.*

A word of warning is needed on the application of Step 7. It sometimes happens that one tries to find a point on a locus in a region of the diagram where in fact the locus does not exist at all. Instead of the sum of the angles being widely different from 180°, it may be quite near it, 190° perhaps. A few further trials may give one, say 184°, and there is a temptation to say that this is near enough. This temptation must be firmly resisted unless it is certain that the locus actually does pass in that region. This certainty demands that another nearby point be found for which the angles sum to less than 180°. If all the trial points lead to sums of the angles which are above or below 180°, even if they are quite near to it, there is a strong suspicion that the locus in fact may be nowhere near these points.

In Fig. 4 is shown that complete root-locus passing through the imaginary axis at $\omega=0.74$. The dash lines are the ones joining this point to the poles and also the horizontal to the left through this point. We measure the angles with a protractor and find that they are −36°, −62° and −83°. The sum is −181°. In this case we may consider this as being near enough. There is no doubt that the locus passes in this region, for it must cross the imaginary axis between zero and the asymptote.

Step 8. *To find the value of G_0H_0K corresponding to a given point on the locus, measure the distance of the point from every pole and zero. Form the product of all the distances to poles and a second product of all the distances to zeros. The value of G_0H_0K is the first product divided by the second product. As K is known, the open-loop gain G_0H_0 can be obtained at once.*

In Fig. 4, the relevant distances are the lengths of the lines drawn from the point at which the locus crosses the zero axis to the poles. They are 1.245, 0.84 and 0.745. Their product is 0.78. Now $K=1/25$, so $G_0H_0=0.78\times25=19.5$. With $\omega=0.74$, $f=0.74/6.28=0.1175$ Mc/s. Thus, the amplifier will start to oscillate at 117.5 kc/s if the open-loop gain exceeds 19.5 times.

BOOKS RECEIVED

Principles of Aerial Design; by H. Page. In this book the author has written at a level which is a compromise between the two normal approaches, i.e. either a complex mathematical treament or a purely descriptive treatment. Where approximations have been used to avoid mathematical complication the reasons have been given and the significance of the approximations indicated. The contents cover the laws governing electric and magnetic phenomena, Maxwell's electromagnetic wave equations and their application, theoretical design principles and practical forms of aerials. A six-page appendix details vector rotation and formulae. Pp. 172; Illustrations 102. Price 50s. Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.1.

Guide to Radio Technique Vol 1; Fundamentals, Valves, Semi-conductors, by E. Julander. This is a book intended to provide a basis for the enthusiast or student who seriously wishes to improve his theoretical knowledge of radio rather than make a continued practical approach. The opening chapters deal with the fundamentals of electricity, complex numbers and transmission units. A complete chapter deals with the construction, theory and operation of thermionic valves; this is then followed by a similar chapter on semiconductors in which a comparison is made with valve circuits. The final chapter deals with generation, propagation and modulation of electro-magnetic waves. A 14-page appendix contains useful data presented in the form of tables and monograms. The book is issued as part of the Philips Technical Library and is a translation of the original Swedish edition. Pp. 238; Figs. 214. Price 37s 6d. Distributed by Macmillan & Co. Ltd., Little Essex St., London, W.C.2.

Servicing Electronic Organs, by C. R. Pittman & E. J. Oliver. The book is written as a practical guide to the theory and operation of electronic organs for the serviceman requiring basic knowledge of this application of electronic techniques. Details are given of the basic circuits encountered and include illustrations and information reproduced by courtesy of ten American organ manufacturers. Originally published in America in 1962. Pp. 191; Figs. 112. Price 30s. W. Foulsham & Co. Ltd., Yeovil Road, Slough, Bucks.

Handbook of Electronic Circuits, edited by R. Feinberg. Intended for the experimenter and laboratory worker, the book contains brief descriptions and circuit diagrams of a wide range of practical circuits which can be used in the overall design of equipment. About 75 circuits are given some of which use valves. Applications include power supplies, waveform generators, amplifiers, frequency converters, counters, waveform modifiers, clamps and electromechanical control. Pp. 195; Price 50s. Chapman & Hall Ltd., 11 New Fetter Lane, London, E.C.4.

