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Wireless World

ELECTRONICS, TELEVISION, RADIO, AUDIO

Are We Getting the Most from Electronics Research?

THE news that 10 per cent of the research effort at the Royal Radar Establishment, Great Malvern, and perhaps other similar Government establishments, is to be devoted to applying to civil uses electronics research undertaken for defence purposes, will be welcomed by those engineers who for too long have seen good ideas pigeon-holed because they were even remotely associated with "classified" projects.

This is a step in the right direction, but does it go far enough? It is to be hoped that there will be a closer liaison between the various establishments so that the wasteful duplication of effort, all too often met with in Government circles, will be overcome. Research on parallel lines in different commercial organizations cannot be obviated in a competitive world, but the waste of public money in Government research establishments through duplication of research is indefensible. At the recent micro-electronics conference at Southampton University, after one speaker from an establishment had described his work on dip soldering techniques, a member of the audience stated that he had been doing identical work at another Government establishment.

Does this decision call for a co-ordinating body? We have, of course, the National Research Development Corporation which fosters research in ideas which might not otherwise be undertaken because they are not commercially viable. And in our own particular field we have the National Electronics Research Council, under the leadership of Earl Mountbatten, set up to co-ordinate electronics research. Even so there must be, and indeed we know there is, a considerable wealth of technology, potentially valuable to industry, which is lost in the labyrinths of Government research establishments. This is not entirely the fault of the particular establishment; it is partly because of a lack of a means of communication between the establishments and industry, and partly because no incentives exist to encourage the adaptation of this technology to manufacturing processes.

While we deplore the multiplication of councils, committees, consortia and the like, it would appear that there is a need for a body to act as a "clearing house" for electronic techniques which could be applied to industrial processes. If, as is suggested in the announcement on page 69, a special department is to be set up in the Ministry of Technology to foster the feeding of information to industry, it is to be hoped that it will be powerful enough to winkle out of the establishments the maximum information. Furthermore, it should include people recruited from manufacturing industries who have sufficient technical imagination to see likely uses for highly specialized electronic techniques which would otherwise remain in cold storage. A good pattern for this is the all-embracing Industrial Automation Group set up by the Committee of Directors of Research Associations in the U.K. Recently the I.A.G. has been trying to promote the more effective use of control engineering techniques.

"For such a time as this" might well be the key text of the electronics research worker. With the Government's call for greater productivity, the door of opportunity to apply electronic techniques to industrial processes has been left wide open. If "know-how" in the hands of Government research workers is not put at the disposal of industrial organizations our friends from across the Atlantic will not be slow in selling their ideas to British industrialists. In the U.S.A. "fall out" from space technology is being adapted to industrial and civil uses by N.A.S.A. which now regularly issues applications reports to, among others, the technical press, but we cannot remember the last time such a report was received from a U.K. establishment.

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PULSE SOUND

625-LINE VISION AND SOUND IN 5 Mc/s CHANNEL?

By A. V. LORD,* B.Sc.Tech., A.M.I.E.E., and E. R. ROUT,* A.M.I.E.E.

THE width of the radio-frequency channel required for broadcasting a television signal of a given video bandwidth could be reduced if the conventional form of sound emission were replaced by one in which the sound is transmitted by means of a signal incorporated within the video waveform. One such method, known as Pulse Sound, utilizes pulses occurring during line-blanking intervals, which are modulated by the sound signal.

Proposals of this nature appeared in technical papers and patent specifications as far back as 1941, and in 1946 details of a proposed practical system, which was based upon the use of duration-modulated pulses occurring within the line-synchronizing intervals, were published†. This system as applied to the 405-line system was demonstrated, but it resulted in a rather unsatisfactory upper audio-frequency limit (i.e. somewhat less than 5 kc/s). In an attempt to show an economic advantage over the conventional a.m. sound system the sound receiver was simplified to an extent which caused the signal-to-noise ratio of the sound output to become unsatisfactory at a receiver-input signal level that was quite usable in terms of picture signal.

The system to be discussed is an extension of the earlier proposals and provides a method of sound transmission which is compatible with the 625-line transmission standards used in the U.K. on Bands IV and V, and also offers the possibility of transmitting 625-line television within the 5 Mc/s r.f. channels at present used for 405-line transmissions in Bands I and III.

The pulse-sound system

The total amount of information which could, in theory, be accommodated within the line-blanking interval of the 625-line standard is very large and a pulse-sound system could be devised which, if no other considerations were involved, would have a very high performance. However, in an attempt to provide a system which may be incorporated into current transmissions without affecting the operation of present-day receivers (i.e. a compatible system), and in order to permit the use of a relatively simple form of pulse-sound demodulator in the domestic receiver, attention has been so far confined to the use of one pulse per blanking interval, the pulse being modulated in position by the sound modulation. The audio-frequency bandwidth is inherently restricted to half the line-scan frequency (i.e. about 7.8 kc/s).

This limitation of audio bandwidth, whilst apparent when using high-quality sound-reproducing equipment, is not considered significant when the signal is reproduced by the audio systems of typical domestic television receivers. If future receivers could be designed so that they were immune to a modulated pulse in the line-synchronizing interval, a second pulse could ultimately be introduced and thus extend the available audio bandwidth to 15 kc/s.

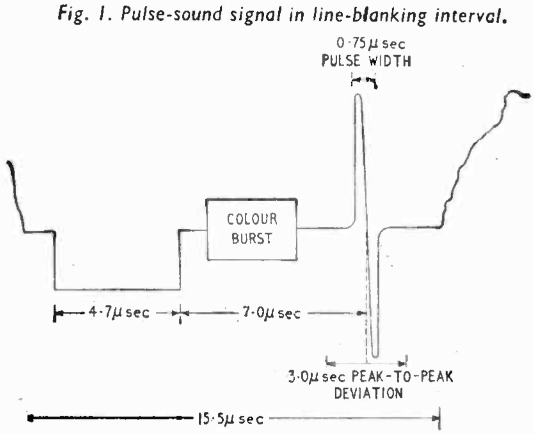
A pulse-sound system may be regarded as compatible with present day receivers if the modulated sound pulses do not disturb the picture (e.g. line synchronization) and if the sound pulses themselves are not visible to viewers. The limited tests so far carried out show that both these criteria are satisfied by sound pulses of the form and position shown in Figs. 1 and 2.

Fig. 1 shows the waveform of a 625-line, line-blanking interval together with the sound pulse. Fig. 2 shows modifications to the field-synchronizing waveform which are necessary in order to preserve continuity of the sound pulses; the modifications to the field-synchronizing signal do not significantly affect the operation of current receivers. The pulses are position-modulated by the audio signal and the maximum displacement is $\pm 1{\cdot}5$ μsec. In order to accommodate this deviation the line-blanking interval has been increased in duration by approximately 3·5 μsec (or 7% of the active-line duration).

The system under bad reception conditions

In the presence of random noise the existing a.m. sound signal provides a service that is substantially better than that provided by the vision signal. The pulse-sound system provides a sound output signal-to-noise ratio that is only some 3 dB worse than that provided by the present a.m. system (i.e. unmodulated a.m. carrier power -7 dB with respect to peak vision power) within the range of signal-to-noise ratios normally encountered inside the service area. However, below a random noise level corresponding to a picture signal-to-noise ratio of between 10 dB and 16 dB (depending upon the sophistication of the sound receiver) the sound output signal-to-noise ratio falls catastrophically. This occurs when the pulse-sound receiver is unable to distinguish between sound pulses and large noise pulses.

Fig. 1. Pulse-sound signal in line-blanking interval.



*B.B.C. Research Dept., Kingwood Warren, Surrey.

†" A method of transmitting sound on the vision carrier of a television system," D. I. Lawson, A. V. Lord and S. R. Kharbanda, *Journ. I.E.E.*, Vol. 93, Pt. III, No. 24, July, 1946.

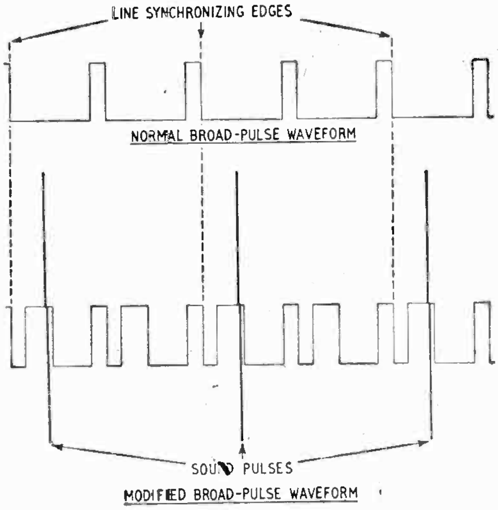


Fig. 2. Line-synchronizing signal providing also a sound-modulation reference.

In the presence of impulsive interference and using the simplest form of pulse-sound receiver, the system is significantly inferior in performance to that provided using a.m. together with a "rate-of-rise" limiter in the receiver. However, it is also possible to use a form of impulsive-interference limiting in the pulse-sound receiver and, in these circumstances, the system provides a slightly lower performance than a.m. (with limiter) in the presence of low and medium levels of impulsive interference and approximately the same performance in the presence of high levels of interference.

The pulse-sound system is very resistant to co-channel interference and would not demand a change to the appropriate C.C.I.R. protection curves. On the other hand, an interfering signal incorporating pulse sound would provoke slightly greater interference than a standard vision signal.

With regard to multipath reception, when ghost images appear on the picture, subjective appraisals have shown that the impairment of pulse sound is likely to be substantially less than the associated picture impairment.

The sound receiver

The intrinsic process performed in the pulse-sound receiver is to measure, once per line, the position of the sound pulse with regard to a regularly recurring position (e.g. the leading edge of the line-synchronizing pulse). The output of a line-flywheel circuit may, in principle, be used as a reference and may be made sufficiently free from disturbances due to noise. However, line-flywheel circuits used in current domestic receivers are subject to disturbance by the field-synchronizing signal and, although this disturbance is tolerable at the top of the picture, it is too severe to permit the flywheel-circuit output to be used for sound-signal demodulation. In receivers designed specifically for pulse sound it should be possible to provide, economically, a higher-performance line-flywheel circuit which is used both for scanning purposes and for providing a stable sound-demodulation reference. The form of synchronizing signal shown in Fig. 2 makes it possible to remove field information prior to the synchronizing of the line-flywheel oscillator.

Other means of demodulation may be used. For example, the audio signal can be recovered from the phase-modulated sound pulses by applying them to an integrating circuit; in this method of demodulation no reference oscillator is required.

The main functions carried out in a pulse-sound receiver are summarized below and Fig. 3 shows, in block diagram form, how the functions are interconnected.

(a) Extraction of the sound pulse from the video waveform:—In order to separate the sound pulse from other components of the video waveform it is desirable to use a gate which is opened once per line for an interval embracing the peak-to-peak deviation of the sound pulse. The sound pulse should also be subjected to limiting at this stage so as to prevent all noise other than that occurring on the high-slope region of the sound pulse from reaching the demodulator, thus minimizing the effects of noise.

(b) Demodulation:—The audio modulation of the sound pulses must be recovered by one of the methods discussed earlier.

(c) Filtration:—The audio signal must be passed through a network which attenuates frequencies above 7.8 kc/s so that spurious signals generated by the modulation process are not reproduced.

(d) Muting:—In order to prevent the possibility of loud and distressing sounds during receiver warm-up, channel-changing, etc., a simple circuit may be incorporated which will silence the receiver when the demodulator is supplied with abnormal signals.

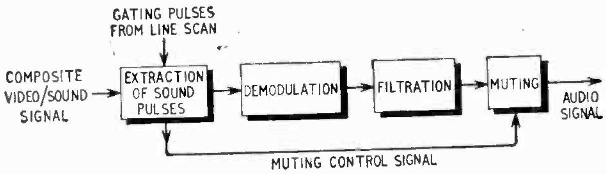


Fig. 3. Block schematic of a pulse-sound receiver.

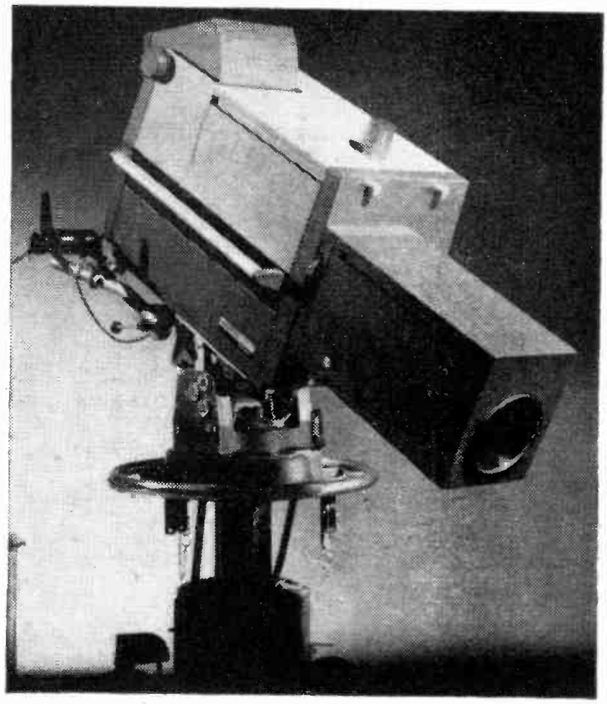
Possible 625-line transmission standards

The pulse-sound system described does not, in practical terms, restrict the choice of video bandwidth and such a system could be used with any 625-line system having a video bandwidth greater than 3 Mc/s. Thus, it is possible to consider the r.f. channel requirements in terms of the television standard alone. For example, if it is considered essential that future 625-line transmissions in the v.h.f. band should use a colour subcarrier of 4.43 Mc/s, it would appear possible to accommodate, using pulse sound, a television signal conforming to Standard G‡ within an r.f. channel bandwidth of 6 Mc/s. If, however, it were considered desirable that future 625-line transmissions in Bands I and III conform to the 5 Mc/s channel bandwidth, as at present used for 405 lines, it is possible to devise a 625-line television standard employing pulse sound and a colour-subcarrier frequency of 3.58 Mc/s which permits this.

Acknowledgement.—The authors wish to acknowledge the co-operation of colleagues who have contributed to the system proposals outlined in this article and to thank the Director of Engineering of the B.B.C. for permission to publish.

‡Monochrome 625-line standard employed in the U.K. with vision bandwidth of 5 Mc/s.

Four-Plumbicon Colour Camera



The new colour camera is designed for compactness and for simplicity of operation. Externally it is similar to the maker's recently introduced Mark V monochrome camera.

WHAT makes the latest British colour television camera stand out somewhat from the steady but unspectacular history of development in this field is that it combines the feature of four-tube operation with that of using Plumbicons for the four pick-up tubes. Both of these features have appeared separately in previous television cameras, but their combined use in this new model, the Marconi Mark VII, constitutes a notable advance in design. In addition, the new colour camera incorporates an improved optical system for spectral separation which gives high transmission efficiency and a reduction of the colour distortion experienced with earlier systems. Thin-film circuits are used extensively throughout the electronic circuitry of the camera, mainly to ensure stability of operation in a range of ambient temperatures.

The main aim in the design has been to achieve a piece of equipment which is compact, light and simple to operate but, at the same time, gives pictures comparable in quality with those of image orthicon cameras. Compactness and simplicity of operation have been achieved by the use of pick-up tubes of the photoconductive type, in place of image orthicons, in association with the improved optical system. The vidicon is the best known and most widely used photoconductive tube, but although it is excellent for film scanning and many closed-circuit television applications it does not provide good pictures when used in broadcasting studio cameras on scenes with low illumination and/or rapid movement. The Plumbicon, however, which is an improved type of photoconductive tube, does meet the required standards of picture quality, particularly when used in a four-tube arrangement. It is fair to say, in fact, that a four-tube Plumbicon camera gives better colour pictures than a three-tube image orthicon camera.

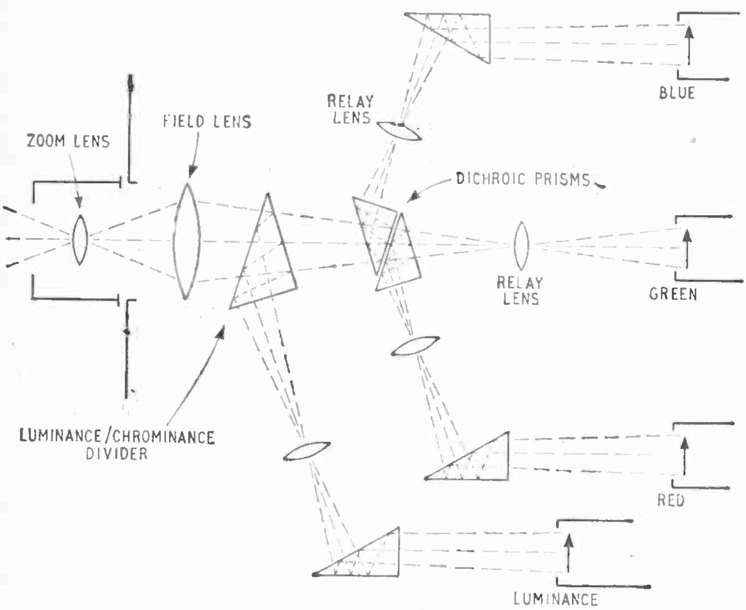


Fig. 1. Simplified schematic of the optical system, showing relay lenses and prismatic separation system.

The four-tube camera, which provides a separate luminance channel in addition to the three colour channels (red, green, blue) of the three-tube camera, is now coming into wider use because of its undoubted advantages for compatible colour television systems. First of all, the extra tube provides a high-quality luminance signal (giving the luminance information for colour receivers and the black and white picture for monochrome receivers) which is independent of the optical registration of the colouring tubes. In a three-tube camera, in which the luminance signal is obtained by addition of wide-band signals from the three tubes, the fidelity of the luminance information (monochrome picture definition) depends very much on the accuracy of registration of the three separate images, and long-term stability of the required accuracy is, in fact, very difficult to achieve. Secondly, a greater degree of optical misregistration between the tubes can be tolerated than with a three-tube camera. A further advantage of the four-tube system is that the luminance value in the reproduced colour picture is predominantly that from the luminance tube alone, and consequently picture degradation caused by colour tube defects is much reduced.

All the four tubes in the camera are Plum-

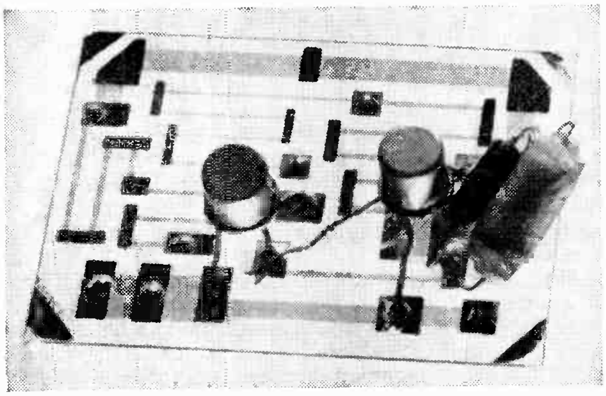


Fig. 2. Typical thin-film circuit module showing how transistors and other separate components are connected.

bicons, as already mentioned. They provide compactness and simplicity of design because the Plumbicon is much smaller than the widely used 4½-inch image orthicon and requires less scanning and focusing power and less complex external circuits. The resolution of the Plumbicon (see appendix) is not quite as good as that of the 4½-inch image orthicon, but it is more than adequate for the narrow-band colouring channels and is satisfactory for the luminance channel. Since the Plumbicon is superior to the vidicon in sensitivity, lag and dark current (the spurious, temperature-dependent flow of charge carriers in the photoconductive layer which can prevent good picture contrast), it is therefore a natural choice for the three colouring channels.

For the luminance channel the Plumbicon is not quite such an obvious choice. The highest quality black-and-white pictures at present attainable are given by the 4½-inch image orthicon, which, because of its non-linear characteristic, has the additional advantage that it can handle a wider range of scene illumination than the Plumbicon, with its almost linear characteristic. On the other hand, because of these very differences in characteristics and other differences in performance and geometry, there would be considerable difficulties in achieving satisfactory registration and performance matching between a single image orthicon and the three colouring-channel Plumbicons. Thus four Plumbicons would seem the best compromise for combining satisfactory picture quality with minimum size and complexity of equipment.

The improved optical system (see Fig. 1) is characterized by its use of a prismatic type of light splitting system, instead of plate-type dichroic mirrors, and by the use of relay lenses. The prismatic system for splitting the incoming light into luminance, red, green and blue components has been adopted partly because it occupies less space than the plate-type dichroic mirror system and partly because it avoids the ghost images, astigmatism, spurious colour gradation across the picture and unfaithful colour rendering with polarized light (e.g. in reflections from hair) which are commonly experienced with the plate system. The main function of the relay lenses, as their name implies, is to extend the length of the light paths from the main camera lens, which is a zoom lens, to the pick-up tubes. This is necessary because, with a four-tube camera, it would be difficult to arrange the tubes and the light-splitting system so that the scene image could be formed directly on the tube targets by the main camera lens. In particular it is desirable to mount all four tubes as near parallel as possible and with similarly orientated images, in order to minimize the differential effect of external magnetic fields on them, and this would be almost impossible with direct image formation. Furthermore, the direct method is operationally inflexible because the main camera lens has to be specially designed for it, whereas with the relay system any standard television camera lens can be employed.

In Fig. 1 the main camera lens forms a primary image of the scene (40 mm diagonal, image orthicon size) in a field lens, which is the first component of the relay system. This image is then focused on to the targets of the four pick-up tubes through the various reflecting surfaces of the prismatic light splitting system. The first prism separates the luminance component by reflecting some of the light into the luminance tube and allowing the remainder to pass through to the colour tubes. This separation, however, is not performed by a conventional semi-reflecting surface in the prism but by an interference layer, as in a dichroic mirror, which reflects at each light wavelength only that part of the energy required by the luminance tube—in other words, the reflection process gives the correct spectral response curve for the luminance channel. Then at each wavelength the whole of the remaining light energy passes through to the colour separation prisms.

Thus the interference layer in the luminance prism combines the function of luminance/chrominance light division with the function of a spectral shaping filter (which would in any case be necessary), but without the loss of light energy that would result from the absorption in a conventional filter. This novel technique therefore ensures minimum loss of light energy and so increases the sensitivity of the camera.

When the camera is required for black-and-white operation only, the special luminance/chrominance separation surface is replaced by a fully reflecting surface—the prism being a dual-purpose one—so that the whole of the incoming light energy passes into the luminance tube.

After the luminance component has been split off, the remaining light is separated into its red, green and blue primary colour components by further interference layers in the dichroic prism system. These components are then directed through further prisms, the relay lenses and spectral trimming filters, to the appropriate pick-up

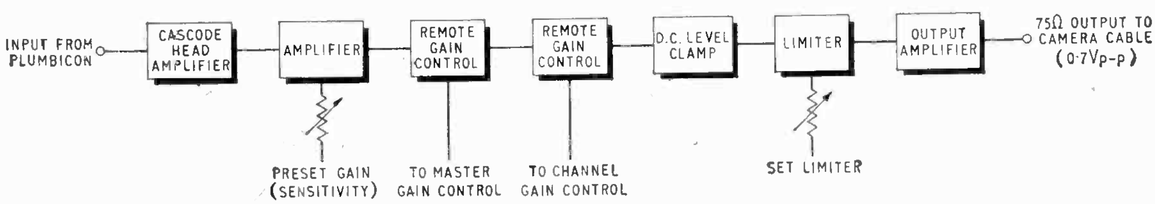


Fig. 3. Schematic of electronic circuits of the luminance channel of the camera.

tubes, where red, green and blue images are formed on the respective targets of the tubes.

Although the resolution of the Plumbicon is not quite as good as that of the image orthicon, maximum resolution through the whole luminance channel (400 lines with 100% modulation) is achieved partly by aperture correction, partly by special attention to the design of the tube scanning yoke, and partly by the use of a high focus-electrode potentional in the luminance Plumbicon (750 V instead of the 250 V used in the chrominance Plumbicons) so that the scanning beam diameter is as small as possible. The sensitivity of the camera is such that, under average studio conditions and with average pick-up tubes, 230 ft-candles (2,500 lux) of illumination on the scene is required with a lens aperture of f/8. (This assumes an illumination colour temperature of 3000° K and a peak scene reflectance of 60%.) With these conditions the signal (p-p)-to-noise (r.m.s.) ratio is 40 dB in the luminance channel (bandwidth 5.5 Mc/s), 36 dB in the red channel, 44 dB in the green channel and 37 dB in the blue channel. With the iris opened to f/4 and the gain of all channels increased by 6dB—this is done by a master gain control—an acceptable picture can be obtained with only 30 ft-candles (325 lux) of illumination.

As already mentioned, the camera design makes extensive use of thin-film circuits (a typical module is shown in Fig. 2), and this technique has been adopted in order to achieve sufficient stability with a range of ambient temperatures to reduce the operational adjustments required to a minimum—what is known as "hands-off" operation. Over 60 of these thin-film circuits are used. The circuitry is completely solid-state, with the exception of a single Nuvistor valve in each of the four vision head amplifiers—used because a transistor with a sufficiently good noise figure for this stage was not available.

Fig. 3 shows, by way of example, a block diagram of the electronics of the luminance channel. The signal from the pick-up tube is first amplified by a head amplifier, using a Nuvistor and a transistor in a cascode circuit, which is mounted directly on the deflection yoke of the tube. The signal then passes through amplifiers with remote gain control (using a photo-sensitive resistor and lamp combination) through a clamping stage which establishes the signal d.c. level necessary for proper operation of the following limiter (which protects subsequent stages from the excessive signal amplitudes that can result from the linear characteristics of the Plumbicon) and finally to the video output stage which feeds a 0.7 V p-p signal into the 75-Ω camera cable.

APPENDIX ON THE PLUMBICON

AS mentioned above the Plumbicon* is a photoconductive type of pick-up tube. It is similar in size and principle of operation to the vidicon but will give better pictures under unfavourable studio and outside broadcast conditions. Relative to the vidicon it has higher sensitivity, slightly lower resolution, faster response and lower dark current—the last-mentioned resulting in notable absence of black shading and accurate black level. The tube measures 19 cm long by 3 cm in diameter and the photosensitive target diameter is 2 cm. It has been given the name Plumbicon by its developers, the Dutch Philips company, because it has a photoconductive target made of lead monoxide (vidicons normally use antimony trisulphide). The particular tubes used in the Marconi camera are of Philips manufacture but we understand that the English Electric Valve Company, E.M.I. Electronics Ltd. and other companies will eventually be making Plumbicon type tubes in Britain.

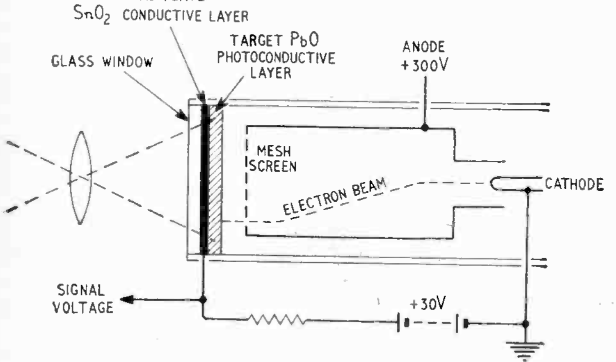


Fig. 4. Basic construction of the Plumbicon pick-up tube.

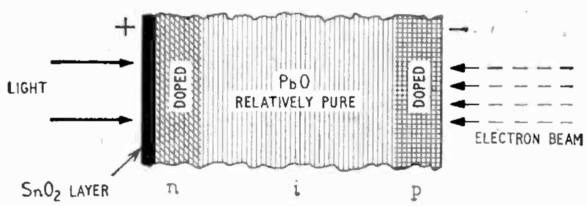


Fig. 5. Three sublayers of the lead monoxide target.

The principle of operation is illustrated in Fig. 4. An image of the televised scene is focused on to the photoconductive target, which is scanned from the rear by an electron beam accelerated by a cylindrical anode (the mesh screen serving to give a more uniform field between target and anode). The target is formed on the glass window of the tube. A conducting but transparent film of stannous oxide (SnO_2) is first laid on the inner surface of the window to form a signal collecting plate, then a layer of lead monoxide (PbO) about 20 μm thick is evaporated on top of that to form the target. The signal plate is held at about 30 V with respect to the cathode, which is earthed, while the free surface of the target scanned by the electron beam fluctuates within a few volts of cathode potential.

What distinguishes the Plumbicon from the vidicon is not only the actual target material but the fact that the signal plate and target unit effectively forms three sublayers, each of differing conduction type, as shown in Fig. 5. The wide inner sublayer of the "sandwich" is almost pure PbO, which is an intrinsic semi-conductor, the sublayer scanned by the electron beam is doped to

(*Continued at foot of page 61*)

* For a detailed description, see "The 'Plumbicon', a new television camera tube" by E. F. de Haan, A van der Drift and P. P. M. Schampers. *Philips Technical Review*, Vol. 25, No. 6/7, 7th July 1964.

MICROWAVE SEMICONDUCTOR "TRANSIT-TIME" DEVICES

The current state of the art in Bell Telephone Laboratories' work on semiconductor devices for oscillation and amplification at microwave frequencies is summarized in the table below. The three devices being studied are characterized by the fact that their operating frequency is partly determined by the time taken for the electrons to move through a region of the semiconductor material—the transit time.

The bulk gallium arsenide device is similar to the Gunn-effect oscillator (described in our August, 1965, issue p. 416), but it will be noted that the Bell workers have also achieved amplification by use of this phenomenon. In practice the device is connected to a 50-Ω coaxial line, and a circulator is used to separate the input and output signals. The other two devices contain a junction which is reverse biased to produce an avalanche breakdown—the silicon avalanche diode being a simple p-n arrangement and the Read avalanche diode a more complicated p-n-i-p structure.

Interest in these solid-state devices as alternatives to thermionic microwave oscillators and amplifiers has arisen because of their relatively small size, good reliability and low cost. Since they make use of larger volumes of semiconductor material than do conventional transistors or tunnel diodes, they can operate at higher power levels, but even so they cannot match the power handling capacities of the triodes, klystrons and magnetrons which at present hold the field.

A silicon avalanche oscillator diode of the simple p-n type is now available in Britain—the Microwave Associates type MA-4980X. It operates at 40 V (with a recommended 1,000Ω series resistor in the supply) and the makers guarantee a minimum output power of 0.1 mW c.w. within the maximum c.w. current rating of 40 mA. Powers of the order of 10 mW are said to be typical for pulsed operation. Usable frequencies are in the 8 to 16 Gc/s range. The diode is constructed in "pill" form, with a threaded cathode prong and a bellows attached to the flat anode cap, and suitable waveguide or coaxial holders are available.

Type of device	OSCILLATOR			AMPLIFIER		
	Freq.	Power output	Efficiency	Freq.	Gain	Noise figure
Bulk gallium arsenide "Gunn effect"	2-3 Gc/s	60 mW (c.w.)	5-6%	2-10 Gc/s	4-5 dB at bandwidth of 600-700 Mc/s	20 dB
Silicon avalanche diode	10.5 Gc/s 10 Gc/s 50 Gc/s	13 mW (c.w.) 100 mW (pulse) 350 mW (pulse)	0·5%	10-11 Gc/s	20 dB at bandwidth of 30 Mc/s	50 dB
Read avalanche diode	5.2 Gc/s	19 mW (c.w.)	1.5%	—	—	—

APPENDIX ON THE PLUMBICON *continued*

make it p-type while the SnO_2 signal plate is strongly n-type and gives rise to a thin n-type region in the PbO. Thus when the tube is in operation the whole structure constitutes a reverse-biased p-i-n diode across which an electric field and capacitance exists.

This capacitance across the target can be considered as being made up of a large number of small capacitors, one at each picture point of the image. Shunting each capacitor is a small current source formed by the charge carriers—electrons and holes—liberated in the target material by the incident illumination at that point. When the electron beam connects with the right-hand plate of a particular capacitor, this capacitor starts to charge from the 30 V supply. As soon as the beam has passed on the capacitor starts to discharge through the shunting current source and the rate at which it discharges depends on the flow of photo-current and hence the intensity of illumination at that point. Thus when a capacitor is being charged through the electron beam, the charging current which flows from the 30-V supply is proportional to the extent of the previous discharge and so to the intensity of the light. This charging current flows through the external resistor and so develops a signal voltage across it proportional to the light intensity at the picture point being scanned.

The good sensitivity of the Plumbicon (300 μA/lumen) results from the fact that there is a high electric field strength throughout the thickness of the target because the major part of it consists of i-type material, which is a poor conductor. Thus almost all the charge carriers liberated in the PbO by the incident light are caused to drift by this electric field and so contribute to a photo-current. The dark current is the small inverse current through the reverse-biased diode, and is extremely low ($<0.5\times10^{-3}$ μA) because of the blocking action of the p-type and n-type sublayers to spurious current (i.e., electrons and holes not generated by light activation). The p-sublayer hinders the entry of electrons into the i-sublayer while the n-sublayer hinders the entry of holes.

Other characteristics of the tube—resolution, speed of response, spectral characteristic—are determined by the properties of the target sublayers, i.e., their thickness, doping substance, and so on. With a well-designed scanning yoke, a resolution of 400 lines with 40% modulation can be obtained. Speed of response to movement in the televised scene (i.e., change of light intensity on an area of the target) is limited by the ability of the electron beam to supply charging current during its brief connection to each picture-point capacitor and by the presence of traps in the i-sublayer. The response is such that the change in tube signal level resulting from a transition from strong to weaker illumination of an area of the target is 95% complete after 0.06 second. The spectral response of the standard tube is somewhat unsatisfactory at the red end of the spectrum (this is partly offset by increasing the gain in the red channel of the camera) but a new Plumbicon with improved red response is likely to become available within the next year.

TORSIONAL STABILITY AND

2.—CONSTRUCTION AND SETTING-UP OF A PICKUP ARM WITH GOOD TORSIONAL AND SHOCK STABILITY

THE dimensions and finished weight for the various components should be adhered to and it is wise to check the gauge of the tubing for the arm beforehand. A $\frac{1}{4}$ in drill should be a free fit inside this.

To ensure the correct shape for the arm, the arm shape diagram is best drawn out full scale and the finished arm laid over this to check.

Use of a balance would be an advantage but an ordinary 12 in wooden ruler balanced on a knife edge under the 6 in mark will suffice to check the weight of components against the coins indicated in the parts drawings.

Before drilling the $\frac{9}{32}$ in dia. and $\frac{3}{8}$ in dia. holes in the pivot block, check that the appropriate rubber tubing is a secure push fit into holes of these diameters.

Holes with slits leading into them (with the exception of the $\frac{1}{2}$ in dia. hole in the base) should be squeezed up slightly to provide a secure friction fit on the parts for which they are intended.

It is hoped that construction of the component parts and their assembly will be self-evident from the drawings. However, some notes on the pivot parts and the initial setting are given.

Pivot parts

The front stabilizer is used to achieve initial static terminal balance and its final horizontal distance from the pivot block should be 0.9 ± 0.1 in depending upon how accurately the various parts have been made and especially the location of the pivot cup in relation to the axis of the longitudinal hole through the pivot block.

Both the setting of the front stabilizer and the depth of the pivot cup cannot, of course, be done until the pivot parts have been made and some notes concerning this are given below.

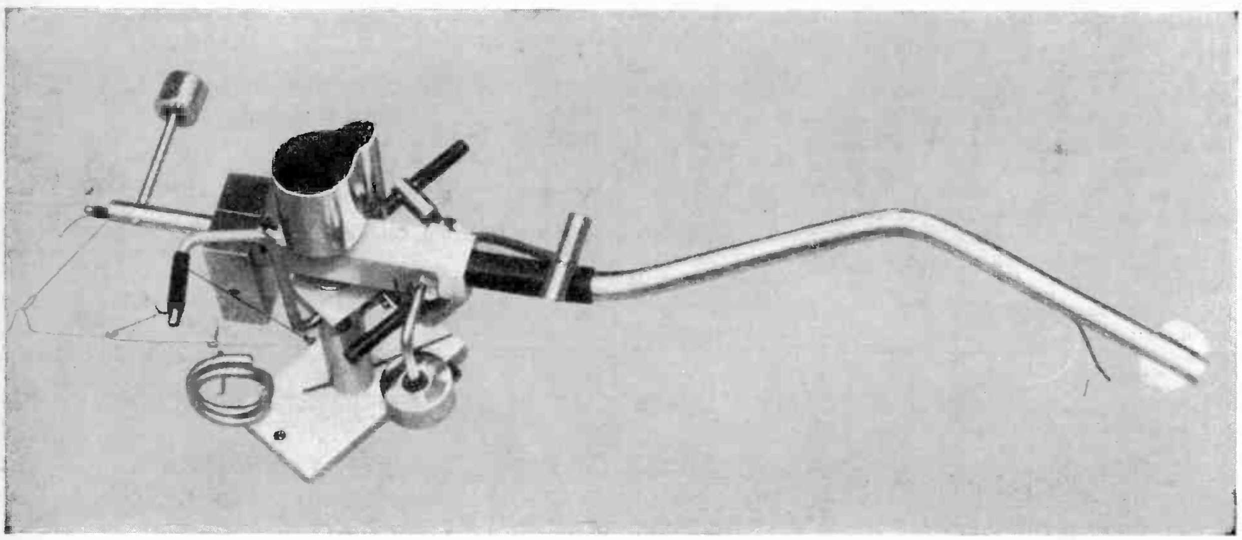
The pivot needle may first be ground to the shape shown in Fig. 10 against a fine abrasive disc to produce a very small rounded tip. The counterpunch used to make the pivot cup is similarly ground and polished to a 90° point before hardening and tempering. This counterpunch is then used to "pop" the cup centrally using a fairly heavy blow to flatten any ridges that may be formed. The needle cup should be hardened and tempered—tempering to a dark straw colour has been found satisfactory. These parts can now be fitted and the pivot cup depth and the front stabilizer now set as follows.

The dummy head is first fitted to the arm in place of a cartridge—its front face being set 9 in from the pivot. An elastic band could be used to hold it in position. The pivot cup is screwed in until its depression lies about 0.075 in above the bottom face of (i.e. inside) the pivot block. With the arm set on the needle the horizontal distance of the front stabilizer from the pivot block is set to give torsional balance. (The counterweight should be adjusted to give horizontal balance and left vertical).

The depth of the pivot cup can now be set by screwing in or out until a rise of $\frac{3}{4}$ in is caused at the head when the 0.5 gm test weight is hung on the split pin at the rear of the arm.

Friction using the fine-pointed needle will probably be a little lower than desired so friction must now be increased. The original needle may be blunted slightly

Fig. 7. View of the completed arm.



THE UNIPIVOT

By J. BICKERSTAFFE

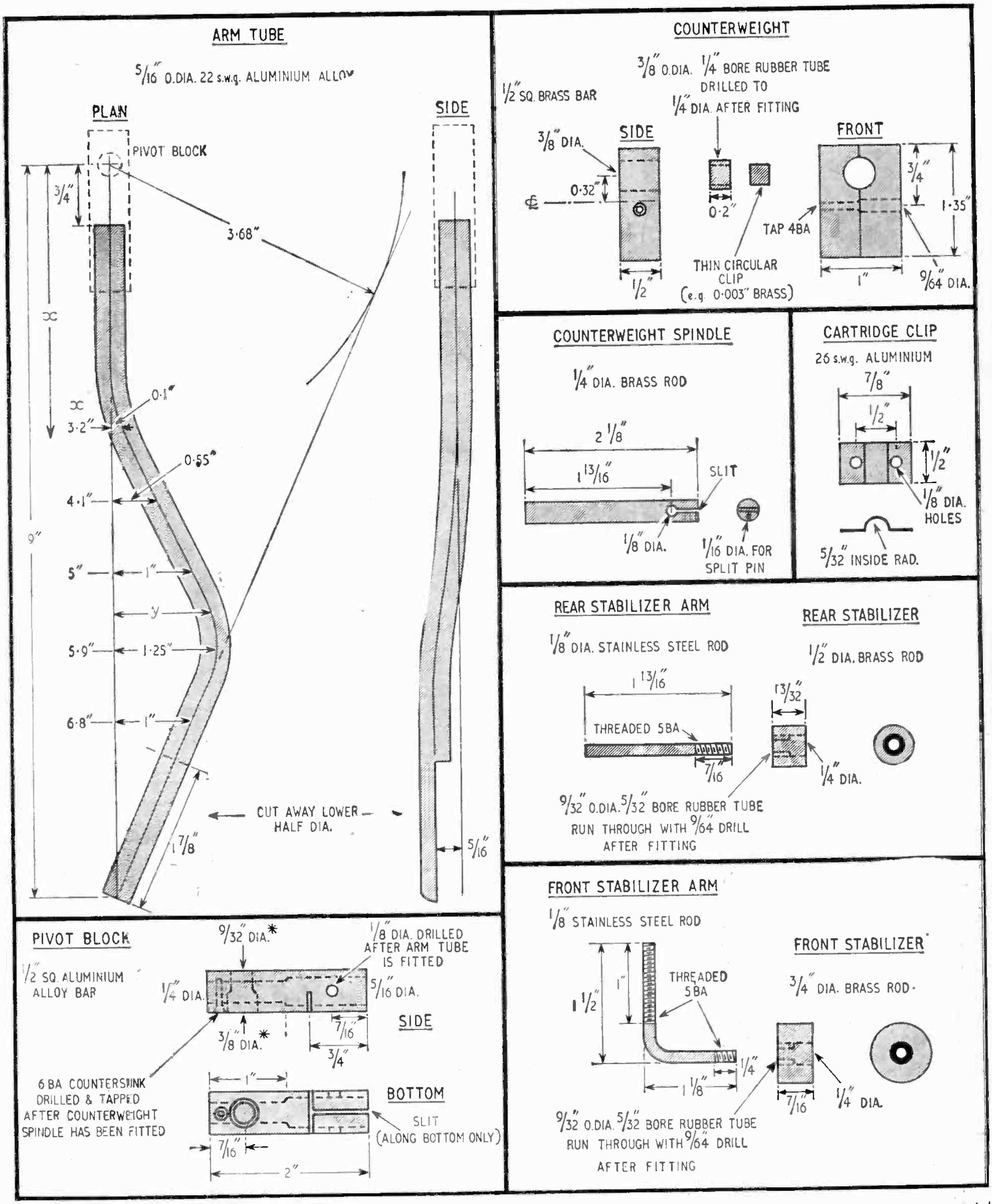


*Fig. 8. Arm parts. *Or diameter required to give secure push-fit. Weights of some of the finished items are as follows:— counterweight 80 gm (9 pennies); front stabilizer 22.5 gm (half-crown plus penny); rear stabilizer 8.2 gm (ha'penny plus sixpenny piece).*

or kept for possible further tests and a fresh needle (or needles) made. The point can be progressively blunted until friction is correct by running the hardened needle in the drill whilst rubbing a fine abrasive across the point. As near spherical a tip as possible should be aimed at and a magnifying glass is useful to check the work.

To check friction using the new needle, balance the arm horizontally and depress the head with a finger. Then allow the head to return very slowly to its rest

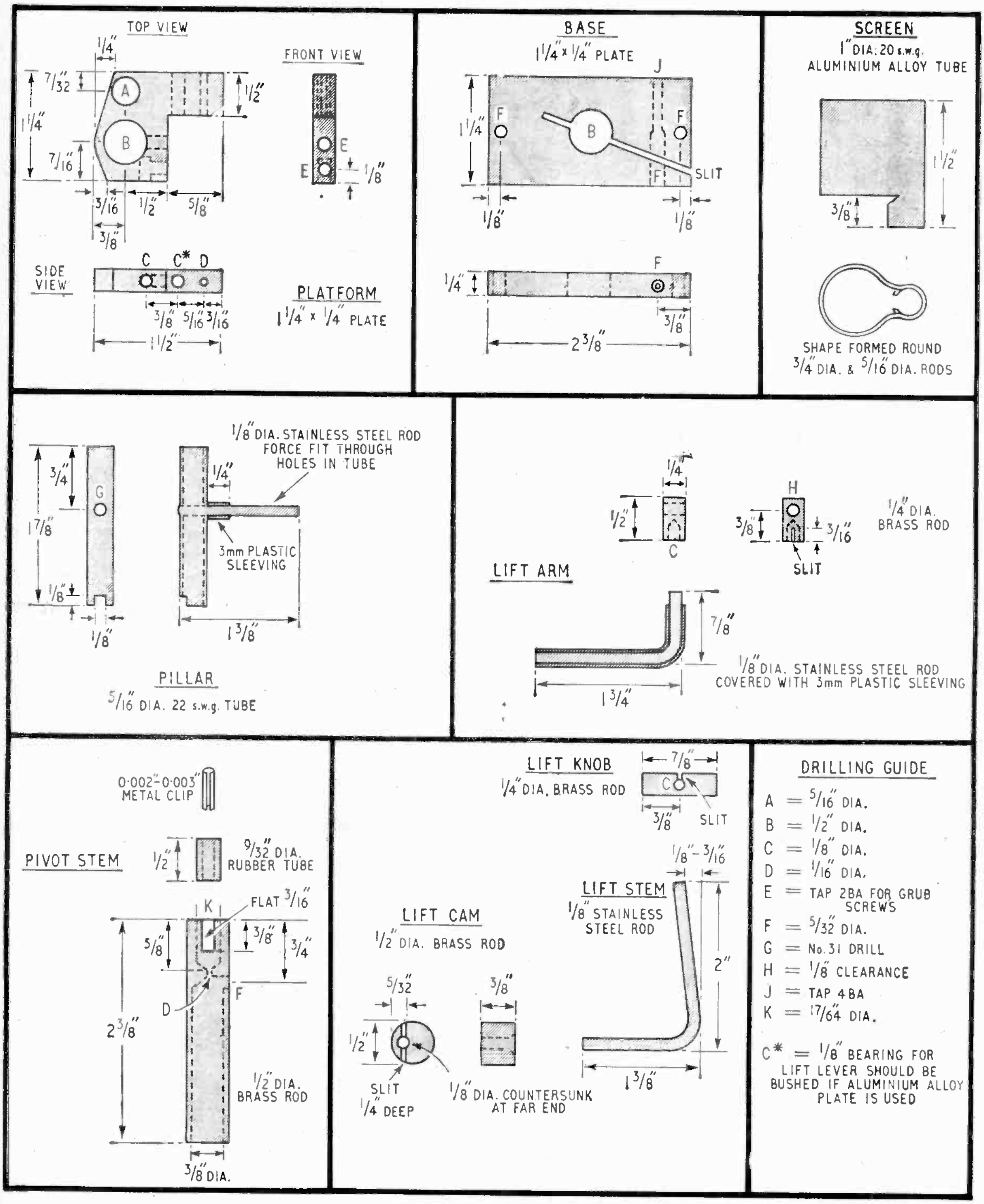


Fig. 9. Pivot assembly parts.

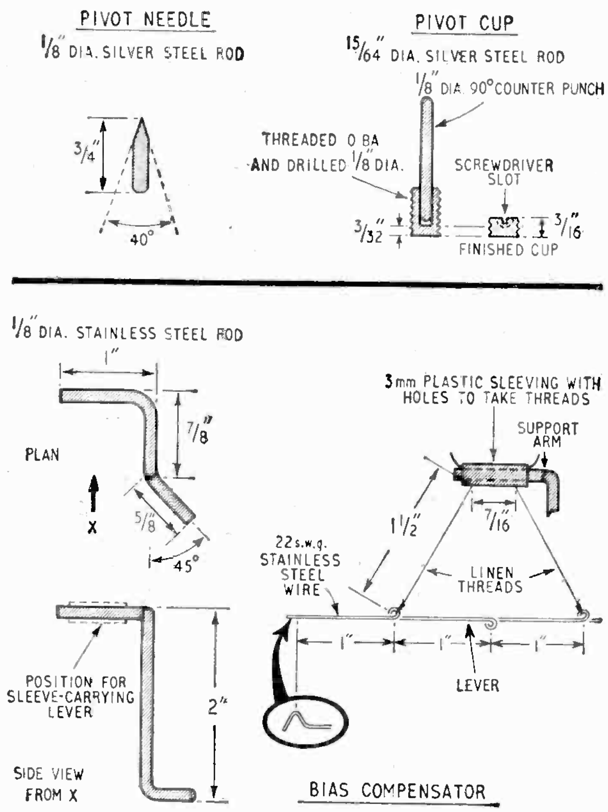


Fig. 10. Pivot.

position. Repeat but this time with the head first raised. The difference in the two heights at which the head comes to rest, in these two cases, should be between 0.17 in.-0.5 in for a friction between 10-30 dynes. The ideal would probably be between 0.2 in and 0.3 in.

It might be worth while bearing in mind that friction can sometimes reduce markedly after a little " running in," but the initial value should not be made too high or the arm may " stick " a few degrees off torsional balance. The useful life of pivots so made appears to be a number of years, but when wear does become excessive it should be apparent by the " sticking " just mentioned. A torsional pivot friction of 30 dynes could cause the arm to track $\pm 1°$ off balance and frictions greater than this are considered excessive in this respect.

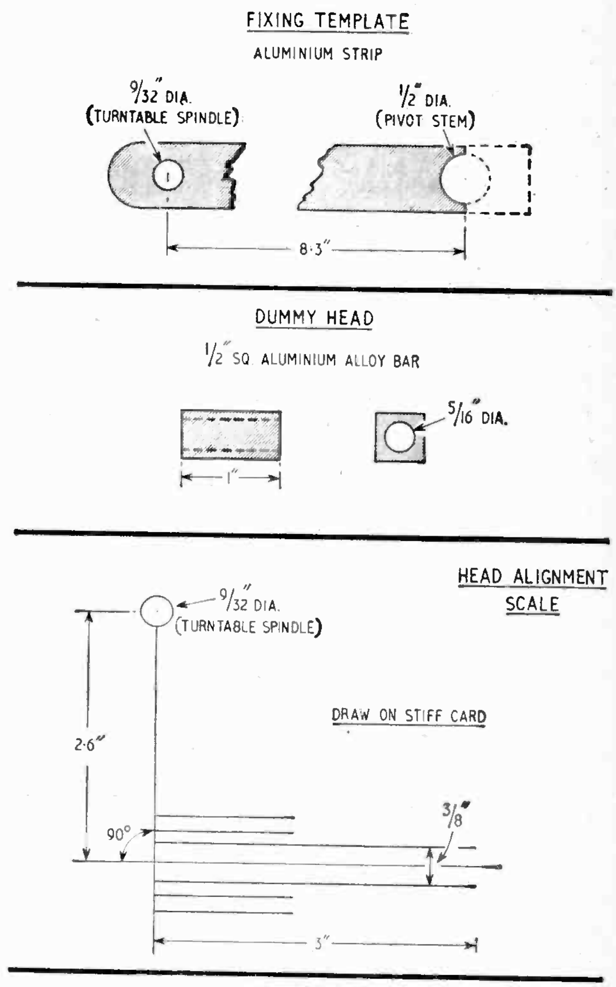
Setting up

When the initial adjustments have been completed the connecting wires from the arm may be plugged into the top of the pillar and spaced out so as not to touch. It is helpful to stroke out any kinks beforehand.

A word of warning here regarding the removal of the lead screen once it has been fitted. This tends to come away with a jerk and it is well to use both hands to gently ease it off without the clamping lugs at the bottom catching a connecting wire.

To set up the arm for use, first drill a hole of about $\frac{7}{8}$ in dia. in the motorboard centred 8.3 in from the turntable spindle. Set the pickup in position with its leads and pivot stem through this hole, then screw down the base using the fixing template to accurately space the pivot from the turntable spindle. (If the pickup is to be mounted on a metal motor plate, to avoid hum loops, it would be wise to either insulate the pickup from it and earth the plate separately or let the pickup provide the only earth connection.)

Lightly clamp the cartridge to the arm and set the pivot height so that with the stylus lowered just clear above a record, the section of the arm tube to which the cartridge is attached is parallel with the record surface. (A lightweight spacer about $\frac{1}{8}$ in thick of, say, paxolin, would be best clamped between cartridge and arm in cases where the stylus lies much less than $\frac{5}{8}$ in below the top of the



TRACKING FORCE ADJUSTER WEIGHTS

1/8" DIA. STAINLESS STEEL ROD. THE WEIGHT HOOK IS MADE FROM 22 s.w.g. STAINLESS STEEL.

TRACKING WEIGHT (gm)	2	1	0·5	0·25
LENGTH OF ROD (in)	* 4·8	2·4	1·2	0·6
WEIGHT (gm)	7·2	3·6	1·8	0·9
* DOUBLE TURN	FORMED AROUND 5/8" DIA. ROD		FORMED AROUND 5/16" DIA. ROD	

TEST WEIGHT OF 0·5gm CAN BE MADE WITH 5·8" 22s.w.g. TINNED COPPER WIRE FORMED AROUND 3/8" DIA. FORMER.

Fig. 11. Fixing template, dummy head, head alignment scale and tracking-force adjuster weight details.

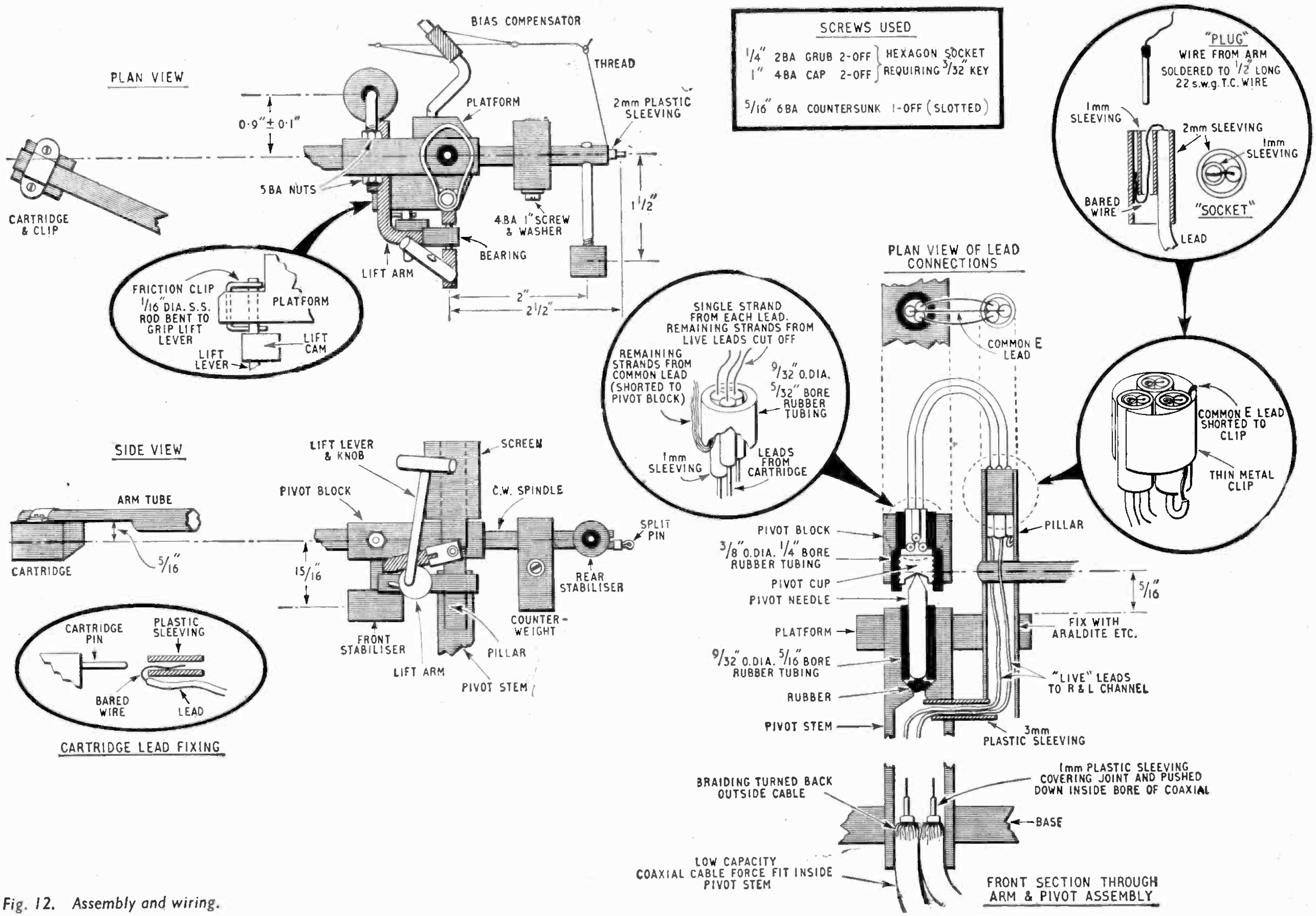


Fig. 12. Assembly and wiring.

cartridge. This should ensure reasonable daylight between the rear portion of the arm and a warped record).