Building and Using Sound Mixers, by R. E. Steele. Essentially of a practical nature, the book contains complete constructional details, parts lists and layout drawings for a number of the author's designs for sound mixers. However, the practical aspect is well supported by explanatory text on mixing technicalities and mixer design. Pp. 152; Figs. 124. Price 30s. Focal Press, Ltd., 31 Fitzroy Square, London, W.1.

Materials Used in Semiconductor Devices, edited by C. A. Hogarth. The book is divided into eight sections, the first being a brief introduction describing the applications of materials. The remaining sections deal with germanium, silicon, selenium, lead sulphide-selenide and telluride, indium, antimonide, bismuth telluride and antimonides of cadmium and zinc. Extensive cross references are included and a 23-page author and subject index is given at the end of the book. Pp. 243; Figs. 101. Price 5gn. John Wiley & Sons Ltd., Glen House, Stag Place, London, S.W.1.

Transistor Receivers and Amplifiers, by F. G. Rayer. Treatment used in the book is essentially of a practical nature and is intended to provide guidance for the home constructor interested in the use of transistors. Basic contents include general descriptions of operating characteristics of semiconductors, aerials, and r.f. amplifiers, superhet circuitry and power supplies. Additional chapters describe printed circuits, test equipment and fault finding. Pp. 164; Figs. 129. Price 30s. Focal Press Ltd., 31 Fitzroy Square, London, W.1.

E

NEWS FROM INDUSTRY

The Flight Simulator Division of **Redifon Ltd.,** has received an order worth £1.5 M from the Ministry of Aviation for three Phantom digital flight simulators. Two simulators are for the Royal Air Force and one is for the Royal Navy. Each simulator has a digital computer for the operational flight trainer and a second computer for the tactical simulation. Each simulator is provided with a Redifon three axes motion system and a colour visual system, allowing the pilot to make his visual approaches and landings at his base. Each simulator also includes a 64 sq ft terrain model, permitting the pilot to gain experience and training in the ground attack mode. The tactical section fully simulates the weapons system, and the aircraft operational radars using the Redifon land mass multi-colour system. Western Airlines of Los Angeles, U.S.A., have ordered three simulators to the value of $ 1.5 M.

Believed to be the first time that a complete town has been wired to relay radio and television, the new town of East Kilbride is to have all 13,500 houses connected to a wired relay system. **British Relay** will lay 300 miles of wire, erect a receiving aerial, and establish a central control station from which all television and radio programmes will be fed into the network. East Kilbride council said the system would ensure satisfactory reception of BBC-2 and eventually colour transmissions, and also subscription television if it is developed in Scotland.

A £300,000 contract has been awarded by the Costa Rican government to **G.E.C. (Telecommunications) Ltd.,** who are to supply a microwave communications system. This will link all the principal towns of Costa Rica together by a ten station network, from the northern town of Liberia to the Panamanian border in the south. It will be installed, commissioned and initially maintained by G.E.C. engineers, who will subsequently hand over the system to Costa Rican engineers, trained locally, and at Coventry. The transistor microwave radio equipment is constructed on the card assembly shelf principle. Design of the circuitry permits the dropping and inserting of circuits at intermediate stations without demodulation of the through traffic.

M.R. Supplies Ltd.—It is regretted that the address of this company was incorrect in their advertisement last month. The correct address is 68 New Oxford St., London, W.C.1.

Following Decca's acquisition of Setpoint Ltd., Decca Radar Ltd. will introduce a range of products in the field of **marine automation equipment.** Setpoint Ltd. will develop for Decca Radar a range of equipment designed to meet the requirements for monitoring and control of main engines and auxiliaries in large motor ships and refrigerated cargo vessels.