The position of the cartridge can now be adjusted for minimum tracking distortion using the head alignment scale. The normal procedure is used, i.e., with the scale placed on the turntable, the latter and the pickup are moved until the last straight section of the arm tube (and cartridge sides) lies between and parallel with the guide lines when viewed from above. The cartridge is then shifted along the arm until the stylus lies directly over the point S on the scale.

Tracking weight is set using the appropriate rings which, if the bias compensator is used, are then transferred to this.

Finally corrections for torsional balance should be made by twisting the counterweight slightly on its spindle. (Very fine corrections may be made by screwing the rear stabilizer a little along its arm—but the stabilizer is best kept to within $\pm \frac{1}{16}$ in of its preset distance from the counterweight spindle). The criterion for balance is that the arm should show no sign of tilting when lowered on to a record.

If the bias compensator is put into use, it should first be assured that the pivot assembly is angled to bring the top of the compensator support arm about 45° to the arm when the latter is half way across a 12 in record. Then with the lever connected to the pickup, the support arm is pushed back or pulled forward until the thread makes a right angle with the arm with the latter over the outer grooves of the record. Finally adjust the thread length until the lever is parallel with the pickup in this position.

Conclusion

It is inevitable that in a brief account such as this some points in the construction and assembly, etc., will have been passed over. But it is hoped that if the reader is interested enough to build the arm he will be interested enough to sort out any little difficulties which may arise.

It is in the author's opinion that anyone with a little practical skill should not meet with any serious difficulty.

The sources of supply for the various materials used by the writer may be of assistance to readers and are given below.*

* Alloy tubing and plate: T. W. Senier & Co. Ltd., 115/121 St. John St., London, E.C.1.

Bar, rod, screws, etc., $\frac{3}{8}$in o.d. × $\frac{1}{4}$in bare rubber tubing, $\frac{9}{32}$in o.d. × $\frac{5}{32}$in bare rubber tubing: K. R. Whiston, New Mills, Stockport, Cheshire.

Wire (miniature stranded p.v.c. covered), low capacity co-axial cable ($\frac{1}{4}$in nom. dia.): Home Radio (Mitcham) Ltd.

Errata: We regret that the blocks for Figs 3 and 4 in Part 1 of the article (p. 24 of January issue) were interchanged.

BOOKS RECEIVED

Circuits Using Direct Current Relays, by A. H. Bruinsma. An interesting book which gives a fairly detailed account of the operation of relays. Mechanical construction, sensitivity and "in" and "out" switching action are considered in detail. Switching via valves and semiconductors is dealt with at length. Automatic sequence circuits for multi-relay operation are also included. The final chapter deals with special circuits and includes details of an automatic relay circuit with successive fixed conditions, simple addition and subtraction circuits and a step switch. Pp. 86; Figs. 66. Price 13s 6d. Philips Paperback distributed by Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.1.

Transistor Pocket Book, by R. G. Hibberd. Written in a lucid style, the book is a comprehensive guide to the principles and characteristics of junction transistors. A short interesting historical introduction traces the development of semiconductors from the late 19th century and leads to an explanation of the principles of operation, equivalent circuits and parameters of the modern transistor. Manufacturing methods are described explaining the effects of different methods and types of junction on the characteristics. Details are included of other semiconductor devices and descriptions of theory, together with practical arrangements, of various circuits are given. The final chapter deals with integrated circuit techniques. Pp. 304; Figs. 220. Price 25s. George Newnes Ltd., Tower House, Southampton Street, London, W.C.2.

Unified Circuit Theory in Electronics and Engineering Analysis, by J. W. Head and C. G. Mayo. The book deals with the application of operational calculus for the study of the output or response of a linear system whatever the nature of the input may be. The authors have attempted to dispel fundamental difficulties by explaining elementary arithmetic in the introduction as a simplified form of operational calculus. Expansion of the text then includes Kirchhoff's equations and the impedance concept, step and impulse functions, the Fourier integral, and general principles of feedback and servomechanisms. Pp. 174. Price 42s. Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.1.

Circuit Theory Analysis, by Joseph Mittleman. Intended specifically as a text book on the solution of circuit analysis problems, the book can also be used as a reference source of theorems, basic equations and other information related to applied mathematics. The introductory text provides a foundation of the fundamentals of electron theory, passive and active circuit elements, Kirchhoff's laws and power and energy considerations. From this basis the text is expanded to take in various circuit configurations and their response to time-domain inputs. Further expansion of the text covers integro-differential equations arising from Kirchhoff's laws, sinusoidal steady-state response of R, L and C networks, resonance phenomena, complex frequency analysis, topology, determinants and Fourier analysis. Worked examples are included in each chapter and problems are included at the end of each chapter to supplement the theory. Pp. 461; Figs. 440. Price 63s. Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.1.

Transistor Electronic Organs for the Amateur, by A. Douglas and S. Astley. An introduction for the enthusiast to the circuits used for electronic organs. A brief resumé of organ terminology and semiconductor theory is given in the first two chapters. Circuits described include oscillators, frequency dividers, tone forming networks, reverberation and percussion methods, and power supplies. Details are given of keying arrangements including home made devices. The final chapter is devoted to keying and special tonal effects. In an appendix, a table of tonal derivations with frequencies up to the 7th harmonic is included. Pp. 76; Figs. 85. Price 18s. Sir Isaac Pitman and Sons Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2.

Tape Recorder Servicing Manual, by H. W. Hellyer. Contains circuit and layout diagrams and perspective views together with servicing instructions of tape recorders from over 62 British, Continental, American and Japanese firms. A 14-page introduction covers basic principles, practice, repair procedure, microphones and impedance matching. Pp.336; near 300 Figs. Price 63s. George Newnes Ltd., Tower House, Southampton Street, London, W.C.2.

WORLD OF WIRELESS

I.T.A. Report

PERHAPS the most significant fact contained in the annual report and accounts of 1964-65 for the I.T.A. is that the total payment to the Exchequer from the entire Independent Television system is about £40M per year. This sum is almost half the advertising revenue and includes £22M collected for the Exchequer by the Authority from the programme companies as "additional payments," these being in the form of an Exchequer levy based on advertising receipts of the companies.

On the engineering side the report considers that the year under review has seen the heaviest station construction programme of any period during the existence of the Authority. Eight new stations were under construction and two of these came into service before the end of the year. Future plans are for expansion at the rate of perhaps six stations a year for the next three years.

During the first full year of the operation of the Authority's Telecommunications and Experimental Group good progress has been made on several development projects. One of these has been a lightweight airborne receiver and telemetry transmitter for the investigation of the relationship between signal strength and heights of transmitting and receiving aerials. A small hydrogen balloon carries the equipment to a height of about 1,500 ft where it is released by a trip mechanism and then descends by parachute. During ascent and descent, Band III signals are received and used to modulate a signal radiated by the airborne transmitter. In this way, the field strength of the Band III signal is continuously monitored and an indication of field strength at different heights is obtained. The 95-page Report, published by H.M.S.O., costs 7s 6d.

Government Research Aids Industry

ABOUT 10% of the research effort of the Royal Radar Establishment is to be made available to assist industrial research. In the branch of microelectronics, especially, R.R.E. has expended considerable effort, and the knowledge gained and techniques evolved will be available to industry through the Ministry of Technology who act as a mediator between Government establishments and industry. It is hoped further collaboration between these establishments and industry will produce research programmes scheduled to run in parallel with defence and industrial requirements. Possibly a separate department will be set up by the Ministry of Technology to facilitate liaison between Government establishments and industry. The overall arrangement will be similar to the N.A.S.A. idea in America where efforts are being made to adapt the vast experience gained from space exploration for industrial and civil applications.

High-speed data transmission networks for computers are required for the rapid transmission of data to and from computers over long distances. At the moment, existing telephone networks are used but the network required would have to be capable of transmitting data more than a thousand times faster than that possible with ordinary telephone lines. This was one of the points made by Mr. R. T. Shaw, of English Electric Leo Marconi Computers, when he was speaking at "Datafair" at Imperial College in January. The new type of transmission network would be similar to that outlined in *Wireless World*, January, p. 6 and should provide a bandwidth or digital rate which could be determined by the user and a costing system based on a fixed minimum charge plus an additional charge depending upon the volume of data and the speed at which it is sent.

An experimental **sun-powered laser** device has been developed by R.C.A. The laser has been built for the N.A.S.A. manned-spacecraft centre, Houston, Texas, and is considered to be one of the first steps towards a 50M mile communication link between Earth and spacecraft in the vicinity of Mars. An R.C.A. engineer said that no spacecraft power would be needed to operate the laser, sunlight concentrated by a parabolic mirror would be sufficient. The experimental system consists of a 31-in parabolic mirror, the laser, the modulator and associated electronics, optical elements and an optical receiver, all of which are mounted equatorially on the satellite to automatically track the sun so that the rays are always reflected from the mirror on to the laser.

What is claimed to be the ***smallest television receiver*** *in the world has been built by engineers of the American Westinghouse Electric Corporation to demonstrate the use of microminiature circuitry and is only 3½in high, 4½in long and has a c.r.t. of 1in diameter. An employee of the Corporation is shown using a pair of tweezers to examine one of the thin-film components used in the receiver.*

New B.B.C. Relay Station.—The B.B.C. has brought into service the television and v.h.f. sound relay station at Churchdown Hill, situated about three miles N.E. of Gloucester. The station, which will serve some 140,000 people, is one of a large number of low-power relay stations being built to extend and improve the coverage of television and v.h.f. sound services. Transmissions will be horizontally polarized and the station will broadcast BBC-1 television in channel 1 (max. e.r.p. 250 W) and the sound services (max. e.r.p. 27 W) on 89, 91.2 and 93.4 Mc/s. For satisfactory reception of BBC-1 transmissions very careful positioning of the aerial may be necessary to avoid interference from other stations using this channel—particularly the high power station at Crystal Palace.

BEAMA at the 1966 South African Show.—The British Electrical and Allied Manufacturers' Association is to take over the entire British pavilion at the 1966 Rand Easter Show which is to be held at the Milner Park Show Grounds in Johannesburg from March 29th to April 11th. A special feature will be a display showing British contributions to the many branches of electrical engineering including telecommunications, automation and industrial applications. In 1964, British exports of electrical equipment to South Africa amounted to £24 million of which £8 million was for radio, electronic and telecommunication apparatus.

Semiconductor Terms and Definitions.—"Supplement No. 2, Semiconductors and Semiconductor Devices," has been made to the British Standard publication, "Glossary of Terms used in Telecommunication (including Radio) and Electronics." The supplement is a 19 page publication listing semiconductor terms and definitions. Price 5s; Supplement No. 2(1965) to British Standard 204: 1960; British Standards Institution, 2 Park St., London, W.1.

Specialist Course on Transistors.—A five-day course entitled "Transistors: principles and circuit techniques," is to be held at the Bournemouth College of Technology from February 28th to March 4th and is intended for students whose minimum qualification is H.N.C. The course costs 6 gn and further details can be obtained from the college.

A new **University Science and Technology Board** under the chairmanship of Professor Sir Ewart Jones, F.R.S., has been set up by the Science Research Council to advise on the support which the Council should give to science and technology in the universities. The board, which replaces the Research Grants Committee and the Postgraduate Training Awards Committee of the D.S.I.R., will work in close touch with other research councils and the Ministry of Technology.

B.B.C. Scholarships Awards.—To selected honours graduates, the B.B.C. awards annual scholarships which provide the opportunity to work for a higher degree, the post graduate study subject being within those fields of physics or engineering that have an application to television or sound broadcasting. The 1965 scholarships, each for three years, have been awarded to E. Trickett and J. Clarke. Mr. Trickett is to undertake research at Durham University on "The electric charges and masses of raindrops as measured at the ground and above the ground level." Mr. Clarke is to do research at Birmingham University on "The study of sporadic E in the atmosphere using aperture synthesis."

Semiconductor Light Sources and High Impedance Thermo-electric Devices is the title of a series of 9 weekly evening lectures to be given by specialists from industry. The fee for the lectures, which start on February 2nd, is £2 10s. Further details are available from Department of Electrical Engineering, Southall College of Technology, Beaconsfield Road, Southall, Middlesex.

A new film **Electronic Computers and Applied Mathematics** is available from the Central Office of Information. Made in America, the 3-reel film runs for 24 minutes and is an introduction to the application and operation of digital computers. Methods of data infeed, storage, programming and coding are explained in outline. The film can be hired (15s for one day) from C.O.I. Central Film Library, Government Building, Bromyard Avenue, Acton, London, W.3.

"WIRELESS WORLD" INDEX

The Index to Volume 71 (1965) is now available price 1s (postage 3d). Cloth binding cases with index cost 9s 6d, including postage and packing. Our publishers will undertake the binding of readers' issues, the cost being 35s per volume including binding case, index and return postage. Copies should be sent to Associated Iliffe Press Ltd., Binding Department, c/o 4 Iliffe Yard, London, S.E.17, with a note of the sender's name and address. A separate note, confirming despatch, together with remittance should be sent to the Publishing Department, Dorset House, Stamford Street, London, S.E.1.

From School to Computer.—Students straight from school are having the opportunity to take a full-time degree course in a subject hitherto generally considered as a post-graduate study—computing science. The course is being held at Staffordshire College of Technology and the syllabus, drafted in close liaison with English Electric Leo Marconi Computers, has been officially approved by the Council for National Academic Awards. For the time being all students applying for the course must have mathematics at "A" level but the College policy is to dispense with this requirement as early as possible, the College attitude being that although success in mathematics often indicates an aptitude for computing it has been found that other students unsuccessful in mathematics are equally suitable.

The **tracking down of licence dodgers** by Post Office detector cars has been proving very successful. For the year ended 31st March last year, the number of successful prosecutions was 22,000. Nine detector cars, each fitted with over £1,000 of equipment, have been in use since January 1963 and due to their success the number is to be doubled as soon as possible.

Abbreviations Ancient and Modern.—R. D. A. Maurice, a B.B.C. Research Department man who has been deeply involved in colour television development and the ensuing systems battle, added the initials "N.T.S.C." to the greetings on his Christmas cards to all his French friends this season. The new meaning for the old abbreviation, Dr. Maurice explained, was "Noel Toujours Sans Couleurs". (Another version, also somewhat cynical, is "Never Twice the Same Colour".)

A course of six lectures, **"Reliability Engineering for Electronic Systems,"** will be held at the Borough Polytechnic successive Tuesday evenings beginning February 8th. The course is intended for engineers of degree or H.N.C. standard in electrical engineering. The fee is £1 15s. Further details are available from the Borough Polytechnic, Borough Road, London, S.E.1.

Old "Sparks" Reunion.—The Royal Flying Corps Wireless Operators Old Comrades Association is to hold its annual reunion dinner on March 26th. Details can be obtained from the Secretary, E. J. F. C. Hogg, M.B.E., 57 Hendham Road, London, S.W.17.

Readers in the Penarth area of Glamorgan may be interested to learn of the recently formed **St. Cyres Electronics Group** which is holding weekly meetings on Fridays at the County Secondary School, St. Cyres Road, Penarth. A series of seven Mullard film meetings began on January 14th.

PERSONALITIES

F. C. Wright, C.B.E., F.C.G.I., M.I.E.E., who has been appointed deputy chairman of Standard Telephones & Cables, joined the company as a student graduate in 1925. Although initially and primarily a telephone engineer, he was from 1945 until 1956 in charge of the transmission laboratory, where he was responsible for considerable development work in the field of microwave transmission and also submarine cable repeaters. In 1956 Mr. Wright became assistant managing director and managing director from 1958 to 1961 when he was appointed vice-president of I.T.T., Europe. He is

F. C. Wright

also a director of several companies in the S.T.C. group including Standard Telecommunication Laboratories Ltd. and Kolster Brandes Ltd.

R. H. Hacker, M.B.E., managing director of Hacker Radio Ltd., has been elected chairman of the Radio Trades Examination Board in succession to **E. A. W. Spreadbury,** who has served for the past four years. Mr. Hacker, with his brother (A. G.) formed Hacker Radio in 1960. The previous year they resigned from the joint managing directorship of Dynatron Radio, which has been a wholly owned subsidiary of E. K. Cole Ltd. (Ekco) since 1955. Dynatron Radio was founded in 1927 as H. Hacker & Sons. Mr. Spreadbury is technical editor of our associate journal *Electrical & Electronic Trader.*

Robert Telford, M.A.(Cantab.), M.I.E.E., who was recently appointed managing director of the Marconi Company, has been elected to the board of directors of the subsidiary company Marconi Instruments Ltd. Mr. Telford, who joined Marconi's in 1937, is chairman of the Electronic Engineering Association.

W. Philip Rowley, M.B.E., M.I.E.R.E., manager of the telecommunications division of Ultra Electronics group of companies for the past two years, has joined

W. P. Rowley

the radio division of Standard Telephones & Cables as marketing manager (communications). Prior to joining Ultra he was formerly assistant managing director of W. S. Electronics which became part of the Ultra telecommunications division. During the war Mr. Rowley was commissioned in the Royal Corps of Signals and was at one time Staff Officer (Radio) at Supreme Headquarters, Allied Expeditionary Force. S.T.C. have also announced the appointment of **Clifford E. Harris,** M.I.E.E., as technical manager (communications) in the radio division. He was previously chief engineer of Plessey's Ilford development unit, having begun his career with the Marconi company.

C. E. Harris

R. F. Champion, A.M.I.E.R.E., who, as announced in last month's issue, recently became marine products manager of Redifon, has been appointed assistant manager of the Communications Division.

A. G. Manson, a senior member of the engineering staff in the Plessey Components Group's Resistor Division, has been appointed to the technical executive committee of the Committee of European Associations of Manufacturers of Passive Electronic Components (C.E.P.E.C.). Mr. Manson joined Plessey in 1951 as a development assistant in the Resistor Development Laboratory and since 1955 has represented the company's resistor interests in the R.E.C.M.F., and is chairman of the Federation's reliability sub-committee. Mr. Manson is also one of the U.K. representatives to the International Electrotechnical Commission serving on its technical committee for capacitors and resistors.

A. G. Manson

In succession to **H. G. Anstey,** A.M.I.E.E., A.M.I.E.R.E., who recently became head of engineering in the B.B.C. North Region, **D. M. B. Grubb** has been appointed assistant superintendent engineer, television engineering operations. Mr. Grubb joined the B.B.C. in 1938 and latterly has been projects engineer, with responsibility for the engineering planning of future television developments. **G. Salter,** who succeeds Mr. Grubb as projects engineer, joined the B.B.C. in 1943. For the past year he has held the post of assistant superintendent engineer, television recording, to which **T. B. McCrirrick,** A.M.I.E.E., M.I.E.R.E., has been appointed. Mr. McCrirrick joined the B.B.C. in 1943 and since 1963 has been engineer-in-charge, television studios, London.

The first resident engineer at the new short-wave transmitting station now under construction on Ascension Island for the B.B.C. External Services, is **J. M. Rowe** who joined the Corporation in 1943. Since 1962 he has been with the external services unit of the Planning and Installation Department.

Group Captain C. Stephen Betts, C.B.E., M.A., who commanded R.A.F. Fylingdales, the Ballistic Missile Early Warning Station in Yorkshire, from 1963 until last year when he took a course at the Imperial Defence College, has taken over command of No. 1 Radio School, R.A.F. Locking, Somerset, and become Air Commodore. After graduating at Sidney Sussex College, Cambridge, Air Commodore Betts, who is 46, joined the R.A.F. Technical Branch in 1941 and during the War served with Coastal Command on signals duties. In 1952 he became Command Signals Officer, Air Headquarters, Iraq, later taking the advanced guided weapons course at the R.A.F. Technical College, Henlow, Beds. For three years from 1955 he was attached to the Guided Weapons Dept., at R.A.E. Farnborough, and was later chief instructor commanding the Weapons System Wing at Henlow.

David J. Whittle, M.A., A.M.I.E.E., who is 37 and a graduate of Queens' College, Cambridge, has joined Southern Independent Television as chief engineer. After graduating he went to the Marconi Company where he was initially involved in the design of experimental telerecording systems. In 1956 he joined Alpha T.V. Services (Birmingham), which runs studios for A.T.V. and A.B.C. in the Midlands, eventually

D. J. Whittle

becoming chief engineer. For a year from June 1964 he was director of engineering with Tolvision Ltd., one of the four companies which withdrew from the G.P.O. pilot scheme for subscription television. For the past few months he has been a consultant.

J. R. Sandison has been appointed resident engineer of the B.B.C. Far Eastern Station at Tebrau, Malaya, to succeed **R. J. Keir,** O.B.E., B.Sc. (Hons.), M.I.E.E., who completes his tour of duty at the end of March, and returns to his previous post of engineer-in-charge of the short-wave transmitting station at Skelton, Cumberland. Mr. Sandison joined the B.B.C. in 1938. Since 1963 he has been with the Planning and Installation Department and is at present the senior site engineer on Ascension Island.

M. V. Richings, Assoc.I.E.E., A.M.I.E.R.E., who has been with Dawe Instruments since the company was formed in 1945, originally as chief development engineer and for the last eight years as chief engineer is also appointed product manager. He will have overall responsibility for the co-ordination and operation of the four product divisions; power ultrasonics, non-destructive testing, instruments and industrial. Mr. Richings, who contributed an article to the January 1964 *Wireless World* on "Acoustic noise measurement and analysis," serves on the International Electrotechnical Commission's committee (29) concerned with electroacoustics.

D. A. Barnes, A.M.I.E.E., A.M.I.E.R.E., divisional manager of APT Electronics Industries, has joined S.T.C. as product manager covering high-stability d.c. power supplies in the company's rectifier division. Prior to going to APT Mr. Barnes was general manager of Roband Electronics.

D. A. Barnes

NEW YEAR HONOURS

There were but few radio and electronics engineers among the recipients of New Year Honours conferred by H.M. The Queen, they included:—

C.B.E.

M. R. Gavin, M.B.E., M.A., D.Sc., M.I.E.E., M.I.E.R.E., professor of electronic engineering, University College of North Wales until his recent appointment as principal of Chelsea College of Science and Technology.

O.B.E.

W. N. Anderson, A.M.I.E.E., head of telecommunications and experimental group, I.T.A.

R. F. Brown, chairman and managing director, Racal Electronics Ltd.

C. W. Earp, chief engineer, radio division of Standard Telephones & Cables.

M. A. Frost, head of B.B.C. transcription service.

K. D. U. Rogers, operations controller, Associated Television.

L. F. Scantlebury, Wh.Sch., A.C.G.I., D.I.C., A.M.I.E.E., staff engineer, G.P.O.

E. G. A. Williams, engineer, Guided Weapons & Electronic Production Div., Ministry of Aviation.

M.B.E.

F. Ahl, lately communications officer, Ministry of Aviation Radio Station, Gloucestershire

W. D. Hatcher, B.Sc.(Eng.), A.M.I.E.R.E., senior assistant, B.B.C. television maintenance co-ordination.

R. W. Hobbah, senior engineer, Cable & Wireless, concerned with installation work at Suva and Jesselton on the commonwealth cable.

S. Pitham, senior executive engineer, Post Office radio station, Goonhilly.

G. P. Sudell, deputy controller, Ministry of Defence (Army), Telecommunications Group, Berlin.

A. G. Wilson, senior scientific assistant, Radio & Space Research Station, Science Research Council, Slough.

B.E.M.

J. C. Goodrum, radio officer, P.L.A. Thames Navigation Service.

Dr. M. R. Gavin (C.B.E.)

R. F. Brown (O.B.E.)

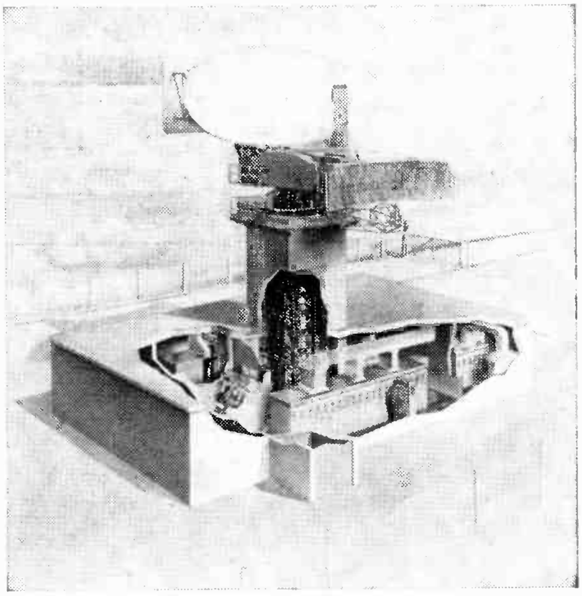
C. W. Earp (O.B.E.)

NEWS FROM INDUSTRY

£100 MILLION EXPORT ORDER

THE biggest single export order in the history of this country for the supply of its own equipment has been obtained from the Government of Saudi Arabia. Worth over £100M, the order, for a complete air defence system, has been placed with a consortium of firms including the British Aircraft Corporation, Associated Electrical Industries Ltd., and Airwork Services Ltd.

Approximately £25M of the order is for the supply of a ground environment radar defence system together with data handling and communications equipment. A.E.I. Electronics, working in conjunction with the Royal Radar Establishment, Great Malvern, have developed the radar system—designated Type 40. Incidentally, this is similar to the equipment being offered in the A.E.I. proposals as part of the I.T.T. consortium bid for the £110M N.A.T.O. "Nadge" integrated air defence contract. Claimed to be the most advanced surveillance and tactical control radar in the world, Type 40 is also suitable for civil air traffic control purposes and provides instantaneous 3-dimensional positional information on all aircraft within the coverage of the radar. Radar information is processed by microelectronic data handling computers. Some of the electronic units are duplicated and are included in a continuous, automatic testing system which in event of failure not only gives instantaneous indication of the fault but also automatically switches a standby unit in circuit.



The American firm of Raytheon will supply the Hawk surface-to-air anti-aircraft missile together with communications equipment; this will bring the total value of the order to within the region of £125M.

I.L.S. AT LONDON AIRPORT UPGRADED

THE instrument landing system on runway 10 L at London Airport (Heathrow) has been cleared by the Ministry of Aviation to Category II standards to allow suitably equipped aircraft to land in visibility minima previously defined as unsuitable—namely visual range down to a quarter of a mile and cloudbase down to 100ft. To date, however, no civil airliner has Ministry of Aviation approval to land under these conditions, but the upgrading will allow experimental aircraft to evaluate all-weather landing systems such as the Autoland system developed by the Royal Aircraft Establishment's Blind Landing Experimental Unit at Bedford.

Current minimum visibility and cloudbase conditions for civil flying (Category I) are half a mile and 200ft respectively. These regulations are laid down by the International Civil Aviation Organization.

The ground equipment, to which this upgrading applies, is manufactured by Standard Telephones and Cables Ltd. Identical equipment, designated STAN 7/8, has been adopted as standard for all major airports in the United Kingdom, and is in use at 21 international airports overseas.

Many thousands of fully automatic landings have been made by BLEU in recent years, including some at Heathrow. The first Autoflare landing on a scheduled passenger carrying flight—fully automatic up to the point of "flame-out" just short of the runway—was made by a B.E.A. Trident on 10th June last year. Since then many Tridents have made similar landings in fine weather.

$25M Canadian Colour TV Tube Plant.—R.C.A. Victor Company, Ltd., the Canadian subsidiary company of the Radio Corporation of America, is to build a $25M factory to manufacture colour television tubes in Ontario. It is scheduled to be completed in about eighteen-months time and have an annual output of at least 300,000. More than 1,500,000 Canadian homes are within viewing range of the U.S. border stations, and in October Canadian television stations will begin using colour.

Two-year TV Picture Tube Guarantee.—At the turn of the year several manufacturers announced that their picture tube guarantees had been increased from twelve months to two years. Among the names are Thorn-A.E.I. Radio Valves & Tubes Ltd., who make Mazda and Brimar c.r.ts; Mullard Ltd.; and Cathodeon Electronic Ltd.—a member of the Pye group of companies. Each of the manufacturers state that their guarantees also apply to tubes registered (by guarantee) during 1965. The length of guarantee was increased from six months to one year in 1959.

Cossor Electronics and **Ferranti** have both received contracts for equipment for the McDonnell Phantom F4M aircraft on order for the Royal Air Force. Cossor's order, worth about £175,000, is for transponders, Ferranti's is for the inertial navigation and attack systems and is worth about £1.75M.

Racal Electronics Ltd. subsidiary company in Ottawa has received a contract worth over 1.6 million dollars from the Canadian Department of Defence Production. The contract calls for automatically-tuned, high-frequency, s.s.b. radio systems, identical to those already in service with the Royal Air Force. The majority of this equipment will be manufactured in the United Kingdom and the remainder will be made in North America under the guidance of Racal (Canada) Ltd.

Marconi Sixty Series airborne radio navigation and communications equipment is to be fitted to three Super VC-10 aircraft on order for East African Airways. Doppler navigators are included in the installations, which will form the primary en-route navigational system in the aircraft.

Anglo-Japanese Commercial Treaty.—The restrictions on Japanese radio and television receiver imports to this country were lifted on 1st January 1966.

The Livingston Group have vacated their headquarters at 31 Camden Road, London, N.W.1. All the Livingston companies are now on the Greycaines Estate, Bushey Mill Lane, North Watford, Herts. (Tel.: Watford 44344.)

Heathkit.—Demonstration facilities are provided at Daystrom's new London showroom, at 233 Tottenham Court Road, W.1. (MUSeum 7349.) A sound-proofed listening room is being constructed.

FROM RUSSIA WITH LOVE

– NIR Alias SECAM-4 Alias SEQUAM

A POLITICAL COMPROMISE COLOUR TELEVISION SYSTEM?

PARKINSON maintained that work expands to fill the available time and this appears to be so of the development work on colour television systems, which is currently occupying many of the most inventive engineers in Europe. In the twelve years that have elapsed since the Federal Communications Commission in the U.S.A. adopted the N.T.S.C. system of colour television, using a compatible monochrome signal to which is added a quadrature-modulated subcarrier, many variations of this system have been proposed in Europe.

The SECAM System* eventually adopted frequency-modulation for the subcarrier, with the transmission of only one colouring signal on any particular scanning line. Such techniques necessitate the use of a delay-line and a commutating switch in the receiver to provide, at the same time, both the required colour-difference signals for the decoder.

The PAL System.—The use of a memory element with a storage time of one line-scanning interval, which is an essential part of the SECAM receiver, proved to be a very fruitful idea and has found a use, one way or another, in later systems: for example, in the Phase Alternation Line system of Dr. Bruch and in the Additional Reference Transmission (ART) system of Dr. Mayer. In the PAL system† the phase of the quadrature-modulated subcarrier is alternated on successive lines and this enables, among other things, phase errors to be corrected.

The ART System.—Dr. Mayer's ART system‡ provided a reference signal for decoding the quadrature-modulated subcarrier, by inserting a reference frequency across the whole of the active part of the line scanning period; this reference rode up and down on the luminance signal and provided an automatic correction for level-dependent distortion of the subcarrier.

The New SEQUAM System.—The International Radio Consultative Committee (C.C.I.R.), the O.I.R.T. (East European broadcasting authorities) and the European Broadcasting Union have been discussing and endeavouring to co-ordinate the work in Europe on colour systems, but as readers will know, Europe is divided into two camps, one favouring PAL and one favouring SECAM. However, we understand that at the last meeting of the E.B.U. in Rome, details of a new Russian system, which might be described as a compromise solution, were talked about by members of the French delegation. The subject of the new system was not raised officially in any of the formal discussions. This new system, known as NIR in the U.S.S.R., has been called SECAM 4 by the French, but since it uses a quadrature-modulated subcarrier on alternate lines, it has been unofficially christened SEQUAM. Following the Rome meeting, the B.B.C. announced that one of their engineers, Mr. B. W. B. Pethers, had put forward a proposal for a similar system in April 1963 (see page 75).

*See "Receiving SECAM," by M. Cox. *Wireless World*, September 1963, p.432.
†"PAL," by M. Cox. *Wireless World*, December 1963, p. 584.
‡"ART: a new colour system," *Wireless World*, June 1964, p. 307.

Although no official statements about the Russian system have been published we have gathered together the following notes from engineers who are at present studying it.

Transmitted Signals.—It is believed that the Russian proposals include transmitting on alternate lines of any one field (Fig. 1) a substantially normal N.T.S.C. signal (Fig. 2). However, the amplitude of the subcarrier is the square root of the N.T.S.C. subcarrier; for example, the subcarrier signal on these lines can be written as

$$\sqrt{s}.\cos(\omega t + \phi)$$

where s would be equal to

$$\sqrt{I^2 + Q^2}$$

or, since the Russians use the red and blue colour-difference axes,

$$\sqrt{\left(\frac{R'-Y'}{1.14}\right)^2 + \left(\frac{B'-Y'}{2.03}\right)^2}$$

($\omega = 2\pi f_{subcarrier}$, t = time, ϕ = phase angle indicating phase modulation, R' and B' = gamma-corrected voltages corresponding to red and blue camera signals, Y' = gamma-corrected luminance voltage, I and Q = alternatives to R′—Y′ and B′—Y′ axes shown in Fig. 2).

The SEQUAM signal, therefore, carries the hue information by means of the phase modulation (ϕ), and informa-

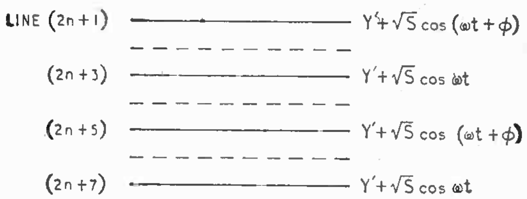


Fig. 1. The signals transmitted on alternate lines of any one field (full line) are the luminance signal plus either a phase-and-amplitude modulated subcarrier or an amplitude modulated subcarrier of constant phase. (Broken lines indicate subsequent interlaced field.)

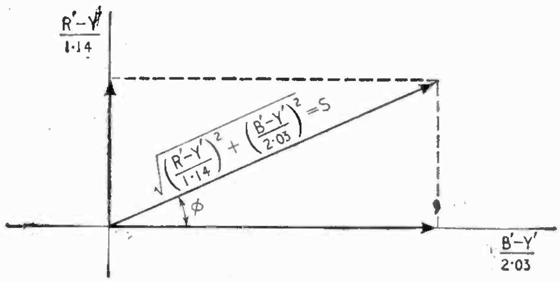


Fig. 2. Reminder of how the N.T.S.C. chrominance signal is formed by amplitude modulation of a pair of suppressed subcarriers of common frequency in quadrature by two video voltages derived from the R′–Y′ and B′–Y′ signals.

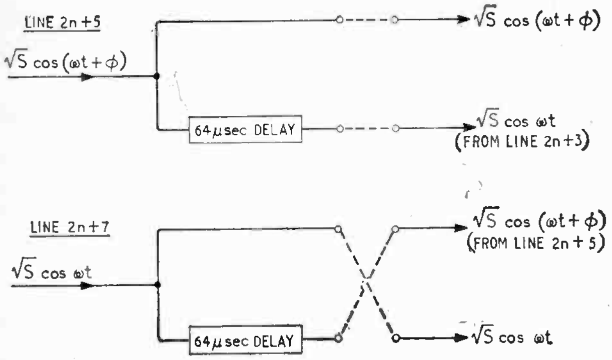


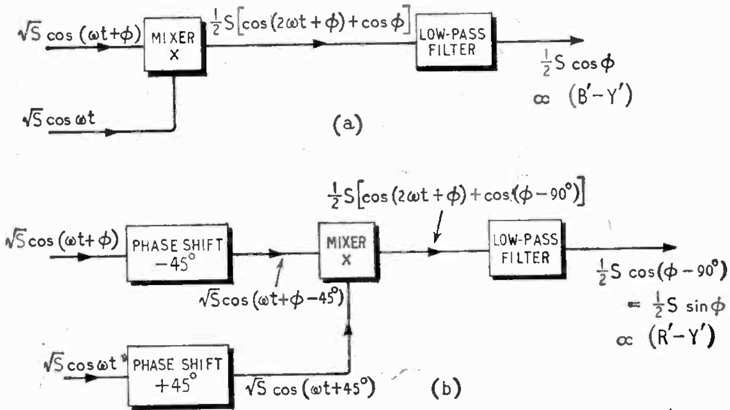
Fig. 3. In the receiver a delay line, of the accuracy required for PAL receivers, is used with a commutating switch which changes over during the line blanking interval, to provide both the phase-modulated subcarrier and the constant-phase signal simultaneously to the colour demodulators.

tion about the saturation is conveyed by the ratio of the square of the subcarrier amplitude to the luminance signal amplitude.

The other lines of that field contain a subcarrier signal which has no phase modulation; that is to say, it is transmitted with a constant-reference-phase which could be, for example, the phase of the $\frac{B'-Y'}{2.03}$ axis shown in Fig. 2. However, the amplitude of this constant-phase-reference signal is modulated by $\sqrt{s}$, as for the phase-modulated signal:

$$\sqrt{s}.\cos \omega t$$

The transmitted signal, then, uses an N.T.S.C.-type subcarrier which is sequentially transmitted although not in the same manner as in SECAM, and an ART-type reference signal across the whole width of the picture, although the amplitude of the reference signal is normally larger than it is in the ART system.



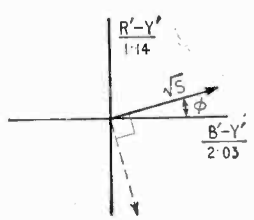


Fig. 4 (a). Two mixer-type synchronous demodulators in the receiver multiply the two subcarrier signals; a low-pass filter then rejects the 2ωt term to give a signal proportional to B′−Y′ (b). To obtain the red difference signal, the multiplying process is repeated on the incoming signals after they have been phase shifted by −45° for the phase modulated signal and +45° for the constant-phase reference.

The SEQUAM Receiver.—In the receiver a delay line of the PAL type, together with a commutating switch of the SECAM type, provide both $\sqrt{s}.\cos(\omega t+\phi)$ and $\sqrt{s}.\cos\ \omega t$, simultaneously for each line (see Fig. 3). The signals are decoded by multiplying them together, as in mixer-type synchronous demodulators (Fig. 4). Direct multiplication of the signals, as shown in Fig. 4(a), gives the product:

$$\tfrac{1}{2}\, s[\cos(2\ \omega t+\phi) + \cos \phi]$$

A low-pass filter is used to reject the high frequency $2\omega t$ term, leaving a signal:

$$\tfrac{1}{2}\, s \cos \phi$$

that is to say, apart from the amplification factor, it gives the $(B'-Y')$ signal.

A second mixer-type demodulator, Fig. 4(b), is used to multiply again the two signals, but only after one has been phase shifted by −45° and the other by +45°. The result of this multiplication is a signal which is

$$\tfrac{1}{2}\, s[\cos(2\ \omega t+\phi) + \cos(\phi-90°)]$$

equal to

$$\tfrac{1}{2}\, s.\sin \phi$$

or, neglecting the amplification factor, $(R'-Y')$.

It will be seen that the receiver does not need a reference generator although it uses N.T.S.C.-type synchronous demodulators.

Technical Advantages of SEQUAM.—The advantages and disadvantages of this system compared with either N.T.S.C., PAL or SECAM are not yet clear to us. It should have immunity to both linear and level-dependent phase-distortion but not to level-dependent amplitude-distortion. The compatibility will probably be worse than with N.T.S.C. since the square root of s is larger than s for the range of subcarrier signals involved, that is to say, for s between 0 and 0.63. It will not have all the advantages of SECAM for tape-recording. Also, it is not yet clear whether the noise performance will be significantly different from that of SECAM IIIa.

The combined luminance-plus-chrominance signal for yellow and cyan colour-bars will be greater than in N.T.S.C. and this will limit the depth of modulation of the transmitter. At the same time there will be some form of correlation between the noise on successive field lines which may make the noise more visible, but there is argument among the experts as to the exact effect of the multiplying process on the subjective appearance of the noise.

The signal will not have as much immunity as the PAL signal to attenuation of the upper sideband of the subcarrier, which probably does not matter for the Russian and French standards but might worry those European countries using standard G, i.e. those countries with a close subcarrier-sound carrier spacing of about 1 Mc/s.

Political Advantages.—Experimental work is now being done on the system—notably by the B.B.C. and ABC Television in Britain—and a more detailed appraisal can be expected in the next few months. The political advantages of the system should, however, be considered as well. It could be that such a system, which combines features which have been invented by several different European countries, would enable all European nations to agree on a common system without loss of national dignity.

B.B.C. MAN ANTICIPATES RUSSIAN COLOUR TV SYSTEM?

REPRODUCTION OF ENGINEER'S 1963 REPORT

"21-4-63 **B. W. B. PETHERS**

A further alternative colour television signal encoding/decoding system

This paper describes in three versions, a colour television system having the following basic characteristics:—

(1) Insensitivity to errors in absolute or differential phase existing over a spatial (per field) or temporal interval of two lines.

(2) Simple decoding equipment—no subcarrier regeneration—no electronic switching—no line or field identification circuitry.

(3) Subcarrier locked to line pulses and therefore producing stationary patterning, also permitting the mixing of two encoded signals. As hue information is carried by subcarrier phase the resultant hues obtained in such a mix would be similar to those obtained in an optical mix.

(4) Saturation information is carried by subcarrier amplitude allowing of simultaneous fading of picture luminance and saturation. Also subcarrier amplitude goes to zero in scene " whites."

(5) In versions 1 and 2 the transmitted subcarrier amplitude bears a much more linear relationship to scene saturation than does that in present practice N.T.S.C., theoretically permitting of a better signal/noise ratio (e.g. less " cross colour ") or lower levels of transmitted subcarrier.

(6) Vertical chrominance resolution is approximately halved in version 1, unimpaired in version 3, whilst only the saturation resolution is halved in version 2, all with respect to vertical luminance resolution.

Horizontal chrominance resolution—all three versions can be operated with unequal bandwidth colour difference axes giving a higher effective colour-resolution than SECAM.

Version 1

During lines 1, 3, 5, etc. of a field the transmitted signal, E_M, has the form:—

$$E_M(1,3,5 \text{ etc.}) = E'_Y(1,3,5 \text{ etc.}) + k\sqrt{c}\,(1,3,5 \text{ etc.}) \cos(\omega_{st} + p)$$

whilst during lines 2,4,6 etc.:—

$$E_M(2,4,6 \text{ etc.}) = E'_Y(2,4,6 \text{ etc.}) + k\sqrt{c}\,(2,4,6 \text{ etc.}) \cos(\omega_{st} + p + h(2,4,6 \text{ etc.}))$$

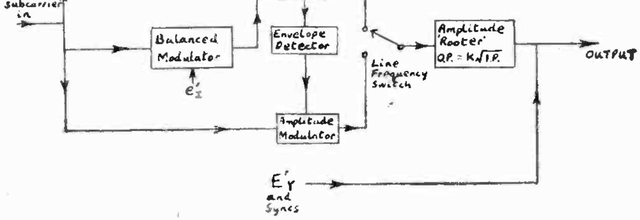


Fig. 1. Version 1 encoder.

The B.B.C. Explains

Authoritative information on the details of the new system of colour television originating in the U.S.S.R. is not available but sufficient is known in principle to enable the basic proposal to be understood; what appears to be the same or very similar system was proposed by a B.B.C. engineer, Mr. B. W. B. Pethers, in April 1963. At that time, an intensive study was taking place of the characteristics of the three colour television systems, N.T.S.C., SECAM and PAL, and the proposal for the new system was not pursued because it was thought at that time that its advantages with respect to the other system were not, on the surface, sufficiently strong as to justify the production of yet another system in an already complicated situation. However, as this system of colour television is now being considered internationally, it may be of interest to see the details of the system (and of two more systems which are suggested developments of it) as proposed in 1963.

In the text printed here the inventor's hand-written papers are copied word for word, as are the block diagrams associated with the systems.

S. N. WATSON.

B.B.C. Designs Department.

where $E'_Y = \cdot 3E_R^{1/\gamma} + \cdot 59E_G^{1/\gamma} + \cdot 11E_B^{1/\gamma}$,

k is the chrominance/luminance transmission factor,

c = instantaneous chrominance amplitude $= \sqrt{e'^2_I + k_2 e'^2_Q}$

ω_s = angular velocity of subcarrier

p = subcarrier phase at $t = 0$

and h = instantaneous hue angle $= \tan^{-1} \dfrac{e'_Q}{e'_I}$

This encoding is achieved with the basic encoding equipment of Fig. 1.

In the decoder the chrominance signal, $E_M(n) - E'_Y(n)$ where n is the temporal line number, feeds (a) a 64μs delay line and (b) two synchronous detectors operated in quadrature, i.e.: one of the detectors has a 90° phase shift networks in one of its inputs. These inputs:—

$$k\sqrt{c(n)} \cos\left[\omega_{st} + p + \begin{matrix} 0 \\ \text{or} \\ h(n) \end{matrix}\right] \text{and}$$

$$k\sqrt{(cn)} \sin\left[\omega_{st} + p + \begin{matrix} 0 \\ \text{or} \\ h(n) \end{matrix}\right]$$

are multiplied by the output of the 64μs delay line:—

$$k\sqrt{c(n-1)} \cos\left[\omega_{st} + p + \begin{matrix} h(n-1) \\ \text{or} \\ 0 \end{matrix}\right]$$

to give low frequency product components:—

$$k^2\sqrt{c(n)}\sqrt{c(n-1)} \cos \begin{matrix} h(n) \\ \text{or} \\ h(n-1) \end{matrix} = \underline{k^2 e'_I}$$

and

$$k^2\sqrt{c(n)}\ \sqrt{c(n-1)} \sin \begin{matrix} h(n) \\ \text{or} \\ h(n-1) \end{matrix} = \underline{k^2 e'_Q}$$

It will be seen that the chrominance amplitude com-

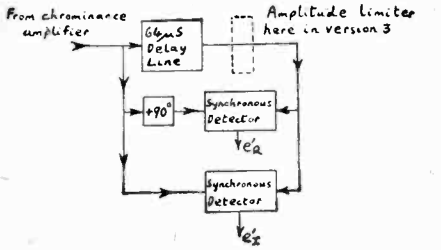


Fig. 2. Basic decoder

ponent $\sqrt{c(n)}$ is reproduced on lines (n) and $(n+1)$ and the hue information $h(n)$ is also reproduced over these two lines resulting in the aforementioned halving of vertical chrominance resolution.

The basic decoding equipment is shown in Fig. 2.

Version 2

During line (n) the transmitted signal, E_M has the form:—

$$E_M(n) = E'_Y(n) + k\sqrt{c(n)} \cos [\omega_{st} + P(n-1) + h(n)]$$

where E'_Y, k, c, ω_s and h have the same significance as in version 1 whilst $P(n-1)$ = transmitted subcarrier phase during the previous line. This encoding is achieved with the basic encoding equipment of Fig. 3.

The decoder has the same form as that used in version 1 i.e., Fig. 2.

The quadrature synchronous detector inputs:—

$$k\sqrt{c(n)} \cos [\omega_{st} + P(n-1) + h(n)]$$

and

$$k\sqrt{c(n)} \sin [\omega_{st} + P(n-1) + h(n)]$$

are multiplied by the output of the 64μs delay line:—

$k\sqrt{c(n-1)} \cos [\omega_{st} + P(n-1)]$ to give low frequency product components

$$k^2\sqrt{c(n)}\sqrt{c(n-1)} \cos h(n) = \underline{k^2 e'_I}$$

and

$$k^2\sqrt{c(n)}\sqrt{c(n-1)} \sin h(n) = \underline{k^2 e'_Q}$$

Here it will be seen that although the chrominance amplitude component $c(n)$ is reproduced over lines (n) and $(n+1)$ thus halving the vertical saturation resolution each line carries fresh hue information and thus there is no reduction of vertical hue resolution.

Version 3

During line (n) the transmitted signal has the form:—

$$E_M(n) = E'_Y(n) + kc(n) \cos [\omega_{st} + P(n-1) + h(n)]$$

where all the symbols have the same significance as in version 2. The encoding equipment is as per Fig. 3 but minus the amplitude "rooter."

The decoder has the same form as that used in versions 1 and 2 with the inclusion of an amplitude limiter in the 64μs delay path.

The quadrature synchronous detector inputs:—

$$kc(n) \cos [\omega_{st} + P(n-1) + h(n)]$$

and

$$kc(n) \sin [\omega_{st} + P(n-1) + h(n)]$$

are multiplied by the *limited* output of the 64μs delay line:—

$\cos [\omega_{st} + P(n-1)]$ to give low frequency components:—

$$kc(n) \cos h(n) = \underline{ke'_I}$$

and

$$kc(n) \sin h(n) = \underline{ke'_Q}$$

Here not only does each line carry fresh hue information but the chrominance amplitude component (n) is reproduced on line (n) only resulting in full vertical chrominance resolution. This version, however, has an inferior signal/noise ratio to versions 1 and 2 due to the signal/noise ratio worsening effect of the limiter and the fact that chrominance amplitude and not saturation is coded linearly as subcarrier amplitude.

Modifications to the basic system

It would obviously be impractical to expect the decoder and encoder (versions 2 and 3) loop delays to remain equal to 64μs to within 5° of subcarrier (3ns) at all ambient temperatures and degrees of component ageing. It is therefore necessary to provide automatic sampling and correction of the loop delay times. In the case of the decoder this provides automatic hue control.

The delay error can be divided into two components:—an error of one or more whole cycles of subcarrier and a phase error within the correct cycle. The former will be decoded as registration errors whilst the latter will be decoded as a constant hue error throughout the picture.

If it can be assumed that the uncorrected error can be restricted to less than 180° of subcarrier (110ns) then the residual phase error can be corrected, once per line, as follows:—

(1) The encoder loop is broken by a unidirectional device of high phase stability, e.g., a kathode follower.

(2) A burst of subcarrier timed to coincide with the "back porch" is injected at the output of the kathode follower.

(3) A synchronous detector compares the injected burst phase with that arriving at the input of the kathode follower after traversing the loop (the input burst is prevented from reaching the output of the kathode follower by cutting off the kathode follower with a correctly timed inhibiting pulse).

(4) The filtered synchronous detector output controls a phase shift section in the loop.

In the decoder the output of the quadrature signal synchronous detector is sampled during the back porch and here again the filtered samples are used to control a phase shift section in the decoder delay line.

If either of the delay units cannot be maintained to within the 110ns tolerance then a two-mode control must be used the coarse control being, for example, a bistable circuit switched negative by the leading edge of the envelope of the delayed burst and switched positive by

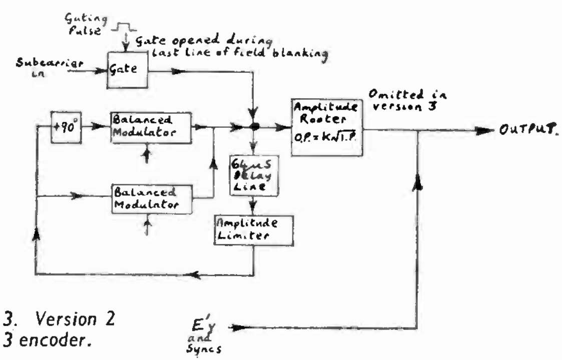


Fig. 3. Version 2 and 3 encoder.

the leading edge of the envelope of the undelayed burst. The resulting pulse will have a sense and duration proportional to the delay error and can, after integration, also be used to control the phase shift section.

What is Holding Back the F.E.T.?

A PRACTISING CIRCUIT ENGINEER TAKES AN INQUIRING LOOK AT THE FIELD EFFECT TRANSISTOR

By J. B. FRANKLIN

IF you are in electronics, the chances are you have heard of the field effect transistor (usually abbreviated to f.e.t.) because the technical press has given it no little attention over the last two years.* You probably know that it is a special kind of semiconductor amplifying device with the high input resistance of a thermionic valve in contrast to the low resistance of an "ordinary" transistor. The f.e.t. was little more than an interesting curiosity of semiconductor physics for a decade, until in 1964 it suddenly seemed to catch the fancy of the circuit man. And now, in 1966 some thirty companies (five of them in the United Kingdom) have moved hopefully into the business of manufacturing f.e.ts. In the outcome, the existence of some three hundred different f.e.t. type numbers at the time of writing would seem to suggest that before long the f.e.t. will come into wide-scale use. It seems, therefore, that the forward-looking engineer should now be mastering this "new" device, which some people confidently predict will soon take the place of the "old" valve and transistor.

But what is happening outside the manufacturers' walls? What is the user doing? To try to find this out, I first acquired a working knowledge of f.e.t. circuit problems by making up a number of published circuits to get the feel of the device. I then set off on a one-man survey of my circle of amateur and professional engineering friends and acquaintances . . . with intriguing results. Out of fifty-one questioned, only three had not heard of the device. But, of the remaining forty-eight, only five could be said to have a working knowledge of f.e.t. characteristics, and only one had put together a circuit with actual devices . . . and this sole experimenter had done so at his employers' expense. I also failed to come across any commercial equipment incorporating f.e.ts; valves, yes; transistors, yes; but f.e.ts, no. Clearly the f.e.t. has not yet made a practical impact on users. What is holding it back?

Before we try to answer this question, let us first consider why some thoughtful engineers believe the f.e.t. is likely to supplant the transistor. In doing this, we shall confine ourselves to the device characteristics, as its physics have been examined at length in a number of articles recently.

Advantages claimed for F.E.T.

Looking back to the 1950s, we can see that the transistor superseded the valve as the general-purpose amplifier for three main practical reasons: it was more efficient (no heater), more compact (no large vacuum space), and it worked on low supply voltages. However, it had one characteristic which proved a disadvantage in some circuits. Its input looked like a forward-biased semiconductor diode with an input resistance of between 50 and 5,000 ohms, whereas the valve input looked like a reverse-biased thermionic diode with a resistance reckoned in megohms. This transistor "defect" was critical only in very-high-impedance, low-level circuits; fortunately these "electrometer" applications tend to form only a small percentage of circuit requirements; however, they do exist, and until the f.e.t. arrived on the scene they had to be covered by valves.