*The **aerial structure** for the satellite earth station on Ascension Island in the South Atlantic to be owned and operated by Cable and Wireless Ltd. has been set up for tests on the Marconi radar test site at Rivenhall, near Witham, Essex. The aerial structure is undergoing nearly two months of overall testing before being shipped to Ascension, and COMSAT has agreed to loop tests being conducted with the Early Bird satellite.*

Design studies have been completed by **English-Electric-Leo-Marconi** for a multiple access machine computer system (4-75) which can be used by up to 200 people simultaneously. It can transmit data for processing via a terminal point in the user's office. The paging technique used, permits the addressing unit to select the pages of the programmes most frequently employed by subscribers, ensuring that they are always immediately available. The least used pages of each programme will be held in the computer's backing store, but will be obtainable in one sixtieth of a second. The system has been designed for universities, research centres, Government departments and commerce.

A.E.I., G.E.C. and Plessey have formed a **satellite communications consortium,** to build and sell complete communications satellite ground terminals. It is estimated that the market for civil terminals is worth £100 M, and joint engineering teams are working on designs to meet the requirements of this international market.

Claimed to be the largest micro-electronics factory outside the U.S.A., the new **Marconi micro-electronics plant** will occupy a $6\frac{1}{2}$ acre site at Witham, Essex. Granted final planning approval, this £1 M project should be fully operational in 1967, and will house the Division's research, development, production and commercial departments.

Domestic Receiver Supplies.—Manufacturers' disposals of television sets to the home trade during the first quarter of this year, according to B.R.E.M.A's figures, were 409,000 compared with 470,000 for 1965. Radio receivers delivered were 382,000 against 444,000 in 1965 and 489,000 in 1964.

The **Switch and Control Company,** of Vale Road, Watford, manufacturers of heavy current multi-bank and multi-position switches for industrial control, has joined the Livingston Group. Manufacturing facilities have been transferred to the Livingston factory on the Greycaines Estate, North Watford.

The contract for a complete 625-line television station, to be installed in the Songkla Province of Thailand, has been awarded by the Thai government to **Pye TVT Ltd.,** of Cambridge. It is the second Pye station to be ordered for Thailand and will include two 5 kW transmitters operating in parallel with a high gain aerial system which will give an e.r.p. in excess of 100 kW.

A reciprocal agreement for the interchange of microwave technology has been concluded between Microwave & Electronic Systems Ltd. (M.E.S.L.) of Newbridge, Midlothian, Scotland, and Sanders Associates, of Nashua, New Hampshire, U.S.A. Under the agreement, M.E.S.L. will manufacture exclusively in the U.K. the entire range of microwave products of Sanders Associates for a period of seven years.

DISA.—Dansk Industri Syndikat A/S of Denmark, have now opened a United Kingdom branch at 116, College Road, Harrow, Middlesex (Tel: 01-427 9263) where stocks of equipment, accessories, and spare parts will be held. This equipment provides for the measurement of flow, turbulence, vibration, strain, torsional vibration and pressure. DISA also handle Lyrec tape recorders for correlation measurements and frequency transformations. Technical bulletin DISA Information (No. 3) is now available. The manager of the U.K. branch is Mr. A. L. Cussens.

The annual report of **BSR Ltd.** records that during 1965 78.6% of their production was exported compared with 65.3% the year before. Exports to the U.S.A. totalled 55% in 1965 and 38% the previous year. The company's profit after taxation was £1.378 M in 1965 and £1.404 M the year before.

Racal Electronics Ltd.—An increase of some 20% in the company's profit before taxation is reported for 1965/6 compared with the previous year. The figures are £730,745 and £610,641.

The turnover of the **A.E.G.-Telefunken Group** for 1965, amounted to DM 4,135 M. The increase over the previous year is about 9%. Exports rose to DM 884 M, an increase of 2% compared with 1964.

Belling-Lee Ltd., have sold 74% of their share capital to the industrial holding company, Ada (Halifax) Ltd., which is a subsidiary of Philips Electronics and Associated Industries. Directors and management of the company remain unchanged.

SGS-Fairchild Ltd. is moving its administrative headquarters and applications laboratory from Ruislip, Middx, to a new office block to be named Planar House at Aylesbury, Bucks. The present premises at Ruislip will be devoted entirely to the production of monolithic semiconductor devices.

A.B. Metal Products Ltd. of 119/127 Marylebone Rd., London, N.W.1, are handling the range of quartz crystal products produced by CTS Corporation of Elkhart, Indiana. Mr. R. P. Caton is in charge of this section.