The f.e.t. is also like the transistor in being heaterless, small and low-voltage, but its input looks like a reverse-biased semiconductor diode (or, in some versions, like an insulator). This gives it an input resistance which can be higher even than a thermionic valve. But this is not all. The f.e.t. designer claims that it is also better than the transistor because it shows better noise characteristics, it is more resistant to nuclear radiation, it is inherently less prone to thermal runaway, it exhibits a kind of non-linearity that can be exploited in automatic-gain-control applications, it has superior cross-modulation characteristics, it has zero "offset-voltage" (specially suited for chopper applications), its gain does not fall off materially at very low temperatures, and it is the only amplifier device that it has been possible, so far, to fabricate as an integral part of the structure of an integrated circuit. Further, the f.e.t. manufacturers suggest that the device has such valve-like characteristics that a valve-trained engineer feels immediately at home with it and can use all his acquired skills immediately in designing for f.e.ts. These are quite impressive claims and, on the face of it, it is difficult to see why the f.e.t. has not already completely ousted the transistor.

F.E.T. symbology and terminology

Before we go on to look into the matter more closely, we must know a little about f.e.t. symbols and characteristics. Regrettably, manufacturers' data sheets as yet show little sign of standardization of either of these. This may present a barrier to the wider use of f.e.ts now, but national bodies are already working to produce agreed common standards. For the purpose of this article, I shall

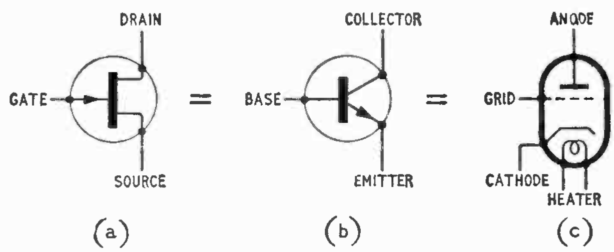


Fig. 1. Correspondence between electrodes of (a) f.e.t. (b) transistor, and (c) thermionic valve.

* See, for example, "Field-Effect Devices" by G. H. Olsen *Wireless World* June, 1965, and "The Field-effect Transistor at V.H.F." by U. L. Rohde, *W.W.* January, 1966.

use the fairly common terms and symbols I am accustomed to; these in no way anticipate any standardization committee recommendation.

As a form of solid-state semiconductor amplifier, the f.e.t. uses a circuit symbology derived from the transistor. Unfortunately, from the circuit diagram point of view, there are already *six* different basic kinds of f.e.ts, each in triode or tetrode form, calling in total for *twelve* different symbols. (And this does not take into account pentode versions already under development.) In Fig. 1, the symbol for one type of f.e.t., an " n-channel, junction-gate triode " is used to illustrate the relation between the electrodes of the f.e.t., the transistor and the valve. The f.e.t. electrode terminology is not undescriptive, as the input control electrode is known as the " gate " (usually denoted " G " and corresponding to the transistor base or the valve grid), and the output electrode as the " drain " (" D," corresponding to the transistor collector or the valve anode). The common electrode of the f.e.t. is the " source " (" S," corresponding to the transistor emitter or the valve cathode).

There are many ways of classifying f.e.ts. Device designers, by the nature of their approach, tend to look at the device in terms of such things as control gate fabrication, semiconductor polarity, semiconductor material, or manufacturing technique. When the circuit engineer starts using f.e.ts, on the other hand, he will find that the first thing he must know is whether the device he selects is a " depletion " or an " enhancement " type. This is because he cannot even begin to set up the d.c. bias on a stage using f.e.ts until he knows this. These new terms are related to the output (drain) standing current when the input (gate) is short-circuited to the common terminal (source). This current is denoted by I_{DSS}, i.e. the current as it flows between the drain and source (first two subscripts, D and S) with the remaining terminal, the gate, short-circuited to the common terminal (third subscript, S, now denotes " short-circuit "). In an enhancement-mode device there is no standing output current when the input is short-circuited, i.e. I_{DSS} is effectively zero. Such an f.e.t. has to be biased on for linear amplifier operation, like a transistor. In a depletion-mode f.e.t., on the other hand, a standing output current flows when the input is short-circuited, and the device has to be biased off, like a thermionic valve. This is illustrated in Fig. 2 using the symbols for " insulated-gate, n-channel " f.e.ts. This again brings us some new terms that require a word of explanation.

In the present state of the f.e.t. art, the control gate is isolated from the remainder of the device in one of two ways; either by a reverse-biased diode (when the device is known as " junction-gate ") or by a layer of insulation (" insulated-gate "). The insulated-gate f.e.t. also appears under other names, such as MOSFET (=Metal-Oxide-Semiconductor-Field-Effect-Transistor), or MOST (=Metal-Oxide-Semiconductor-Transistor). Because M.O.S. refers only to one particular technique for gate isolation which happens to exist at the moment, and other techniques may arise in future to which these initials might not be applicable, there is a growing tendency to standardize on the nomenclature IGFET (=Insulated-Gate-Field-Effect-Transistor) as the generic description for this class of device. I myself use IGFET by preference and have also coined my own phrase JUGFET (=Junction-Gate-Field-Effect-Transistor) to distinguish the junction-gate version. The circuit engineer will find that in many applications it does not matter to him whether the device he uses is a JUGFET or an IGFET; they are often interchangeable circuit-wise, so long as the two devices being compared are both of the same bias

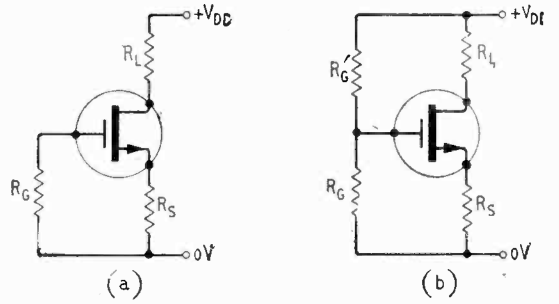


Fig. 2. Primary difference between depletion- and enhancement-mode insulated-gate f.e.ts illustrated in basic d.c. bias arrangements for linear amplifier operation: (a) depletion-mode unit biased off like valve; (b) enhancement-mode unit biased on like transistor

type, i.e. enhancement or depletion. At present, enhancement types can be obtained only in IGFET construction, but depletion types can be either JUGFET or IGFET.

Both JUGFETs and IGFETs are available in two polarities, " n-channel " or " p-channel," just as transistors can be " n-p-n " or " p-n-p." To the circuit engineer used to transistors or valves, this presents no real difficulty, as all he has to remember is that the n-channel f.e.t. works with a negative earth or " deck " (like a valve or *n*-p-n transistor), and the *p*-channel with a positive deck (like *p*-n-p transistor). If you check back to the specific example in Fig. 2, you can now recognize that it is an n-channel device by the lower (source) arrow pointing the same way as the emitter arrow of an n-p-n transistor. That it is an IGFET is shown by the gate terminal being completely separated in the drawing from the remainder of the device If it had been a JUGFET, the gate junction would have been indicated by a "diode" arrow making actual contact as in Fig 1. A useful rule to identify the polarity of any triode f.e.t. is to note that when any arrow points from left to right, the device is n-channel and vice versa.

F.E.T. characteristics

By now you may be feeling a little bewildered by these new terms, but I hope you will press on because this is one of the hurdles that any potential user of the f.e.t. must clear. It is all rather unfortunate, and I am sure that the mystique surrounding the f.e.t. in this way contributes not a little to its slow acceptance. The position is made no easier by the long list of parameters used in data sheets to specify the device. In practice, f.e.t. performance is mainly controlled by a few basic parameters and we shall confine our attention to these.

In a depletion f.e.t., the drain current, I_{DS}, is controlled by the gate-to-source voltage, V_{GS}. In normal operation (above a certain drain voltage), the drain current is given to a good approximation by $I_{DS} = I_{DSS}(1 - V_{GS}/V_P)^2$, where I_{DSS}, already mentioned earlier, is the drain current flowing when the gate is shorted to the source, V_{GS} is the gate-to-source voltage, and V_P is the " pinch-off " voltage. The pinch-off voltage has a precise physical meaning, but in practice its value is determined as the reverse voltage which has to be applied between gate and source to reduce the standing drain current to a small fraction (usually 1/1000) of I_{DSS}, its value with gate shorted to source. So in order to set up the circuit biasing of a depletion f.e.t., you must know both I_{DSS} and V_P.

In an enhancement f.e.t., I_{DSS} is zero, and the formula given above does not apply. For such types, the important parameters for biasing are V_T (the threshold voltage between gate and source at which drain current begins to flow) and a " gain factor," b. These two parameters control the enhanced drain current according to the formula $I_{DS} = \frac{1}{2}b\ (V_{GS} - V_T)^2$. At present, data sheets do not usually specify b, but it can be derived from the relationship $b = g_{fs}^2(2I_{DS})$, where g_{fs} is the forward transconductance normally given in the data sheet for a specified drain current, I_{DS}.

The controlling low-frequency a.c. parameter of the f.e.t. is the forward transconductance g_{fs}, mentioned above, which is very often designated g_m or s, and which represents the rate of change of drain current with gate voltage. Its importance can be seen from the approximate formula, $A_v = g_m R_L$, for the low-frequency voltage gain of an f.e.t. amplifier with a resistive load, R_L.

At higher frequencies, parasitic capacitances between the gate and the other two terminals become significant, and ultimately limit the gain-bandwidth product of the f.e.t. A useful single indicator of these is C_{GSS}, the common-source short-circuit input capacitance.

The last important major parameter of the f.e.t. governs its noise performance. Usually this is stated as a spot noise figure at 1,000 or 10 c/s with a source resistance from 1 to 10 MΩ.

Those who want to go more deeply into the characterization of f.e.ts should consult one of the books about them such as " Field Effect Transistor Applications " by W. Gosling, Heywood, 1964. Meanwhile, recognizing that the strange terms and symbols used for specifying the device may be one reason for the slowness with which practical designers are taking up the f.e.t., let us see what other explanations there might be.

Possible reasons for slow acceptance

First of all, how does the f.e.t. compare in cost with the transistor? An analysis I made recently of the small-quantity price from one manufacturer showed a range of figures from about £1 to £40, with a median of about £5. A corresponding spread of prices for conventional transistors would show a median of about 10s. F.e.ts are thus in general about ten times dearer than transistors at present. Until prices come down a very long way, we are not likely to see the transistor supplanted.

On availability, there is no real difficulty, for most manufacturers appear most anxious to meet your requirements " off the shelf," so this cannot be a barrier to the spread of the f.e.t. In the United Kingdom alone you can obtain f.e.ts from Ferranti, Fairchild, M.C.P. Electronics (TRW devices), Mullard, Semitron, Texas Instruments and Walmore (Siliconix devices).

Designing circuits for f.e.ts is quite a bit different from both transistors and valves. Superficially, there appear to be plenty of published circuits around, not only in manufacturers' literature, but also in technical articles and in books devoted to the f.e.t. I said " superficially," because, if you wanted to make up a simple low-voltage, single-stage audio amplifier to try your hand, you would find it difficult to locate a practical circuit to copy. On the other hand, you will find a plethora of specialized items like a.g.c. amplifiers, frequency meters, timer circuits, flip-flops, differential amplifiers, operational amplifiers, d.c. millivoltmeters, bilateral constant-current sources, and sample-hold circuits. It is as if the circuitry published for the f.e.t. consisted of a diet of cream puffs without bread and butter. It is natural to expect that manufacturers would concentrate on circuits which are difficult for the transistor, but in the process they seem to have ignored the everyday requirements of the bulk of circuit engineers, who in the end will have to be converted from transistors.

Another difficulty is that with strange parameters used in specifications, the user finds it difficult to compare different manufacturers' devices. Figures of merit can, in fact, be derived, but are still not in common use. At low frequencies, a figure of merit that gives an indication of amplifier gain is $g_{fs}/(V_P I_{DSS})$. Other things being equal, this indicates that a low pinch-off voltage, V_P, is desirable, as is a high ratio of g_{fs} to I_{DSS}. At high frequencies, a figure of merit commonly used to compare devices for stage gain is g_{fs}/C_{GSS}. These figures of merit are some help, but, as with any new-look device, the designer is still much in the manufacturers' hands.

While the f.e.t. has been coming into production, it must not be assumed that the transistor has stood still. Planar silicon transistors with astonishingly low leakage currents and parasitic capacitances have come into general use. This has made it possible to do now with transistors many of the things for which the f.e.t. was developed. This must undermine the power of the f.e.t. competition somewhat.

F.E.T. limitations

We have been looking outside the f.e.t. itself for possible barriers to its wide acceptance. But we must not overlook possible intrinsic defects within the device. The first is that production spreads of parameters are unfortunately still much wider than desirable. For example in a typical depletion f.e.t. the I_{DSS} for $V_{GS} = 0$ can show as much as 6 : 1 variation between units. This means that quite complex circuits have to be used to set up the initial bias conditions of a stage satisfactorily. But wide spreads of characteristics are not the only trouble.

The IGFET is prone to a drift of characteristics with time. Much research is going on to understand the details of the observed instabilities, and they are currently attributed to the migration of ions in the bulk of the insulation layer isolating the gate. Typically what happens is that if an f.e.t. is operated at high temperature with applied bias voltage, the drain current I_{DS} for fixed gate voltage, V_{GS}, can change substantially with time. This tends to make the IGFET not yet really suitable for accurate linear amplifier circuits, although this defect has less effect on digital (switched) applications.

The f.e.t. is inherently less liable to thermal runaway than the transistor, but it is, particularly in the IGFET form, susceptible to catastrophic breakdown of the gate. The oxide gate-insulating layer commonly used in this device is only about 0.1 micron thick and is liable to break down if a voltage of more than about 50V is impressed on it. Now, because of the high resistance of the layer, it is very easy to build up a large static voltage on the gate which causes the insulation to punch through irrecoverably. In mains-driven equipment particularly, mains-borne voltage spikes can be expensively dangerous. One certain way to ruin the gate dielectric is to solder the gate lead with an electric iron. Another sure-fire destructive technique is to insert the gate lead first into a socket when the main equipment chassis is floating. Manufacturers sometimes supply f.e.ts wrapped in metal foil shorting the leads together to prevent catastrophic breakdown due to charge build-up during storage. It is recommended that this shorting medium is not removed until the transistor is safely inserted in circuit.

Field-effect devices still have a limited gain-bandwidth product as compared with transistors. This is primarily because of the excessive parasitic capacitances from gate to source and drain. The IGFET is better than the JUGFET in this respect, but it is still not so good as the transistor at this point in time.

The f.e.t. fails badly compared with the transistor in the matter of power handling. As yet, most f.e.ts on the market are low-current, low-power devices, and although high-power f.e.ts have been announced in development, they are still not commercially available.

The noise characteristics of the f.e.t. are at first sight most impressive. A 1,000-c/s noise figure of 1dB maximum with a source resistance of 1 MΩ is guaranteed with one commercial junction-gate device, which is very much better than can be achieved from a transistor. But, looking more closely into this, we find that at the lower impedance levels usually met with, the f.e.t. tends to be noisier than the transistor. Moreover, at all impedance levels, the IGFET tends to have significantly poorer noise performance than the transistor.

In conventional transistors, neutron radiation reduces the minority carrier lifetime and therefore degrades performance. The f.e.t. is a majority carrier device and has been claimed to be highly resistant to nuclear radiation damage. This has been found to be true for JUGFETs, but it has also been found that space radiation does affect the characteristics of IGFETs, leading to degradation of performance as in transistors.

Summing up

And what conclusion can we draw from this limited survey of the state of the f.e.t. art? My own feelings are that the f.e.t. has so little advantage technically over the conventional transistor in ordinary "bread-and-butter" circuit applications that it will have to come down well below the transistor in price before it is likely to supersede it generally. Agreed, it is an intriguing device with certain potential advantages in its high-impedance and noise characteristics particularly, but conversely there are many jobs the transistor does (e.g. in high power amplifiers) beyond the capabilities of present f.e.ts. I think the f.e.t. will follow much the career pattern of the tunnel diode. As a specialist device with some extraordinary features, it will find a small place on the periphery of the transistor circuit world, but never seriously threaten to take over from the transistor as a general-purpose unit.

ACOUSTIC YAGI ARRAY DEMONSTRATED AT THE I.E.E.

AT a recent lecture arranged by the I.E.E., Professor Meyer (Göttingen University) spoke on the absorbing subject of electroacoustics. Prof. Meyer, who is well known in the field of electroacoustics, lectured on this subject in London in 1937, and he reported that since that time no radically new methods have been evolved for the transducing process. Developments in the broader sense have, of course, been made and the Professor outlined some of the more recent work. In the field of psycho- and room acoustics it is appreciated that for realistic reproduction of sound, a non-directional sound field is preferred and experiments on coherent (in space and time) and incoherent waves made at Göttingen were described. Analogies betwen acoustic and electromagnetic phenomena were referred to and provide a powerful technique in the study of acoustics. It was pointed out that since the wave equations for acoustics and electromagnetic waves differ in that the former involves a vector and a scalar quantity instead of two vector quantities, it is to be expected that anologous results will be obtained in experiments in which this difference is not relevant.

In connection with these analogies, an acoustic Yagi array was demonstrated. This consisted of a microphone driving the Yagi array, which comprised discs in place of dipole director elements, the cavities between discs forming Helmholtz resonators. The intention was to provide a highly directional sound source, and the directional characteristics were displayed in the experimental set-up. The array operated at 11 kc/s (with a bandwidth of a few kc/s) and the dimensions were roughly comparable with those of an electromagnetic array operating at about 10 Gc/s whose directional characteristics were also demonstrated for comparison.

The technique of displaying the directional characteristics aroused much interest, judging by the audience response, and indeed the display of polar diagrams without laborious plotting was a sight for sore eyes. The sound source was fixed and the array and microphone were rotated through 360° (by hand). This rotation operated potentiometers which altered the bias to the c.r.t. deflection plates so that a circular trace could be obtained. The c.r.t. was part of a storage oscilloscope (which the audience viewed through a c.c.t.v. monitor) and consequently the polar diagram was permanently displayed after one rotation of the array. This technique was repeated with the electromagnetic Yagi array.

UNDERWATER RADIO COMMUNICATION

ELECTROMAGNETIC waves have been successfully transmitted short distances under water at frequencies up to 500 Mc/s, according to a report from the Northrup Corporation of Washington D.C., U.S.A. The experiments have been performed by a Northrup subsidiary, Page Communications Engineers, and it is claimed that the transmissions have been at much higher frequencies than were previously possible. In the first experiments signals from 100 c/s to 500 Mc/s were sent a distance of 12 ft in a small plastics pool. These initial tests, say Northrup, showed that the received signal strength was directly proportional to aerial length and to input power, was independent of frequency and varied with aerial orientation. Larger-scale tests in the shallow water of San Francisco Bay confirmed some of these results. With a 50-ft aerial and ten watts of power, a voice link was established over a distance of 300 ft.

Deep-water tests were then conducted to discount the possibility of "leakage" transmission over a water-air-water path. In these tests, performed from fishing boats outside the mouth of San Francisco Bay, a well-shielded 250-watt transmitter was used to feed a 20-ft dipole aerial lowered to a depth of about 250 ft. At a frequency of 7 Mc/s communication was established over a distance of about 1,500 ft. Signal strength did not vary with changes in depth, as would have been the case if surface wave leakage had occurred.

Throughout these and subsequent laboratory experiments, signalling range was shown to have a direct reationship to aerial length. Northrup say that the tests show promise of at least an order of magnitude improvement over existing underwater communication techniques. Possible applications to oceanographic research, undersea mining and audio/video communication links are being investigated.

Thermostatic Switch Unit

By J. A. SELBY

THIS thermostatic switch unit was built to control the operation of an electric radiator cooling fan fitted to a car. The purpose could have been served more simply by the purchase of a conventional type of thermostatic switch available from motor accessory manufacturers, but as most of the necessary components were to hand, it was felt to be of interest to design a unit which would have considerable flexibility of adjustment and be immune to vibration, and might therefore perhaps prove of use in other temperature control applications.

The sensing element is a normal thermistor (type CZ.1) having a resistance of about 4 kΩ at 18°C and about 1 kΩ in the region of the operating temperature. Any other thermistor could be used, with appropriate changes in certain resistance values. Heating due to the passage of current through the thermistor was ignored although in some applications it might be necessary to choose a thermistor large enough in relation to the current to minimize self-heating.

The circuit shown in Fig. 1 is a derivation of the Schmitt trigger using an n-p-n transistor in the second stage in order that the maximum possible voltage may be developed across relay RLA. This relay was a surplus market item with a resistance of 250 Ω and which operates down to 9 V. Unlike the rather more common circuit using two similar transistors, the two stable states are with both transistors either "cut off" or "bottomed." As the temperature rises the resistance of the thermistor decreases and the base of Tr1 goes negative, triggering the circuit to the "on" state. The point at which this occurs is adjustable by the control RV1 which covers a range of from approximately 40°C to the maximum permissible operating temperature of the thermistor.

It was found that the operating points were unduly dependent on the supply voltage; therefore a Zener diode, Z1, was connected via a 470Ω resistor between the negative line and the emitter of Tr1. If the supply voltage changes, the emitter potential does not change in direct proportion because of the substantially constant potential difference across the Zener diode. Thus, if the supply voltage drops, the emitter goes slightly more than proportionately positive with respect to the positive supply and therefore to the base. Consistent operation was obtainable with supply voltages of between 10 V and 16 V. The Zener diode also has the effect of reducing the backlash between on and off trigger points.

In order to provide a simple and completely independent method of setting up the switch-off point to close limits, no attempt was made to design the inherent backlash of the circuit to any specific value. When the circuit triggers to the "on" condition, the relay operates and contacts RLA1 adjust the base bias of Tr1 to a new value which may be preset as required by RV2. As there is virtually no interdependence with the switch-on adjustment, setting up is extremely simple and it is possible to make the differential between on and off as small as 2°C. If very fine adjustment is desired, it would be preferable to use lower values for RV1 and RV2 and pad them with fixed series resistors. The writer made preliminary adjustments by estimating the desired temperatures and heating the thermistor to these figures by immersion in hot water.

The purpose of the 6·8 Ω and 1 kΩ network connected to the emitter of Tr2 is to minimize leakage current in the cut-off condition by applying a reverse bias of about 80 mV. This would be unnecessary with a silicon transistor.

The diode shunted across the relay coil is for the normal function of suppressing switching transients which might damage the transistor; the CR combination across the load-carrying contacts RLA2 eliminates sparking with an inductive load. Values required depend on the circumstances involved. In the writer's case, 2μF in series with 6·8 Ω were used. Where the load is fed from the same supply source as the control unit, it is unnecessary to use a double pole relay, as contacts RLA1 may be used satisfactorily to switch the load also. An attempt was made to replace the relay by a power transistor but it was soon realized that additional complication was involved by the need to introduce a further transistor with a time-delay circuit to delay the change in bias on Tr1 when triggering to the "on" state occurs. A magnetic relay possesses sufficient time lag and provides a simpler, if less elegant, solution. Resistors are not critical in value but should be high-stability types.

Two points should be particularly noted, however, to avoid destroying Tr1 by excessive base current. First, during initial setting up, RV1 should be set to minimum resistance value and the temperature of the thermistor brought up to working point; RV1 should then be slowly increased until switch-on occurs. Secondly, the cooling system of the equipment involved must be reasonably efficient in order to check any appreciable further decrease in resistance of the thermistor due to continued increase in temperature.

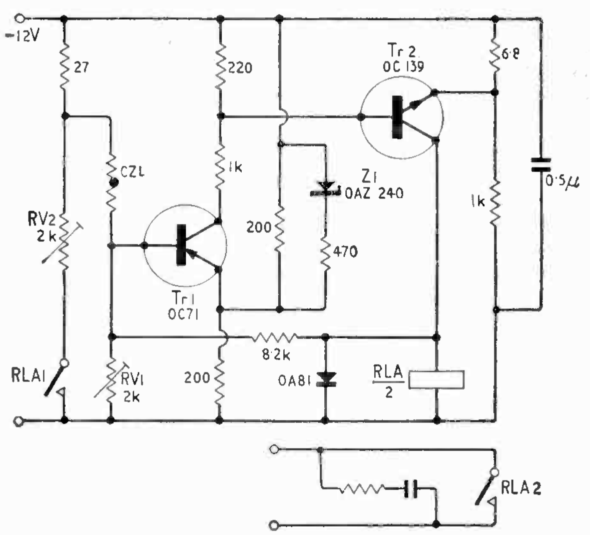


Fig. 1. Circuit of the thermostatic switch unit.

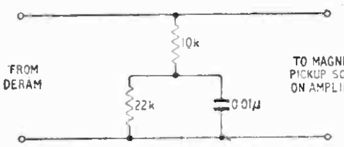
LETTERS TO THE EDITOR

The Editor does not necessarily endorse opinions expressed by his correspondents

Dinsdale Amplifier

I HAVE read Mr. Churchill's letter (December isue) regarding the signal/noise ratio of my amplifier when used with crystal pickups, and agree in principle with his comments.

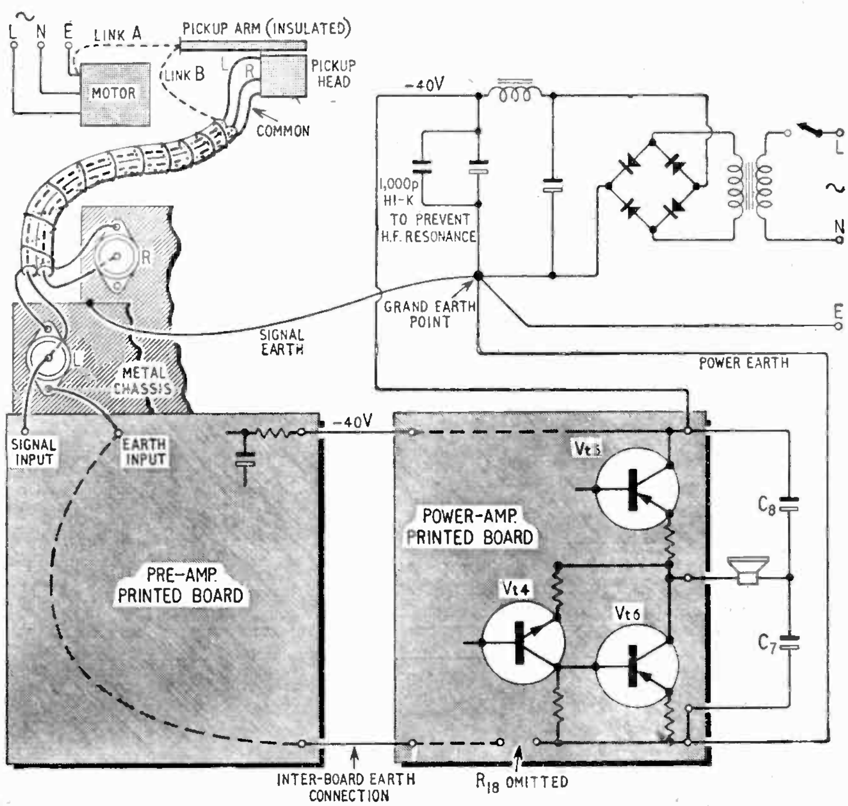
My circuit was originally designed to utilize the same position of the input switch (and hence the same feed-back components) for both magnetic and crystal pickups, and this has led to some compromise over the accuracy of the frequency correction. If an additional position "Crystal Pickup" were used, a feedback loop on the lines of Mr. Churchill's proposal would undoubtedly present an improvement in both s/n ratio and frequency correction, as his own well-recorded experimental results have shown. This extra position could use the present 78 r.p.m. contact, if the latter is not required.



Meanwhile, a number of readers have enquired about the use of the Decca Deram pickup with my circuit as published, and I can report that the velocity-loading recommended by Decca and shown above gives satisfactory results. The extra components can be mounted at the base of the pickup arm, and the magnetic input socket should of course be used.

A further subject often raised by correspondents is that of earthing, particularly regarding the avoidance of earth loops (with their attendant hum and distortion) when connecting the amplifier to other equipment. I therefore include a diagram showing the approved method of earthing. It should be borne in mind that any additional signal sources, e.g., radio tuners and tape decks must be earthed *through the power amplifier*, and not directly to the mains or other earthed equipment.

Farnborough, Hants. J. DINSDALE



Recommended earthing system. The amplifier pickup arm should be earthed via link A or B but not both. The unsleeved screened leads to the pre-amplifier should be bound together with wire over their full length to reduce hum. The only earth connection to chassis and between the two channels is at the input coaxial sockets. For mono operation, two earth lines should be run as shown. For stereo, the power earth and 40V supply should be duplicated, the signal earth may serve for both channels. Note that R18 should now be omitted, as originally proposed by C. Artus.

British Electronics Abroad

FIRST may I introduce myself? I am British and have started a company (New European Electronic Distributors) in Luxembourg to help promote the exports of British electrical and electronic equipment and I feel I must comment on your December editorial "The Image of British Electronics Abroad."

I started N.E.E.D. four months ago. My first idea was to obtain premises and form a permanent "British Exhibition," the charge would have been £25 per month for a year's contract with a three months' notice for each company wishing to exhibit, the premises would have been open from 9.0-5.30 Monday to Friday. Result: no response. Next I thought of a shared stand at the Luxembourg International Fair, charge £75 to each exhibitor for the 10 days. Result: no response. Seeing that last year 220,000 people visited the Fair I thought it would have been worthwhile. This does not seem to fit in with your comment "including those manufacturers who would have gladly taken space in joint-venture displays had they been given the opportunity."

Also a large number of companies I have contacted reply "we are covered by an agent in Brussels." One can imagine an agent in Brussels who is handling British, German, French and perhaps Japanese products, going all out to "Sell British"!

I agree with all your comments and suggest that British companies should have a long second look at their agents abroad and also take a more active part in all exhibitions.

D. W. F. MILLIGAN

New European Electronic Distributors,
Luxembourg.

Loudspeaker Enclosures

DR. BAILEY states that the only safe way of removing the rear cone sound energy is by transmitting it down an infinite transmission line. Below about 500 c/s in the dimensions shown, the front radiation resistance will vary with f^2 and the cone amplitude must increase four times for each halving of frequency. If the transmission line is the controlling impedance there will be a falling bass response of 6 dB/8ve and this will commence around 150-200 c/s, the precise value depending on the diaphragm mass. The fact that this does not happen is because a finite line is used and resonance introduced to hold it up.

There is, of course, nothing wrong in doing this except that it is not true to describe it as "non-resonant."

For practical purposes all cabinet speakers can be considered as simple sources at low frequencies, so that for a given power at a given frequency the required vector sum of the volume velocities from the diaphragm and apertures is fixed. Thus a given volume of air must alternatively be packed into and withdrawn from the box. The energy stored will be a minimum if the excess pressure is uniformly distributed.

If we now introduce a criterion of quality and specify a maximum Q which we will tolerate, we can substitute a real impedance for the box reactance since we must introduce damping, electrical or otherwise, in order not to exceed the specified Q.

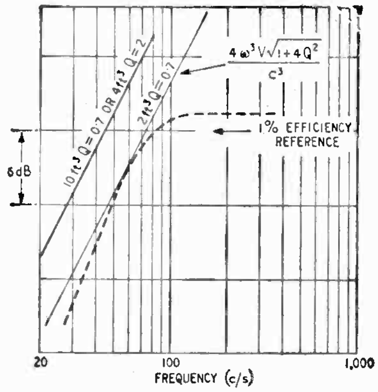
The ratio of the total radiation resistance to the enclosure stiffness reactance is independent of diaphragm or aperture size or the number of apertures and is dependent only on frequency and enclosure volume. We can therefore arrive at a general expression and show that the free field low frequency system efficiency (British Standard 2498: rated efficiency) of a cabinet loudspeaker cannot exceed

$$\frac{4\omega^3 V\sqrt{1+4Q^2}}{c^3}\,\%$$

where $\omega=2\pi f$, V=volume of enclosure, Q=Q-factor, and c=velocity of sound in air.

This assumes adiabatic compression because it is doubtful whether the isothermal case can be realized in practice without introducing too much resistance into the acoustical circuit.

A closed box with zero suspension stiffness could just touch the theoretical limit at one frequency as shown by the curve for a 2ft^3 enclosure with a Q of 0·7. Note that to produce a 6 dB-down point at 30 c/s with the same Q would require a box of 10ft^3. If the box is to be smaller than this the Q *must* be increased and a phase shift design *must* be used if the mid-range efficiency is to



Straight lines show efficiency which cannot be exceeded for a given box volume and permissible Q. Dashed curve is theoretical response for 2ft^3 closed box with Q of 0.7.

be maintained. (It seems that at least 200-300 milliwatts is needed in the mid-range for adequate power, so with a 30-watt amplifier an efficiency of 1% is a good reference.)

If the phase shifting design is in the form of a pipe then the total resistance must be predominantly in the acoustical circuit to avoid excessive Q because the pressure is not evenly distributed and the stored energy is greater for a given volume displacement.

Note that artificially increasing the mass of air in the pipe does not alter the efficiency expression. ρc^2 remains constant (where ρ= density of air) and the effect is to make the pipe appear longer but of smaller cross section, leaving the total volume the same.

Acoustical Mfg. Co.,
Huntingdon.

P. J. WALKER

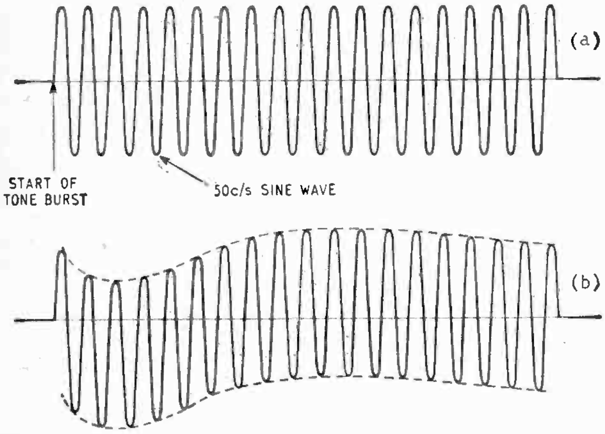
I WAS most interested to read Mr. Ogilvie's letter in the January issue and the details of his speaker system. I am looking forward to comparing it with the "Infinite Baffle" system.

Incidentally, I have had a favourable report from one reader who has wool-filled his "Paraline" cabinet, and also from a colleague who has used wool in his Gough system. This seems to give weight to the contention that resonant systems are to be avoided at all costs.

With regard to the phase-shift characteristics of speakers, I quite agree that variations in speaker impedances can upset amplifier performance. It is for this reason that I have sometimes rather harped on unconditional load stability for good audio amplifiers. Poor amplifiers and speakers do tend to aggravate each other's defects.

Mr. Ogilvie's comments on d.c. transients in amplifiers may be true, but in a good amplifier they should be well below audibility. In a well-designed amplifier the d.c. conditions will change only in the push-pull stages and preferably only in the output stage to any appreciable extent. The net d.c. effect fed out should therefore be very small, as the d.c. changes will be in push-pull so far as the output stage will be concerned. The final resonance exciting effect should therefore be well below audibility.

Tone burst testing of amplifiers can lead to odd conclusions unless great care is taken with the measurements. The input tone-burst test must be bandwidth-limited unless great care is taken with the final interpretation. Otherwise the sidebands of the signal (which is effectively



a sine wave 100% amplitude modulated by a square wave) extend far outside the audible spectrum.

For example, in Fig. (a) the waveform is shown of the typical tone-burst output from a generator. This possesses sidebands far below the sine wave frequency, and indeed the sub-audible components form quite a large proportion of the output. This can be seen by cutting the components below, say, 20 c/s with a filter. The results then appear as shown in Fig. (b). This effect is often blamed on poor amplifier performance, when in reality it is only the natural l.f. roll-off of the amplifier at sub-audible frequencies.

Bradford. ARTHUR R. BAILEY

Torsional Stability and the Unipivot

MR. BICKERSTAFFE gives an excellent analysis of the problems involved with torsional inertia but misses *the* point of design that has to my knowledge only ever been included in one pickup arm (the Hi-light)*. That point is to reduce vertical inertia of the arm so that it is better able to play a record (with the common warp) and so that it will eliminate the worst component of rumble.

To the extent that the arm will twist on playing a warped record (which seems to alarm Mr. Bickerstaffe, for some subjective reason) is its vertical inertia reduced and the tracking weight thus remains more constant. To this extent also is the *vertical* bass resonance of the pickup raised in frequency and so rumble reproduction can be reduced *without loss of bass response* (which is in the 45° or lateral mode).

To understand why this is the most important feature of a pickup arm one must realize that rumble is the limiting factor in dynamic range, since it is reproduced at a level of about 10 dB below 1 cm/sec on a good turntable (whereas tape noise, the other low level limit, is about 30dB below 1 cm/sec.).

Although the loudspeaker does not reproduce this fundamental (about 20 c/s) rumble, the loudspeaker cone will flap freely to and fro (silently) at large amplitudes (since it experiences no enclosure load at this frequency) and thus give doppler effect distortion to all other sounds.

With the 12 dB/octave cut that occurs below the bass resonance there can be a very well worthwhile saving in rumble if the resonance in the vertical mode is high enough.

Such should be the main advantages gained by users of expensive arms. Unfortunately this is rarely the case and I think technical articles should do something towards explaining such facts to the enthusiast.

To return to Mr. Bickerstaffe's sole stated reason for his throwing away these advantages by *preventing* the twisting action; let me throw away Mr. Bickerstaffe's fears and "alarms" and replace them with a reason, i.e., that separation will usually suffer a few dB on most pickups twisting on a warped record. The result may be a slightly moving instrumentalist if listening conditions are perfect.

The customer can thus take his choice based on a knowledge of the alternatives, i.e. either the occasional *slightly* unsteady positioning on the odd badly warped record, or the continual doppler (or phase modulation) distortion from rumble.

If anyone thinks the latter is unimportant let him consider that the rumble *amplitudes* if not attenuated, on even the better turntables, will, after normal bass equalization, be within 2 or 3 dB of the maximum recorded amplitudes at 1 kc/s. The ensuing frequency modulation of all other signals may thus be the largest source of distortion in a reproducing system.

Decca Record Company, J. WALTON
London, N.W.6.

* *Wireless World*, June 1959, "Pickup Arm Design."

Power Supplies

MR. M. HARDING'S letter in the January issue commenting on the last article in Mr. T. D. Towers' series, prompts me to make a further suggestion regarding stabilized power supplies.

If Mr. Harding's circuit is modified by the addition of just two components—an emitter resistor for Tr1 and a Zener diode, the constant current output mode of operation of the power units can be made much more accurate (Fig. 1). Some reduction in maximum output voltage is inevitable, but the maximum output current is, of course, variable if the added resistor is variable. If the constant voltage mode is not required to be quite so

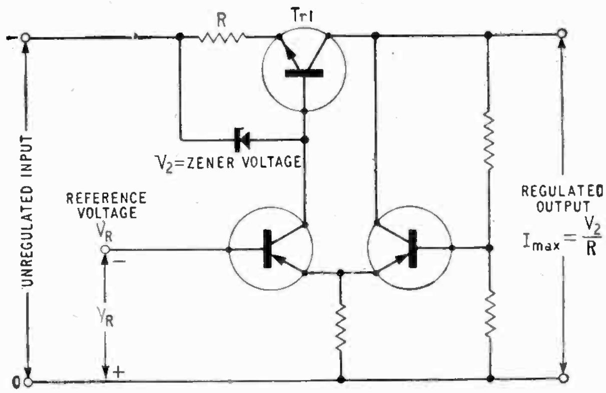


Fig. 1

accurate, one of the complementary pair transistors can now be dispensed with, producing a simple inexpensive circuit (Fig. 2).

Using an n-p-n comparator and a p-n-p regulator we have found the circuit very useful for charging sealed nickel-cadmium accumulators, since the battery may safely be connected when completely discharged and will not be overcharged. A p-n-p power transistor is cheaper than an n-p-n one, and its collector may be grounded

(*Continued on page* 85)

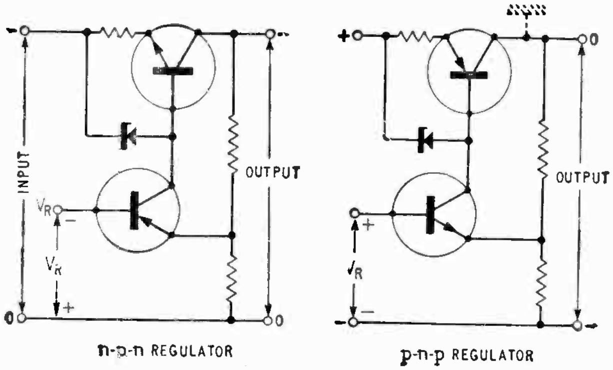


Fig. 2

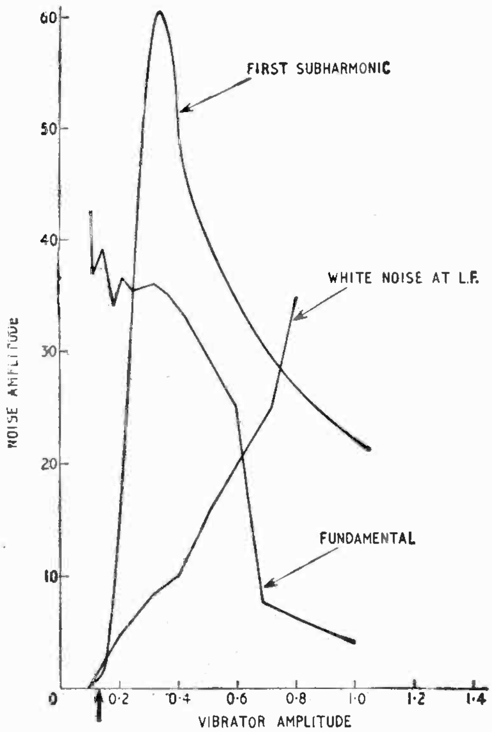
when controlling a negative supply so that cooling is easier, and the current limit may be set at a higher value.

Cavendish Laboratory,
Cambridge. D. WILSON

Acoustics Congress

I CONGRATULATE you on your most excellent report of the Fifth International Congress on Acoustics (November 1965 issue).

However, I would like to correct a misinterpretation in your report of the paper describing noise measurements relating to the threshold and intensity of cavitation of which I was joint author. In this paper we describe the application of our results to the problem of noise radiated from industrial ultrasonic cleaning equipment. These equipments are operated at low ultrasonic frequencies (usually 20-25 kc/s) for maximum efficiency, and the first subharmonic of the driving frequency is both



intense and well within the audio range, and is now becoming a medical health hazard to people working near large installations.

The amplitude characteristics of the fundamental, first subharmonic, and the white noise within a band 0-2.5 kc/s, radiated in a tank containing water subjected to ultrasonic waves, are shown in the diagram. The arrow indicates the amplitude of the ultrasonic vibrator when cavitation sets in. The amplitude of the subharmonic peaks at a relatively high value when the ultrasonic vibrator amplitude gives an intensity of 1 W/cm^2 in the water. This corresponds to the intensity at which industrial cleaners and processing equipments are normally operated. Our results indicate that manufacturers could reduce the noise radiated from their ultrasonic cleaners by merely driving at a higher intensity, and thus move off this high noise peak. To drive the equipment at a higher frequency (your misquote!) could remove the first subharmonic out of the audio range, but would result in a large decrease in cleaning efficiency.

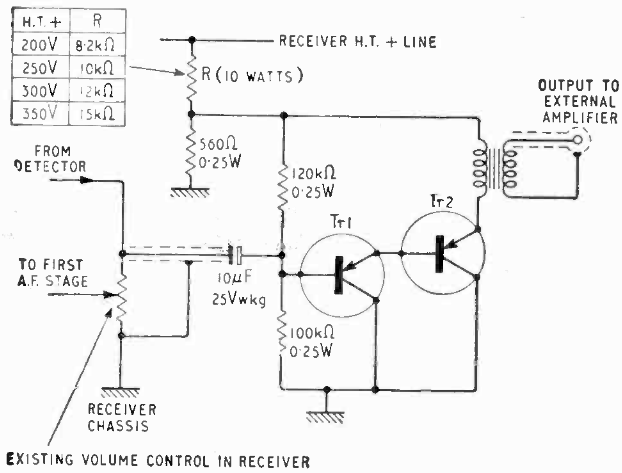
Imperial College,
London. J. PARROTT

Television Sound Quality

I WAS interested to note your correspondents' comments in the December 1965 issue concerning the shortcomings of the audio side of modern television receivers. However, I was rather surprised that the accepted remedy for this appears to be the provision of a separate, highly expensive tuner, when the required audio signal is already present in undistorted form immediately after the sound detector in the receiver. The r.f. and i.f. circuits preceding this point are at least as good as anything the average constructor is likely to produce and it is only the subsequent audio stages and loudspeaker which are responsible for the poor quality reproduction.

The solution, therefore, is to feed the audio output from the sound detector to an external amplifier and loudspeaker system. The writer uses the circuit shown, consisting of an audio transformer to provide isolation from the live chassis of the television receiver, preceded by an emitter-follower arrangement which ensures that the take-off circuit presents a high impedance to the sound detector. The additional drain on the receiver h.t. line is easily met by disconnecting the h.t. supply from the redundant audio stages.

Virtually any silicon transistor is suitable for Tr1 and Tr2, the OC200 being probably the most readily avail-



able. Germanium types are not recommended, in view of the high ambient temperature usually prevailing in modern television receivers.

The coupling transformer should have a ratio suitable for matching into the external amplifier, although this has not been found critical. A transformer of the type enclosed in a metal can is recommended, since otherwise interference may be picked up from the timebases, etc. The d.c. resistance of the primary should be about 2 kΩ, or made up to this value by adding a series resistor, which should be bypassed with a capacitor of 500 μF or more. To avoid placing too much reliance on the transformer inter-winding insulation, and as general good practice, the mains should be connected via a non-reversible plug, wired so that the chassis is connected to mains "neutral," with the on-off switch in the "live" side of the mains.

The arrangement described has been used for some time and has given very satisfactory results. Indeed, it has revealed that the quality of the transmitted sound itself is, on some programmes, not all it might be!

Bath, Somerset. T. M. GEORGE

LITERATURE RECEIVED

"The Gas Laser and its Experimental Applications" is the title of a 31-page booklet published by Scientifica & Cook Electronics Ltd., of 148 St. Dunstan's Avenue, Acton, London, W.3. (Price 12s 6d.) After a general introduction, the booklet discusses laser theory, operation of the laser, and the laser beam. A chapter headed observation of optical phenomena is sub-divided into a demonstration of lens aberrations, Fraunhofer diffraction and interference patterns, Fourier transforms, interferometry, Doppler shift from a moving mirror, and Abbe theory of image formation. A number of references are also included.

"The Sampling Oscilloscope: A Nanosecond Measuring Tool" is the title of a 6-page reprint now available from Tektronix U.K. Ltd., of Beaverton House, Station Approach, Harpenden, Herts.
WW 327 for further details

"Insulating and protective tapes" are described in a 12-page publication (number 481) now available from British Insulated Callender's Cables Ltd., P.O. Box No. 5, 21 Bloomsbury Street, London, W.C.1.
WW 328 for further details

Transistor Applications.—Standard Telephones and Cables have recently published an application note (MK/185X) covering the use of their BCY 42 transistors in (a) a 10 Mc/s wideband amplifier and (b) an audio amplifier delivering 1 mW into a 600Ω load. Copies are available from S.T.C.'s Components Marketing Division, Footscray, Sidcup, Kent.
WW 329 for further details

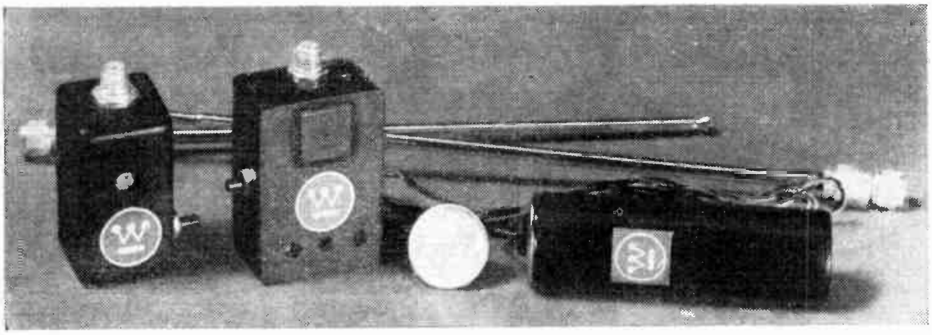
"Measuretest."—Marconi Instruments Ltd., of St. Albans, have launched a new technical publication called "Measuretest." This journal, which is available to all concerned with instrumentation, is to be published six times a year. The first, which was published in December, deals with counters. The second will contain an article on spectrum analysis of modulated signals. The "Marconi Instrumentation" journal will continue to be published.
WW 330 for further details

From EMI Electronics Ltd. we have received a new brochure containing detailed information on their 4½-in **image orthicon television cameras.** Copies of the 11-page brochure are obtainable from the company's Publicity Department at Hayes, Middx.
WW 331 for further details

"Quick Heating V.H.F. Tetrodes and Double Tetrodes" are described in one of Mullard's recent application notes, TP601. The 26-page booklet is based largely on material supplied by P. G. Giles and J. Ling of the Mullard Central Application Laboratory. Abridged data on eight quick-heating valves is contained along with a selection of practical circuits and recommended valve line-ups for different types of transmitter. Copies are obtainable from the Industrial Markets Division, Mullard Ltd., Mullard House, Torrington Place, London, W.C.1.
WW 332 for further details

The British Standards Yearbook 1965 Supplement is the first issue of a separate supplement to the B.S. Yearbook. It deals specifically with publications issued by the International Organization for Standardization (I.S.O.), the International Electrotechnical Commission (I.E.C.), the International Commission on Rules for the Approval of Electrical Equipment (C.E.E.) and the International Special Committee on Radio Interference (C.I.S.P.R.). Details of each publication are included together with a table cross-referencing international publications to British Standards with the same subject matter. Copies, price 7s 6d each, are available from the British Standards Institution, 2 Park Street, London, W.1.

S.C.R. Experimenter's Manual.—The first edition of the RCA Silicon Controlled Rectifier Experimenter's Manual KM-70 has been recently published by the Electronic Components and Devices Group of the Radio Corporation of America, Harrison, New Jersey, U.S.A. Descriptions and operating details for 14 control circuits are included. Theory and operation of solid state devices is discussed in the introduction to this 80-page booklet, which is priced $0.95.



A foretaste of things to come? Microelectronic Citizens Band transmitter and receiver developed by Westinghouse. The transmitter (left) uses two thin-film circuits and provides an output of 6 mW at 27 Mc/s. The receiver (centre), 1.5 in³ in volume, uses a thin-film r.f. stage and semiconductor integrated circuits for the mixer, oscillator (crystal), i.f. stage and a.f. stage. A battery pack is shown on the right.

Point-to-Point Review 1965

By DAVID WILKINSON,* B.Sc., A.M.I.E.E.

IN general, h.f. conditions have been better during the past year than they were in 1964. This is primarily due to the slowly increasing values of sunspot number and IF2, now that sunspot minimum has passed. This rise is well shown by the smoothed values in Fig. 1. In fact, the predicted value of IF2, for December 1965 was 26, compared with −4 for the same month in 1964. In consequence the values of MUF have been some 20% higher throughout the year. This should have resulted in improved circuit working though the change is not likely to be particularly significant yet.

Only two sunspot groups of area equal to, or greater than, 500 millionths of the visible solar hemisphere were reported. The first, of 700 millionths area, crossed the sun's disc from May 15th to 27th, and the second, which grew from 500 to 700 millionths area during its passage across the disc, from September 26th to October 9th.

One sudden ionosphere disturbance (Dellinger type fade) was reported during the year. This occurred on October 2nd and affected Far Eastern radio circuits between 0418 and 0425 G.M.T. but did not cause any complete fadeouts.

The general level of magnetic activity was lower than in 1964, the monthly mean Hartland "C" value for 1965 being 0.49 compared with 0.58 for the previous year.

Such magnetic disturbances as were experienced were usually isolated and of short duration, seldom lasting more than 24 hours and did not seriously affect h.f. communication. No clear pattern of M-region (27-day recurrent type) storms emerged.

Sporadic E continued to exert a marked influence on circuit operations, especially during summer months, and on many routes frequencies were consistently used which were on, or above, the predicted median MUF.

As was mentioned last year†, many well-engineered h.f. circuits of suitable length have shown efficiencies of well over 90%, even in the sunspot minimum years. This is illustrated by Fig. 2 which shows the efficiency of the Barbados-Jamaica circuit for the month of October 1965. It will be seen that the efficiency is plotted to a base of time of day.

This is achieved by averaging the efficiency of the given hour over the 31 days of the month. In this context, it is worth pointing out that the efficiency is calculated on the number of characters that are commercially usable. In other words, an efficiency of 92% implies that the total traffic that could be handled is 92% of the theoretical maximum. It should also be noted that such systems use ARQ (automatic error detection and correction) and that thus, in obtaining the correct version of a mutilated character, some eight characters will be lost, four in each direction of transmission. Thus an efficiency of 92% implies that, very roughly, one character in 100 is received with an error and that, each time, 8 characters are lost in correcting this error. Under these conditions, the undetected error rate might be of the order of 1 in 10^4. By the same token, if ARQ was not employed, the efficiency would rise to 99% but the error rate would be 1 in 10^2.

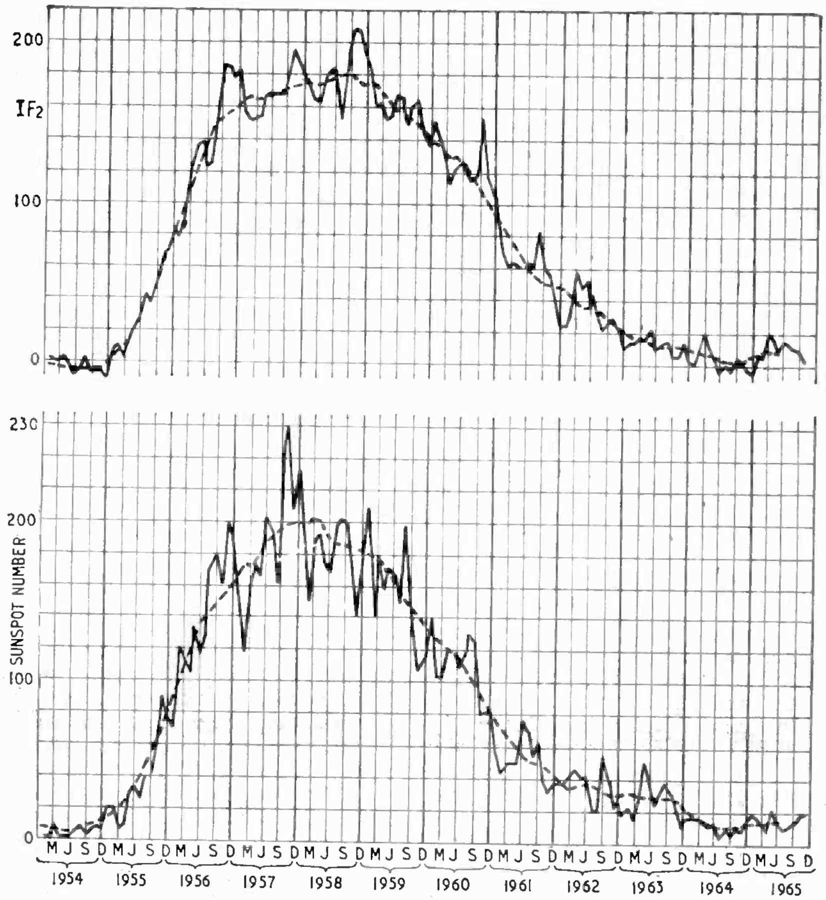


Fig. 1. The monthly and smoothed values of the ionosphere index (IF2) and the sunspot number for the past twelve years.