Fantovox receivers, manufactured in Japan by Novel Dempa Co., are being marketed in the U.K., by E.R. (Factors) Ltd. of 374-378 Harrow Road, London, W.9. (Tel.: CUNningham 0361.)

Pioneer.—The U.K. distributors for the Pioneer Electronic Corporation of Tokyo are now Swisstone Ltd., of 26 Leigh Place, Cobham, Surrey (Tel.: Cobham 2853). Previously, Pioneer were represented by C. E. Hammond.

Lansing.—Ad. Auriema Ltd., of Impectron House, 125 Gunnersbury Lane, London W.3 (Tel.: ACOrn 8765) are the agents for James B. Lansing Sound Inc. of Los Angeles, some of whose equipment was referred to in the article "Audio 66" in last month's issue.

Among the recipients of **The Queen's Award to Industry** was Multicore Solders Ltd. whose name was misquoted in the list in last month's issue (p. 324).

Report on Terran Electronics

FROM an unusually unreliable source come these extracts from a report issued by a delegation of Martian scientists who visited Earth in order to study our electronics industry.

The year which has passed since the first Martian exploration of the planet Terra has seen a considerable change in the attitude of the human inhabitants. It will be remembered that our original landing produced an intense fear-reaction which increased to manic proportions when it was found that Martians were impervious to attack by any Terran weapons.

This mass hysteria slowly subsided when it became clear that our intentions were peaceful, giving way in due course to a somewhat grudging co-operation. It is, however, evident from our telepathy traffic that underlying the veneer of cordiality is a feeling of intense chagrin that, in the event, Terrans were the visited not the visitors. This is understandable seeing that, following their moon-landing success, plans were well advanced for the construction of a crude form of space vehicle with which it was hoped to navigate to Mars. What is less understandable is that even now that the Terrans know that we can read their innermost thoughts they still continue to use their acoustic powers in an attempt to conceal the truth.

It may be asked why our delegation limited its studies to electronics. The answer is that we had no option because Terran technology has progressed no further than the harnessing of the electron, and even in this the degree of knowledge is shallow and the techniques rudimentary. It soon became clear to us that even such long out-moded Martian concepts as fifth-dimensional zeta radiation were not only completely unknown but were likely to remain forever beyond the Terran power of comprehension.

Terrans, as the first exploration party has pointed out, are essentially animus-type computers with animal attachments and as such are somewhat reminiscent in structure to the lower forms of life on our own planet. Their computer element is primarily a survival mechanism and is therefore ill-adapted to scientific research except on a primitive scale. A built-in defence mechanism operates to discount the existence of physical laws which cannot be detected by their senses. senses.

To say that our mission was to study the Terran electronics industry is in itself a statement demanding explanation, in the absence of any Martian counterpart. It appears that some two centuries ago, some external influence—as yet unidentified—caused a degenerate mass mutation in the animus computers and impelled them to herd together to expend their energies in buildings called manufactories. A collection of these manufactories of similar character formed an industry.

The electronics industry is a lineal descendant of this so-called Industrial Revolution; its general mode of operation is similar to most others, and will not be given in detail here. One small facet of the system may be mentioned however, as illustrative of the serious nature of the degenerate mutation. At a given time of the day the operatives of a manufactory leave their homes and converge in a mass upon the industrial building. So primitive are the forms of transport and so congested the routes that the journey may take an hour to complete (a conservative average figure). As, later in the day a reverse mass migration takes place, two hours per day per Terran are taken up. Thus, in a manufactory which employs 5,000 operatives—and some employ far more—there occurs a wastage of at least 50,000 human-hours in every week. Yet this continues unquestioned because the Terran animus computer (or brain as it is termed) has been conditioned to regard it as inevitable.

The control structure of a Terran electronics manufactory is similar to that of most industries. Metaphorically it is in the form of a pyramid with a master-computer or brain at the apex and a succession of levels of lesser computers beneath him in a series-parallel arrangement. Each computer at the level nearest the apex is in direct contact with the master computer (or chairman as he is called) and each computer is in control of several on the level below. Each of these lower level brains is in turn controlling a number on a still lower level, and so on down to the base of the pyramid.

As is to be expected, the broader the base lengths of the pyramid in relation to the perpendicular, the less efficient the organization becomes. In spite of this the trend is toward the amalgamation of manufactories into even more unwieldy structures. The explanation of this can only lie once again in the degenerate mutation and the damage it has caused to the Terran computer.

Each independent manufacturer is in fierce competition with many others. This means, among other things, that every organization which markets a similar type of device, carries out its private research and development on it. Every device thus tends to be researched and developed perhaps a hundred or more times over, with a total expenditure of about 600 years. It might be thought that this terrifying wastage of effort is an argument in favour of amalgamation, because of the reduction in competition. Our investigations show that this is not the case—again, because of inadequacy of control. It is not uncommon to find, in the largest categories of manufactory, that similar devices are being developed by separate teams in adjacent laboratories, each being ignorant of the others' activities.

A detailed account of the present state of the art in electronics is contained in the Appendices to this report. It can be summarized by saying that it is rudimentary; as an example, the most advanced technology yet known consists of the laborious processing of components and metal connections on to, or within, glass or semiconductor platforms. A commonly used term for an electronic equipment is hardware, which in itself is indicative of its primitive nature.

It is no part of the Scientific Delegation's function to decide what action should be taken to assist the Terrans in their plight. We could, of course, in our specialist sphere, advance their knowledge of electronics or even, to a limited degree, enlighten them as to other, and far better, means of communication. But this is not the real issue. The crux of the matter is that Terran industry and commerce (of which electronics is a small part) is so crazily constituted that it periodically promotes global warfare. Our recommendation to the Martian Tribunal, therefore, is that we be authorized to correct the damage which the Terran animus-computer sustained two centuries ago, as it is all too evident that their own scientists, having the defect implanted in their own computer elements, can never hope to effect the repair.

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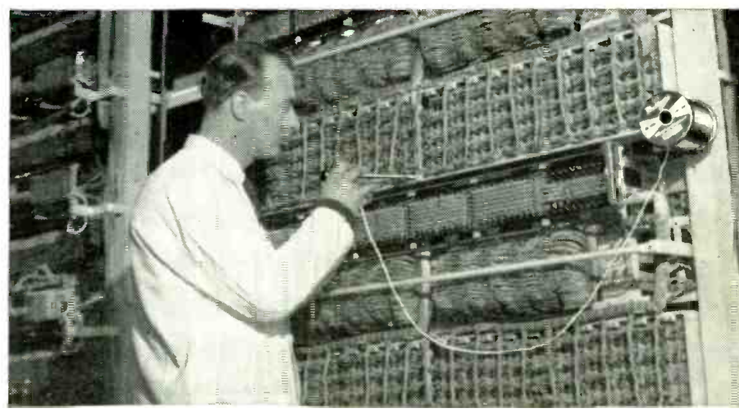
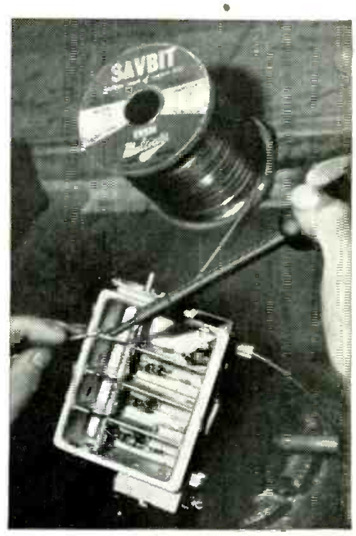
Ferguson Radio Corporation Ltd. The critical characteristics of U.H.F. tuners in television sets demand the highest quality of soldering. Ersin Multicore Savbit alloy, containing five cores of extra fast Ersin 366 flux, is seen here being used by Ferguson Radio Corporation Ltd.

H. J. Leak & Co. Ltd. Ersin Multicore Savbit alloy is shown in use in the wiring construction of the Leak Integrated Stereo 30 Transistor Amplifier. In order to ensure the utmost reliability, the Leak High Fidelity equipment has been made with Ersin Multicore Solder for more than 20 years.





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