*Cable & Wireless Ltd.
†*Wireless World*, Feb. 1965, p. 103.

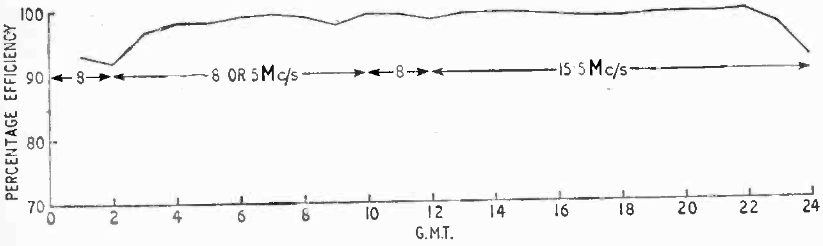


Fig. 2. Analysis of the Jamaica-Barbados radio path efficiency for October last year.

High efficiencies of 95% or over can be achieved only by using dual transmissions at the time of frequency changing and it is only fair to say that very short or long circuits, and those for which the equipment, aerials or sites are not ideal, may have considerably lower efficiencies. "Slick" operation of the circuit is also an important factor.

The Early Bird satellite has been in use since mid-1965 carrying commercial telephone traffic between Andover in the U.S.A. and one of the three European ground stations (Goonhilly in the U.K., Plumeur Bodou in France and Raisting in Germany). The Italian station at Fucino has, in addition, been employed for the transmission of television pictures to the U.S. These satellite channels have given a performance close to that predicted. The only remaining unknown, the question of subscriber tolerance to the time delay, is being actively evaluated by the participating nations.

Two point-to-point communication systems of considerable interest for the American Apollo project, to place a man on the moon, have been announced. First, 2,400 bits/sec data circuits are to be provided, on h.f., between ships in the Atlantic Ocean and Bermuda. There is considerable difficulty in providing aerials of adequate gain on board ship since they must be steerable. However, rotatable log-periodic aerials will be employed both on board ship and at Bermuda, in conjunction with 30kW transmitters. Transmission of a 2,400 bits/sec data channel raises considerable problems because, as is well known, multipath effects will introduce random variations in path delay. Path time differences of 2 m. secs or so, are not uncommon. In this instance the transmission will be carried by twelve 100 baud subcarriers at 200 c/s spacing, each baud carrying two bits by the use of four-phase modulation. This is the first time that such a system has been used commercially.

The Apollo project will also employ a complex network of radio-communication circuits to connect the tracking stations, spaced throughout the world, to the Manned Spacecraft Centre at Houston, in Texas. For this purpose, stations are to be set up at Ascension Island and the Canary Isles, in the Atlantic, and at Carnarvon, in Australia, and Hawaii, to cover the Pacific Ocean. These stations will employ 42ft parabolic aerials or folded cassegrain horn aerials and have a system temperature of 100°K. In addition, four ship-borne stations are to be provided; these will have 30ft paraboloids and a system temperature of 170°K.

The satellites to be used will be a modified version of HS303 (Early Bird), to be called HS303A. These will be in synchronous orbits and "stationed" at approximately 0° and 170°E to cover the Atlantic and Pacific Oceans respectively. These satellites will be among the first to provide a measure of multiple access and, in principle, the satellite capacity may be subdivided into smaller blocks without loss of overall capacity. The building of the earth stations must be completed by autumn 1966.

There has been considerable interest in the use of lasers for point-to-point communications. They were used for the experimental transmission of television in the U.S.S.R., and speech was transmitted to the Gemini VII spacecraft. It will be interesting to see if 1966 brings any commercial application of this new method of communication.

EUROPEAN BROADCASTING CHART

FACING this page is a fold-out inset on which is reproduced, by courtesy of the European Broadcasting Union, a chart showing the present situation in the long- and medium-wave bands in Europe.

In each channel are shown the stations operating in accordance with the 1948 Copenhagen Plan and beneath, in the shaded section, those operating on frequencies not allocated to them in the Plan. Each station is mentioned by name except where a group of stations in a country operate on the same frequency, when only the name of the country or the main station is given with the letter "S" appended.

In the shaded section a station is shown displaced to the left or right of the channel to indicate that its carrier frequency is lower or higher than the channel frequency. The sizes of the station panels are related to the output power and are defined on the chart.

The most significant change in the European situation during the past few months has been the closing down of some 200 low-power medium-wave stations in Spain which were operating on "illegal" frequencies. This has certainly eased the overcrowding in the medium-wave band, but there are still some 240 stations operating contrary to the Copenhagen Plan.

The observations on which the chart is based were made at the E.B.U. Receiving and Measuring Station in Belgium up to November 1st, so that, by now, there may be one or two minor adjustments or additions, including the two latest U.K. "pirates"—Radio Tower (1268 kc/s) and Radio Essex (1353 kc/s).

This copyright chart is produced twice a year by the E.B.U., hence the note drawing attention to changes made "since the last chart."

UNION EUROPEENNE DE RADIODIFFUSION
CENTRE TECHNIQUE
AVENUE ALBERT LANCASTER, 32
BRUXELLES

Supplement to WIRELESS WORLD February 1966

STATIONS DE RADIODIFFUSION EN ONDES LONGUES ET MOYENNES

(Situation du spectre au 1ER novembre 1965)

ZONE EUROPEENNE

LONG- AND MEDIUM-WAVE BROADCASTING STATIONS

(Conditions in the spectrum on 1ST November, 1965)

EUROPEAN AREA

EUROPEAN BROADCASTING UNION
TECHNICAL CENTRE
AVENUE ALBERT LANCASTER, 32
BRUSSELS

LEGENDE

PUISSANCE

- Egale ou supérieure à 100 kW
- Inférieure à 100 kW
- Inférieure à 10 kW
- Inférieure à 1 kW
- Puissance inconnue

S = Stations d'un même pays utilisant la même fréquence et souvent synchronisées.

CANAUX DANS LESQUELS UN CHANGEMENT S'EST PRODUIT PAR RAPPORT AU TABLEAU PRECEDENT

- Apparition d'une nouvelle station
- Disparition d'une station
- Passage d'un canal à un autre
- Emission de brouillage dans le canal

LEGEND

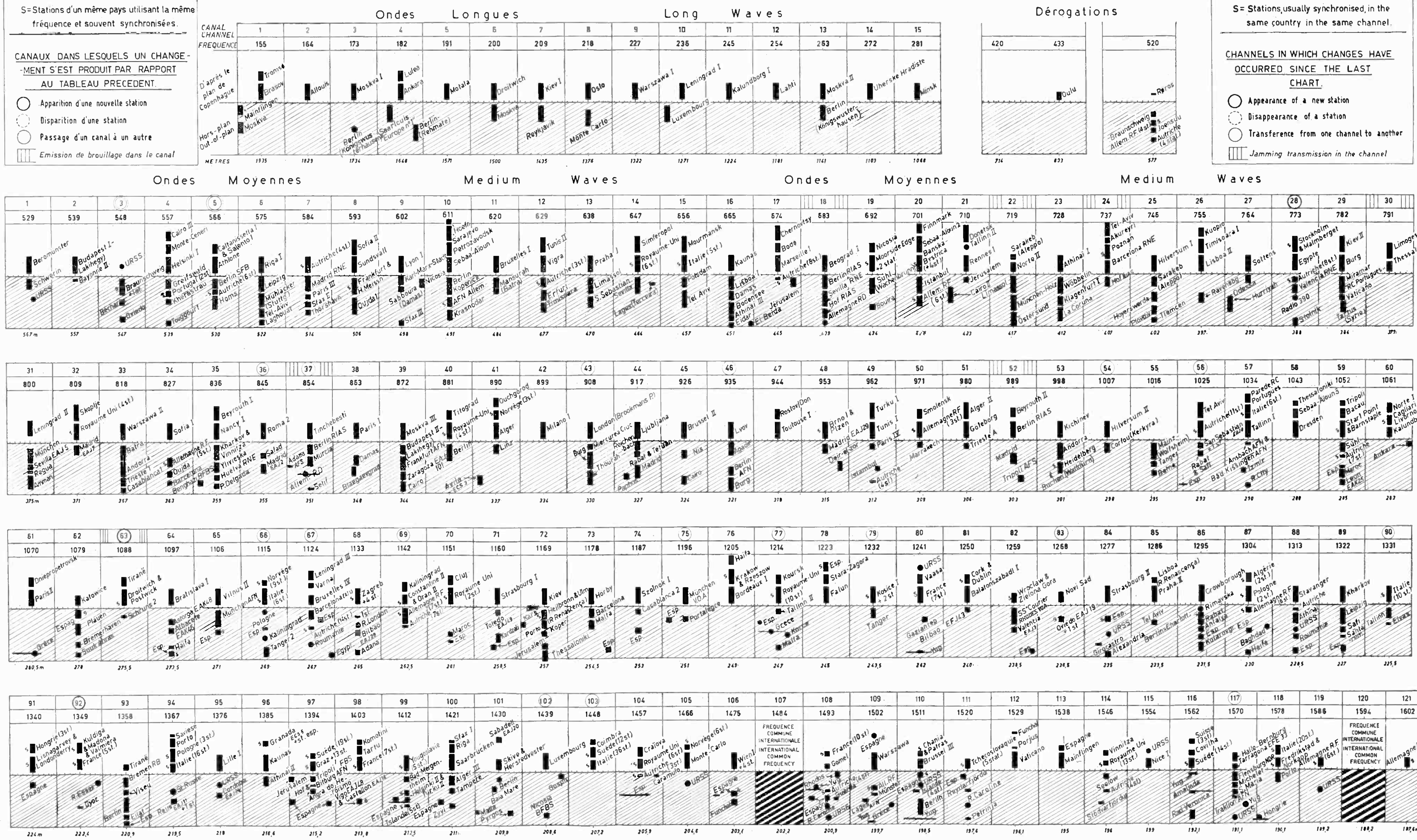
POWER

- Not less than 100 kW
- Less than 100 kW
- Less than 10 kW
- Less than 1 kW
- Unknown

S = Stations usually synchronised, in the same country in the same channel.

CHANNELS IN WHICH CHANGES HAVE OCCURRED SINCE THE LAST CHART.

- Appearance of a new station
- Disappearance of a station
- Transference from one channel to another
- Jamming transmission in the channel



2—PROBABILITY AND STATISTICS

By D. A. BELL,* M.A., B.Sc., Ph.D., M.I.E.E., F.Inst.P.

THIS series started on a basis of "jam today and bread and butter tomorrow", since the first instalment outlined the important results which depend on statistics but we have now to learn how to use statistical techniques. The foundation of statistics must be a theory of probability, and the "frequency" theory of probability is based on the rather elusive concept of the "principle of indifference" or "principle of insufficient reason" which might be better expressed in modern English as the "principle of non-discrimination". If a penny is tossed in the air, we know of no relevant difference between the "heads" and "tails" side, no sufficient reason why it should come down one way more often than the other. Therefore we predict that on average, over a very large number of trials, it will come down as often heads as tails, i.e. the *frequencies* of the two events are equal. But we predict equal frequencies because we have postulated equal probabilities, and conversely we might use equality of the frequencies as a test that the penny and the tossing arrangements are free from bias. Therefore in the frequency theory of probability we equate the frequency of occurrence of an event with its probability. Moreover, there is a convention that probability is measured on a scale between nought (it will certainly not happen) and one (it will certainly happen); and that when there are several independent possibilities with probabilities $p_1, p_2 \ldots . p_n$, their probabilities sum to unity: $\sum_{i=1}^{n} p_i = 1$.

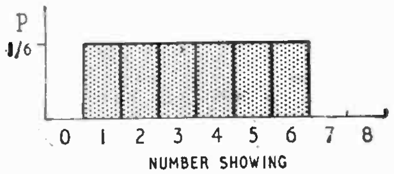


Fig. 1. Probability distribution of numbers thrown with a normal dice.

The second feature follows automatically, because there must be some result from each trial, e.g. on tossing a penny it is practically certain to come down one way or the other (If you want to allow for the possibility of someone snatching it in mid air, or of it standing on edge, you must subtract a little from the value of 0.5 normally assigned to each of the probabilities of heads and tails in order to provide for this new possibility).

Now move on from tossing pennies to throwing dice, so that the number of possibilities on each throw is increased from 2 to 6. Then with an unbiased dice the probability of each of the numbers 1 to 6 is 1/6th, while the probability of 0 and of numbers greater than 6 is zero. This introduces the idea of a probability distribution, in this case a uniform distribution as shown in Fig. 1, where each number which may be thrown is represented by a vertical bar of unit width centred on the scale value. Now suppose I have a trick dice on which the *one* has been replaced by a second *six*. Clearly the probability of throwing a *one* falls to zero, but the probability of a *six* is doubled, giving the non-uniform distribution of Fig. 2. Both distributions satisfy the condition $\Sigma p = 1$, or the area under the distribution curve is unity. By going to a more elaborate mechanism so that there are very many states from which to choose, the discrete states merge into a continuous curve, which is some function of the state variable and the probability sum is replaced by a probability integral $\int p(x)\,dx = 1$. Here $p(x)$ is called a *probability density function*, because it indicates the amount of probability associated with a short range dx of the variable, and $p(x)\,dx$ is the probability of finding a value between x and $x + dx$. This idea of a continuous probability distribution is fundamental to the Poisson distribution of events which will later turn out to be of very wide application, but for the present let us look at some further properties of discrete probabilities.

The simple results arising from the compounding of independent random events seem to flout human common sense just because they are random, i.e. are not governed by any directly systematic rule. For example, if a penny has come down heads three times in succession it is very tempting to say that it is unlikely to be the same for a fourth time. Yet at that moment, when one is looking only one throw ahead, the chance of the one particular result out of two possibilities is 0.5. On the other hand, looking ahead from the start the chance of a run of 4 is $(1/2)^4 = 1/16$. This does not mean that the probability for the last throw is changed by making the first three throws. On the contrary the probability of a run of 4 was 1/16 at the beginning, but if one has had the good fortune to have a run of three there is a fifty-fifty chance of extending it to a run of four.

At this point one might think of investigating the probabilities of the various patterns of heads and tails which might occur in a group of four and one point is worth making: if one asks for any one specific pattern, be it four heads, or first and last tails with middle two heads, or any other, it has a probability of 1/16. The direct approach to this is that with four primary choices there are 16

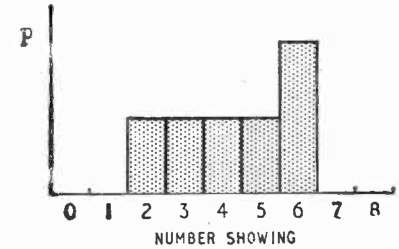


Fig. 2. Probability distribution for throws with a trick dice on which the "1" has been replaced by a second "6."

*University of Hull

possible combinations, all equally probable, so the probability of each is 1/16. If the intuitive (but false) idea that a run of four alike is less likely that a mixed set is still troublesome, remember that the probability of getting the "right" answer on any one of the four occasions is 1/2; so if the successive events are independent the chance of getting them all "right"—whichever way up may be "right" on each occasion—is 1/16.

The fifty-fifty case of tossing the penny is not the best for further investigation, because its symmetry might conceal important properties of the more general case of unequal probabilities. So suppose there is a game of dice in which only *sixes* count. Since the probability of throwing a *six* is 1/6, the average (over a very long run) of the number of throws required to get a *six* is just 6. But, objects the gambler, I do not want to play all night so as to be able to work to the average; I want to know what are the odds on getting *nought*, *one*, or several *sixes* in the first 8 throws, say. Taking the worst case first, the probability on each throw of failing to secure a *six* is 5/6; therefore for 8 independent throws the chance of no *sixes* is $(5/6)^8$. If the first throw is a *six*—with probability 1/6—a result

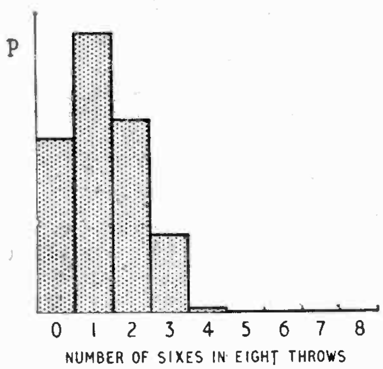


Fig. 3. Probability distribution (binomial) resulting from choices from a larger number of states (the number of "6's" in eight throws of a dice).

of one *six* only requires that the remaining 7 must be blank with combined probability $(5/6)^7$; or if the first is a blank—with probability 5/6 which together with the 1/6 of the previous case makes the sum of probabilities for the first throw equal unity—the second throw might be the lucky one, leading to a combined probability $(5/6)(1/6)(5/6)^6$. Thus the combined probability is the same whichever of the 6 throws is the lucky one, and the total probability of one *six* in 8 throws is $8(1/6)(5/6)^7$. The number of arrangements with two lucky throws is the number of ways of choosing 2 items out of 8, weighted with probability 1/6 for each of the lucky throws and 5/6 for each of the blanks, and so on. Hence we can now write:

$$P(0) + P(1) + P(2) + \ldots + P(8)$$
$$= (5/6)^8 + 8(1/6)(5/6) + \binom{8}{2}(1/6)^2 (5/6)^6 + \ldots\ldots\ldots\ldots + (1/6)^8$$

where $\binom{n}{r} = \dfrac{n!}{r!\,(n-r)!}$

is the number of ways of choosing r things out of n, or a binomial coefficient. The nine probabilities are thus the successive terms in the binomial expansion of $(1/6 + 5/6)^8$. Since $(1/6 + 5/6)^8 = (1)^8 = 1$, the requirement that $\Sigma P = 1$ is obviously satisfied. A histogram of this probability distribution, which for obvious reasons is called a binomial distribution, is shown in Fig. 3. One can then consult any text book and find that if the distribution is defined by $(p + q)^n$, with $p + q = 1$, the mean value is np and the variance npq; but that is anticipating, since *variance* has not yet been described.

Having established the general formula $(p + q)^n$, let us return to another binary example, $p = q = \frac{1}{2}$, namely a model known as Galton's apparatus (Fig. 4). Small spheres are allowed to fall one by one out of a hopper in such a way that each one strikes symmetrically a pin P_1 and has equal probabilities, 0.5, of being deflected to the right or to the left. It then strikes either pin P_{21} or pin P_{22} with again equal probabilities of deflection to right or left. There is only one sequence of events which leads a sphere to travel to the extreme right-hand edge of the array, and one to the left, but various zig-zag paths through the pins will bring it out more or less in the middle. If the spheres are collected at the bottom in an array of transparent cells they will build up faster towards the centre of the array and will in fact delineate the probability distribution as a function of distance from the centre: it will be a symmetrical binomial distribution. Now if the number of pins and the number of cells in the receiver are both increased the steps in the binomial distribution will decrease and it will approximate to a smooth curve. The limiting curve is the one known as the *gaussian* or *normal law of errors* distribution. It is probably the best-known and most widely tabulated statistical function, but it has been introduced here as a limiting form of the binomial distribution rather than as a distribution in its own right, because there is no simple physical derivation of the mathematical form of the gaussian which is:—

$$p(x) = \frac{1}{\sigma\sqrt{(2\pi)}}\, exp\,[-(x - x_0)^2/2\sigma^2] \quad .. \quad (1)$$

where x_0 is the mean and σ^2 the variance (to be defined shortly).

The mathematical proof that the

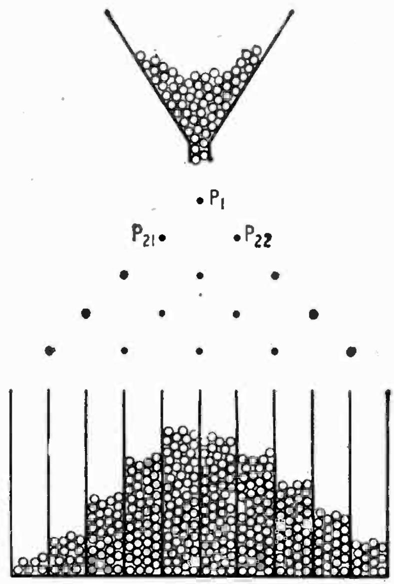


Fig. 4. Galton's apparatus for forming a symmetrical binomial distribution. Small spheres fall from the hopper and are deflected through the arrangement of pins (P) into the array of cells.

gaussian is a limiting form of any binomial distribution which is not too unsymmetrical is not difficult but a little cumbersome, and can be found in textbooks. The essential step is to replace the factorials in the binomial coefficients by exponentials; and this is achieved with the aid of Stirling's theorem which is so frequently useful as to deserve mention. Factorials increase very rapidly: 5! can be calculated in one's head as 120; 10! is over three and a half million; and 100! is nearly 10^{158}. (Clearly there is little future in calculating binomial coefficients of high order, and that is why the gaussian distribution is so valuable as a limiting approximation to the binomial). Such rapidly growing quantities are best handled as logarithms through the logarithmic form of Stirling's theorem which states that

$$\log_e(n!) = n.\log_e n - n + \tfrac{1}{2}\log_e(2\,n\pi) + \log_e S \;\ldots\ldots\ldots\ldots\ldots\ldots \;(2)$$

where $S = 1 + \frac{1}{12n} + \frac{1}{288n^2} - \frac{139}{51840\,n^3} \ldots\ldots$

For $n = 100$ the series S exceeds unity by only 0.08% so it is usually ignored entirely; and for n large the term which contains n only in the argument of the logarithm is unimportant, so that commonly used approximation is:—

$$\log_e(n!) \approx n \log_e n - n \ldots\ldots \quad (3)$$

For further reading

The reader who wishes to take statistics seriously should by this time be thinking about textbooks. The writer's "Statistical Methods in Electrical Engineering" (Chapman and Hall) is elementary but endeavours to establish the probability foundations fairly firmly and has the bias indicated by its title. T. C. Fry's "Probability and its Engineering Uses" (Van Nostrand) is a classic work with emphasis on telephone engineering and has useful tables including factorials, binomial coefficients and functions of the Poisson distribution. K. A. Brownlee's "Industrial Experimentation" (H.M.S.O.) is useful for the field known as *the design of experiments* and for quality control. Burington and May's "Handbook of Probability and Statistics with Tables" provides a concise encyclopaedia of definitions and formulae which is valuable when one has acquired some general knowledge of the subject. It also has tables of the most-used statistical functions.

Transistor Pulse Generator

100 c/s–100 kc/s WITH VARIABLE DURATION AND 20 ns RISE TIME

By C. DJOKIC, Dipl.Ing., A.M.I.E.R.E.

THE pulse generator to be described is a compact transistor unit with its own stabilized power supplies. The generator was designed for a University teaching laboratory but it is felt it could also be of use in research applications where a high-quality instrument is not needed.

It consists basically of an oscillator which triggers a monostable "pulse-stretcher" to produce pulses of various durations. The oscillator covers the range 100 c/s to 100 kc/s in three ranges and the pulse duration can have any length from 1 μs to 1 ms, again in three ranges dependent on the oscillator range. The output pulse can be either negative or positive in the range 0 to 6 V at low impedance and has a rise time of 20 ns (Fig. 1).

The oscillator

The oscillator covers the range from 10 μs to 10 ms, in three ranges: 10-100 μs, 100 μs-1 ms, 1-10 ms. The transistors Tr1 and Tr2 are arranged as an emitter-coupled multivibrator. A variable potentiometer (the Fine control) enables the output frequency to be set within any of these ranges. The oscillator output is rectangular and is differentiated by R_1C_1 and applied to the monostable pulse-stretching circuit. The differentiated output pulses have a duration of 0.15 μs and thus do not affect the operation of the monostable circuit. The negative pulses are supressed by diode D1.

Monostable pulse -stretching circuit

The pulse-stretcher operates with two transistors, Tr3 and Tr4 and their associated components, as shown in Fig. 2.

Considering the components R_2, R_x, R_3, R_4, R_5, as constituting an equivalent resistance R_t (Fig. 3) it is possible to obtain a 10 : 1 change in pulse width if R_t changes from 2.3 kΩ to 23 kΩ. This is achieved by varying the potentiometer R_4 from zero to its full value. Normally the transistor Tr3 is off and transistor Tr4 is on. If the transistor Tr4 is triggered from the pulse generator it will turn off and the voltage at point A (V_c) will change from near zero to −13.5 V and C charges with a time constant $T = CR_t$. Eventually the voltage at point B reaches a value such that Tr3 turns off. In the absence of diode D3 point B would go positive and C would discharge

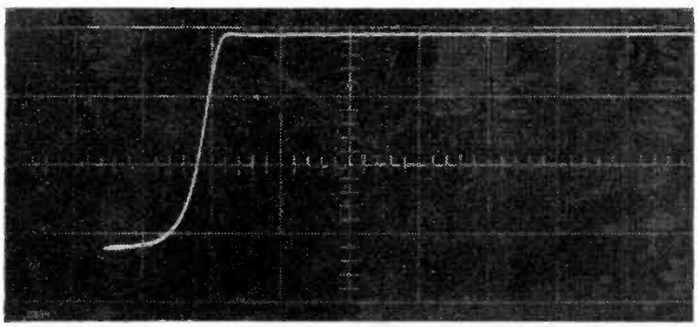


Fig. 1. Rise time of output pulse: abscissa 50 ns/cm.

C. Djokic, born in Yugoslavia in 1911, graduated at the Ecole Polytechnique, Paris, in 1936. Since coming to England he has spent ten years (1951-61) with the Ever Ready Company, as designer of industrial electronic instruments, and since 1961 has been on the staff of the Physics Department of the University of Birmingham.

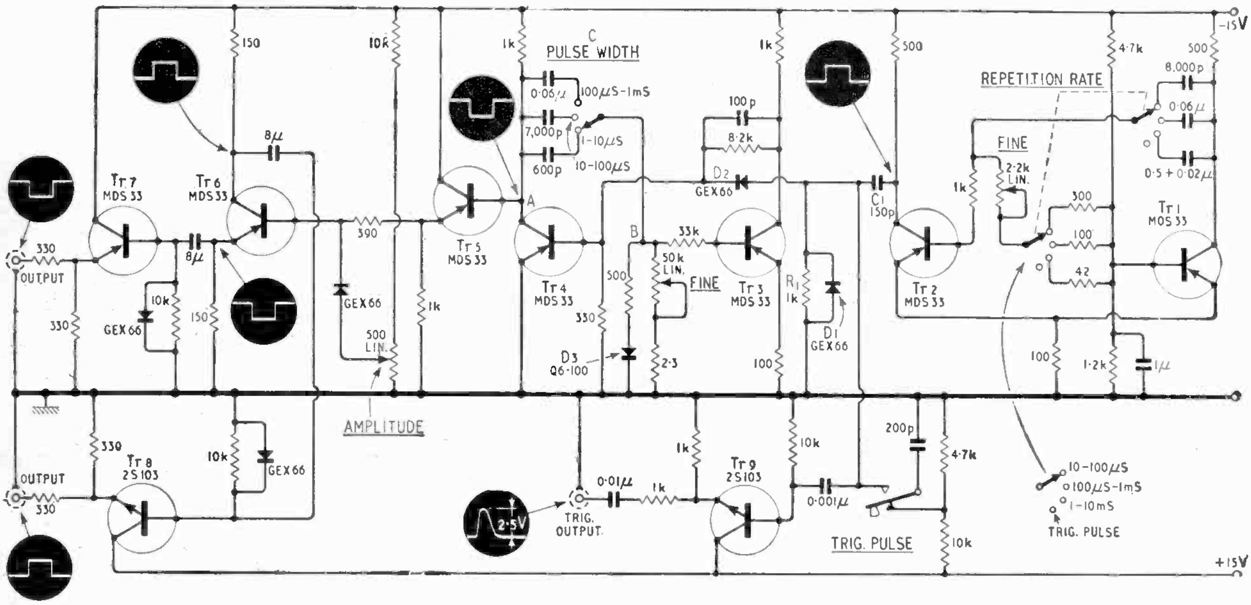


Fig. 2. Complete circuit of pulse generator. Tr1 and Tr2 are the oscillator transistors, Tr3 and Tr4 form the monostable pulse-stretcher, Tr5 forms a buffer stage and Tr6 is a phase inverter.

through R_t (now R_4 and R_5). However, as D3 is present the discharge path for C is through D3 and R_6. This results in a rapid recovery of the pulse-stretcher circuit and enables it to be retriggered immediately (after 13 ns).

The pulse duration (Fig. 4) de-

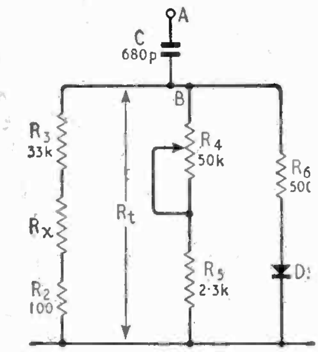


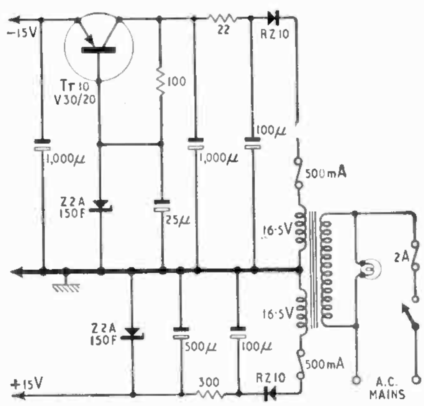
Fig. 3. Equivalent resistance (R_t) at points A and B of Fig. 2. R_x represents the saturation resistance of Tr3.

pends on the Fine time constant CR_t and also on the characteristics of the transistors Tr3 and Tr4. These transistors are type MDS33* and have a minimum β of 30. Using the circuit of Fig. 2 it was found that to achieve a 1 μs pulse $R_t = 2.3\,\text{k}\Omega$ and $C = 680\,\text{pF}$. This accordingly fixes R_t at 23 kΩ.

The forward impedance of the diode D3 is too small to be taken into consideration but as R_6 is in parallel with R_t, which for a pulse of 1 μs duration is 2.3 kΩ, the resulting resistance is about 400 Ω. The discharge path for C is completed *via* transistor Tr4 and is of negligible impedance compared to 400 Ω. The discharge time of C is the dead time T_d for the pulse circuit (a constant 13 ns).

Output stages

The output stages consist of transistors Tr5, Tr6, Tr7 and Tr8. Transistor Tr5 acts as a buffer between the high impedance output from transistor Tr4, and the phase-splitting circuit around Tr6. The pulses obtained from transistor Tr6 have 180° phase difference and are applied to output emitter-followers Tr7 and Tr8. The



output impedance is of the order of 450Ω and 330Ω and current limiting resistors are connected in series with the output to prevent damage.

Acknowledgment:—I wish to express my gratitude to Professor W. E. Burcham for permission to publish this article. I am also indebted to Dr. H. V. Van der Taay and Mr. G. C. Barney for their advice.

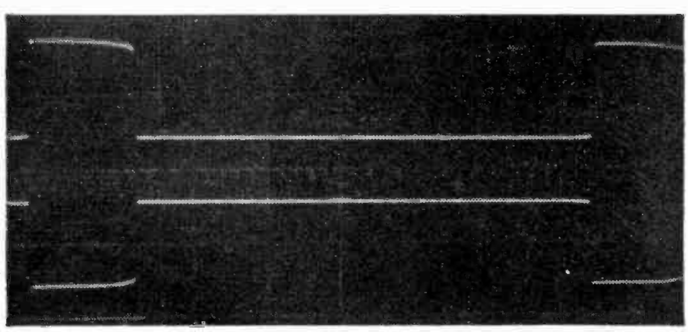


Fig. 4. Typical output waveforms.

* Semiconductors Ltd.

Stray Oscilloscope Traces

AN INVESTIGATION OF A WELL-KNOWN PHENOMENON

By T. P. GRIEG,* B.Sc.(Eng.)

MOST experimenters, at some time, will have touched a wire attached to the Y or A terminals of an oscilloscope and perhaps been surprised to see a large amplitude trace, similar in shape to that in Fig. 1 and at mains frequency, appearing on the tube face. With the wire connected to the Y terminal, i.e., direct to the deflecting plates, the size of the voltage waveform obtained with a typical oscilloscope might be of the order of 100 V pk-pk. If a connection to the amplifier of the oscilloscope is touched, the voltage is so large that clipping of the waveform occurs.

Preliminary investigation

The explanation of the phenomenon is by no means simple or straightforward. One's first thought is that somehow or other, the operator's body is picking up this voltage from stray magnetic or electrostatic fields associated with the mains supply. Although the body does "pick up" a voltage mainly by electrostatic coupling to mains leads, this can hardly account for the large deflecting voltage produced. Some simple experiments soon show that this explanation is not the answer and also give some clues as to what, in the writer's opinion, is the cause of this phenomenon.

First, if a long coaxial cable is connected between the Y and E terminals of the oscilloscope and the cable unwound so that the far end is in a location well removed from possible sources of mains pick up (in the middle of a public park, for example) the waveform still appears on the tube when the centre conductor of the cable is touched. It is interesting when doing this to compare the sizes of the traces produced when standing on the grass and on a tarmac path. The waveform in the former case will be found to have the larger amplitude.

Secondly, if the chassis of the oscilloscope is connected to a reliable earth then it is impossible to produce the above effect when connection is made to the Y plates. Connection to the A terminal with high amplifier gain will, however, produce a trace on the oscilloscope. This is definitely a "pick up" effect, as can be shown by placing the end of the wire near the mains lead of the oscilloscope. The closer the end of the wire is to the mains lead, the larger the trace obtained. The operator's effective earth resistance also has an effect. Some "pick up" of voltage thus does occur but the size of the voltage induced will generally be small. It should be remembered here that in some commercial oscilloscopes, the E terminal is connected to the chassis and is floating. (This enables the voltage across a component, both ends of which have a voltage to earth, to be displayed.)

Finally, the human element can be removed by connecting the Y terminal directly to earth. A wave of even larger amplitude than that obtained with the operator touching the wire appears on the tube face.

The results of these experiments demonstrate that the major cause of the above effect is certainly not pick up of stray fields. In fact, the voltage which causes the trace appears to be produced inside the oscilloscope itself. The only part played by the human body is to complete a path which enables this voltage, or part of it, to be applied to the Y deflection plates of the oscilloscope.

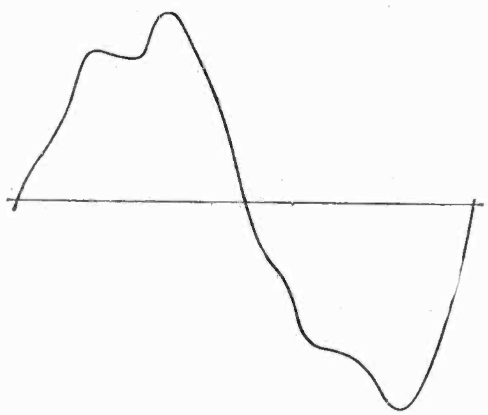


Fig. 1. Typical trace at mains frequency obtained by touching Y or A terminal of oscilloscope.

Chassis potential

Further experimentation shows that the source of this voltage is the chassis itself. When it floats it takes up an a.c. potential to earth. This potential can sometimes be felt by the user of an oscilloscope, if he brushes the back of his hand against a bare part of the chassis. If he touches the chassis, however, its potential is immediately brought down to a non-dangerous level. The lower his resistance to earth, the lower the potential and it is impossible to receive an electric shock from this source. There is generally a sufficiently high voltage to earth to make the neon lamp in a tester screwdriver light up, which may give the impression that the chassis is lethally "live." The explanation of this is that the combined resistance of the neon protecting resistor and the body's resistance is sufficiently high to maintain the voltage of the chassis at a level which will make the neon strike.

To see why the chassis takes up a potential to earth and to investigate the factors on which the size of this potential depends a search must be made in the oscilloscope for points with alternating potentials to earth which are capacitively coupled to earth. The search soon reveals the principal offender, *viz* the mains transformer. A simplified diagram of a mains transformer, and the capacitances of the various windings to chassis is shown in Fig. 2. The ends of the various windings have different potentials to earth and these potentials

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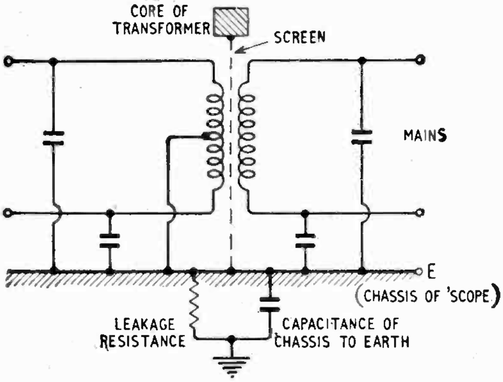


Fig. 2. Derivation of oscilloscope chassis potential, showing capacitances of various windings to chassis.

are coupled to the chassis by their individual capacitances to chassis. These capacitances comprise not only the capacitance of the windings to the screen but also their capacitances to the core of the transformer. A more detailed representation of the transformer is feasible but it is so complicated that it becomes extremely difficult, if not impossible, to analyse or even visualize what will happen. The path which enables these potentials to affect the chassis is completed by its insulation resistance in parallel with its capacitance to earth. There results a capacitive mixing system, the net effect of the different winding potentials and their capacitances being as illustrated by the circuit to the left in Fig. 3. With this capacitor voltage-divider arrangement, the potential that the chassis takes up depends on the effective potential of the transformer windings to earth, their effective capacitance to the chassis (the top end of the divider) and on the leakage resistance and capacitance of the chassis to earth (bottom end of the divider). Reducing the bottom-end impedance by, for example, connecting an external capacitance between the E terminal of the oscilloscope and earth will reduce the voltage of the chassis to earth. This can be checked by using a measuring oscilloscope of sufficiently high input impedance not to drastically affect the results. Again, touching the chassis of the oscilloscope puts the body's insulation resistance in parallel with the bottom-end impedance, lowering it, which also brings down the potential of the chassis to earth. If the operator cares and dares to remove his shoes and stockings and stand on an earthed plate, it will be found that the potential of the chassis is considerably attenuated. Electric shocks from this source are thus impossible.

It is difficult to modify the effective potential of the transformer to earth or its effective capacitance to chassis. A simple test to show that the transformer is probably the cause of the trouble is to disconnect the transformer screen from the chassis and connect it to earth. This will alter the voltage of the chassis to earth, the change being dependent on the construction of the transformer: how close the windings are to the chassis and also whether the transformer is shrouded or not.

Effect on Y plates

This circuit then seems feasible, and consideration must now be given as to how the potential of the chassis has an effect on the deflecting plates. One of the *y* deflecting plates is connected to chassis and the other is taken out directly, or through a capacitance, to the front Y terminal. When this terminal is touched the insulation resistance of the operator's body completes the path to earth, enabling part of the potential of the chassis to be applied to the deflecting plates (see the circuit to the right of Fig. 3). Once again we have a voltage divider, the top end being the capacitive reactance of the plates and the bottom end the impedance connected between the Y terminal of the oscilloscope and earth. The voltage applied to the deflecting plates will be greater the lower the bottom-end impedance and also the smaller the capacitance of the deflecting plates. Some tests were carried out to verify the above using an old Cossor 339 double-beam oscilloscope and an E.M.I. measuring oscilloscope, the results of which are given below. The size of the voltage being applied to the deflection plates was estimated from the length of the trace using the calibrating voltage of 50 V pk-pk available on the Cossor oscilloscope.

Condition (Y terminal used d.c. connected)	Deflecting voltage (pk-pk)	Chassis voltage (pk-pk)
(a) No connection to Y	0V	180V
(b) Y joined to true earth	127	132
(c) As in (b) but with E.M.I. oscilloscope removed	135	—
(d) 1 MΩ between Y and earth ..	97	158
(e) 10 MΩ between Y and earth ..	21	168
(f) Y to earth, 1000 pF between chassis and earth	115	122
(g) Operator on wooden floor with leather shoes touching	88	152
(h) As (g) but with rubber shoes ..	24	172
(i) Operator sitting on wooden stool on wooden floor	18	172
(j) Operator on earthed plate, no shoes or stockings	133	142
(k) 100 pF between Y and earth ..	26	172
(l) Operator with leather shoes on earthed plate	133	140

There are some inconsistencies in these results, notably in (b) and (f) where the two voltage readings should be the same. These are probably due to the crude and unavoidable method of measurement.

However, the results are in general agreement with the postulated equivalent circuit of Fig. 3. Raising the impedance between Y and earth has two effects. First, the voltage across the deflecting plates, which is displayed on the Cossor oscilloscope is reduced, and secondly, the potential of the chassis rises. This is just what could be expected from the double potential divider arrangement of Fig. 3. This can then be taken, with fair confidence, as a reasonable equivalent of the actual, very complicated circuit responsible for this effect. Incidentally, the results demonstrate quite effectively how the body's total earth resistance is changed by, for example, changing one's shoes. The old adage "there is nothing like leather" does not apply to insulation resistance!

When the A terminal of the oscilloscope is touched

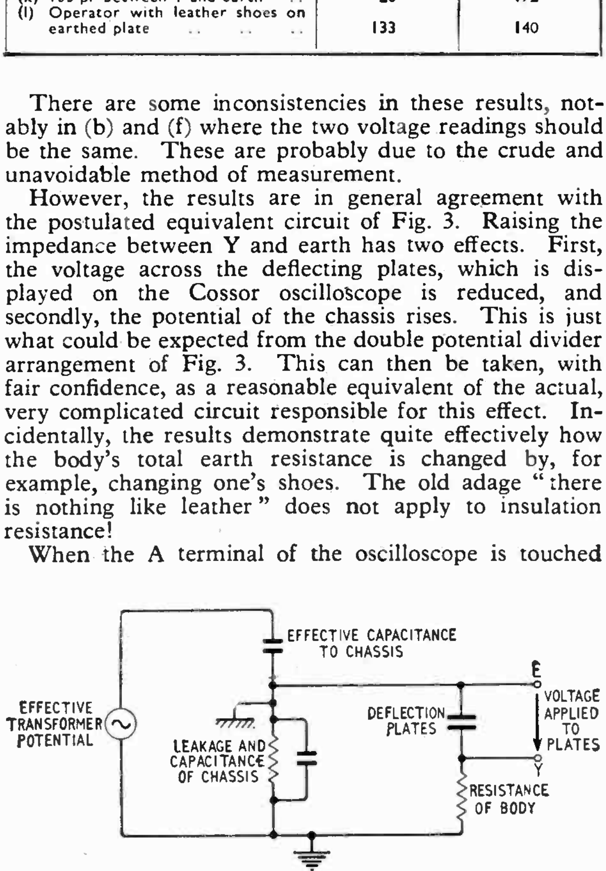
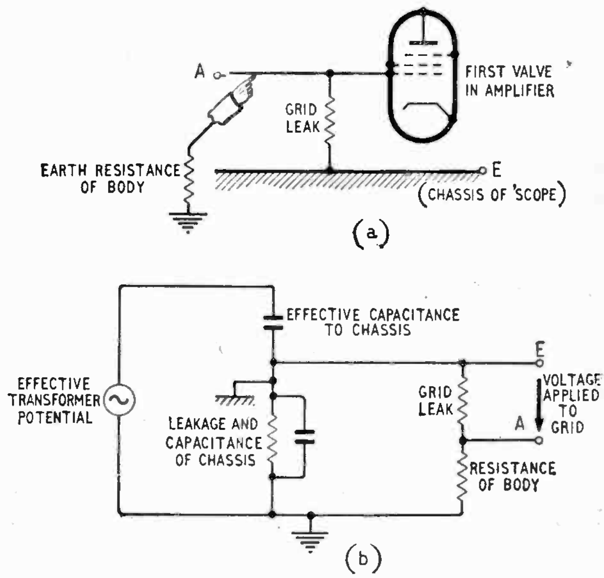


Fig. 3. Equivalent capacitor voltage divider resulting from Fig. 2.

Fig. 4. (a) Touching A terminal on oscilloscope introduces chassis potential to grid as shown at (b). The effect is similar to hum produced when a grid of an a.f. amplifier is touched.



(Fig. 4 (a)) the potential of the chassis is transmitted in part to the grid of the first valve in the amplifier. The method by which this takes place is shown in Fig 4 (b). While the voltage applied to the grid of the valve will depend on the body's resistance to earth, there will generally be sufficient to overload this valve and to produce a large clipped trace on the tube face. This is also the explanation of the loud hum produced by the loudspeaker of an a.f. amplifier if the grid of one of the valves is touched. Earthing the chassis should reduce this hum to negligible proportions.

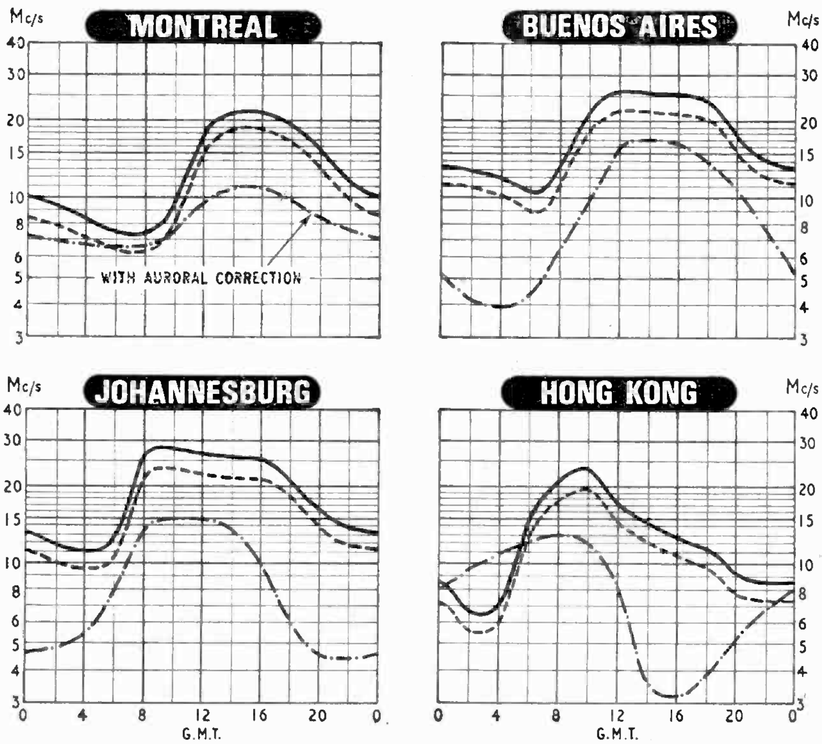
Conclusion

Summarizing, the mains-frequency trace that appears on the face of an oscilloscope when the A or the Y terminal is touched is due to the alternating potential which the chassis takes up and the major source of this potential is the mains transformer. The effect is removed by earthing the oscilloscope chassis, but this is not always desirable. In many present-day oscilloscopes it is standard practice to earth the chassis.

The distorted waveform produced by this effect (e.g. Fig. 1) contains the 3rd harmonic which presumably arises at the transformer and is accentuated by the capacitor network.

Finally, I would like to thank my colleagues who have helped in the experiments and with suggestions, and also some of my students who provided completing paths with varying degrees of resistance.

H. F. PREDICTIONS — FEBRUARY



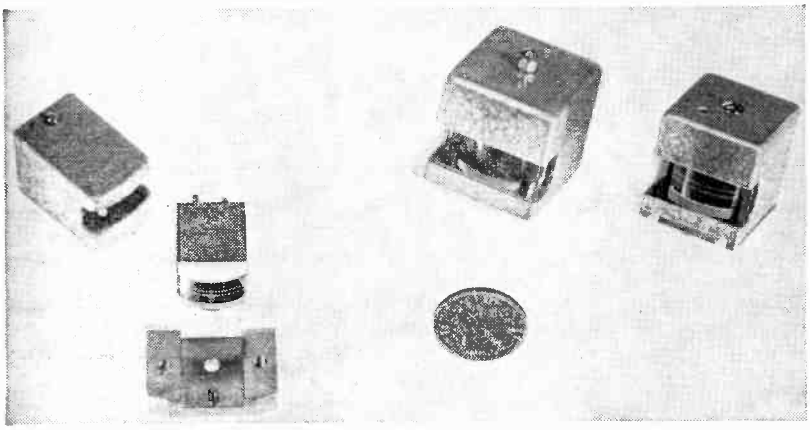
The prediction curves show the median standard MUF, optimum traffic frequency and the lowest usable frequency (LUF) for reception in the U.K. Unlike the standard MUF, the LUF is closely dependent upon such factors as transmitter power, aerials, and the type of modulation. The LUF curves shown (drawn by Cable and Wireless Ltd.) are for commercial telegraphy and assume the use of transmitters of several kilowatts and aerials of the rhombic type.

The Northern Auroral Zone passes roughly through Alaska, Hudson Bay, Iceland and Northern Norway. Radio paths passing through this zone are subject to additional absorption, and a correction is made for this in the calculation of the LUF.

The higher daytime MUFs, characteristic of the winter months, are now apparent for circuits predominantly in the Northern hemisphere.

NEW PRODUCTS

equipment systems components



Ferrite Magnetic Heads

DESIGNED for professional audio recording equipment the new series of ferrite magnetic heads from Mullard's are said to have shown that after 300 hours running time at a tape speed of $7\frac{1}{2}$ in/sec, the output of the ferrite head —measured at 8 kc/s—was only 1.5 dB down, and remained substantially unchanged after a further 5,000 hours. The electrical properties of the heads remain virtually unchanged throughout their working life, which is said to be considerably longer than the laminated-metal types.

Much lower bias currents can be used with these ferrite heads as they have a lower h.f. core loss and a lower eddy current loss than the laminated types. A further reduction in drive current is possible by increasing the bias frequency—a technique which may give only marginal advantage with metal heads.

The frequency response, to quote Mullard's is "generally much better than that of a metal head because the effective electrical gap length corresponds closely to the physical gap length. This is due to the stress-free nature of ferrite which allows it to be machined accurately during manufacture without altering its electrical characteristics—an advantage not shared by metal heads."

Record and replay heads are being produced. Half, full, stereo-twin and two types of quarter-track twin heads are available. Replay heads have 3 μm gaps and record are available with 25 μm (full-track only), 12 μm or 7 μm gaps.

These ferrite heads can be supplied either fixed or adjustable. The adjustable types are housed in a Mumetal screened case and facilities are provided for adjustment of "height" and "tilt," and for final azimuth adjustment with the Mumetal screen in position. A magnetic or non-magnetic outer screen can also be supplied. Shims are available for the fixed types.

WW 301 for further details

SUB-MINIATURE ZENERS

A SERIES of sub-miniature Zener diodes with a three-watt maximum power rating are being produced by Motorola Semiconductor Products Inc. Units in this series—coded IN 4728-64 —have an average volume of only 0.0016 in^3. Continuous rating at 50°C ambient is 1 W, but up to 3 W is possible with suitable heat sinks. Voltage ratings range from 3.3 to 100 V; with standard tolerances of 5 and 10%.

The U.K. stockists for Motorola products are Celdis Ltd., of Trafford Road, Richfield Estate, Reading, Berks.

WW 302 for further details

M.O.S. Field-effect Devices

TWO new metal oxide silicon field-effect transistors, FI100 and FI0049, are now available from SGS-Fairchild.

The FI100 is a single P-Channel device with an input impedance exceeding $10^{13}\Omega$ and operates in the "Enchancement" mode—that is, the conduction between drain and source is achieved only when a biasing voltage is applied to the gate. Chopper and multiplex switching applications are suited to FI100, which features a high ratio of "off-to-on" impedance, zero offset voltage, low capacitance, and low leakage currents. The device can also handle large signals, being limited only by the breakdown voltage characteristics which are in excess of 30 V. The FI100 can be directly coupled to form all basic logic configurations which dissipate pico-watts of power, and can accommodate a much higher fan out than conventional bi-polar transistors.

The FI0049 is essentially two FI100s on a single chip. It may be used as a dual input switch or paralleled to form one device. The advantage of paralleling is that the "on" resistance is halved to 250 Ω maximum and the g_m is doubled to 4,000 $\mu\Omega$ minimum.

The address of SGS-Fairchild is 23 Stonefield Way, Ruislip, Middx.

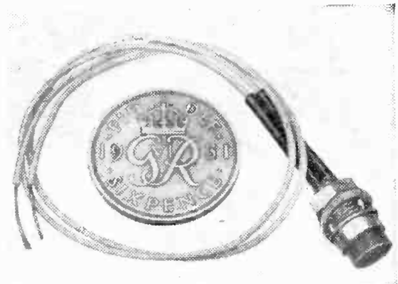
WW 303 for further details

SMALL INDICATOR LIGHTS

LESS than half-an-inch in length and just over quarter-of-an-inch in diameter, is the new sub-miniature indicator light announced by Thorn Special Products Ltd., 284 Southbury Road, Enfield, Middx. Designated Type 0951, this unit is suitable for 5 or 6 V circuits giving respectively an average life of 60,000 or 5,000 hours according to which voltage is used. The indicator can be used on panels up to 0.128 in thick, requires a 13/64 in diameter hole, and is secured by a 2BA locknut.

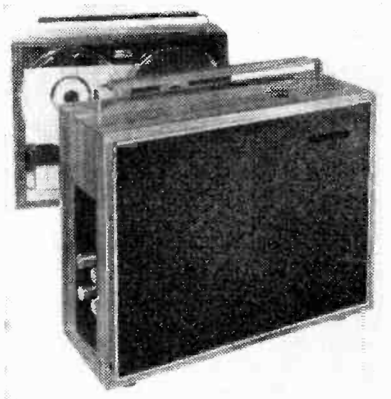
The cylindrical epoxy resin lens for this indicator is available in red, orange, yellow, green, blue or clear.

WW 304 for further details



Vertical Domestic Recorder

THE first product of the recently formed company of Van Der Molen Ltd., of 42 Mawney Road, Romford, Essex (Mr. Van der Molen was previously with Elizabethan), is a transistor tape recorder, the design of which marks a departure from the usual pattern. Normally, recorders (and decks) are designed for horizontal operation and as a result the loudspeaker size is restricted to, at least, the height of the cabinet. To overcome this limitation, in an effort to improve the reproduction without resorting to an external loudspeaker, the deck and loudspeaker are mounted on opposite sides of the teak case (see photograph). This allows a circular 8 in loudspeaker to be used. The overall size of the recorder is about 15×12×8 in and it weighs 16 lb. The tape deck (imported from Italy) was designed specifically for vertical operation.



The amplifier (with AD 161/162 complementary output stage) produces about 4 W r.m.s. continuously or 5 W music rating. Three speeds are provided—$1\frac{7}{8}$, $3\frac{3}{4}$ and $7\frac{1}{2}$ in/sec—giving an amplitude response 3 dB down at 5, 10 and 15 kc/s respectively. With the recording level indicator just indicating maximum input on peaks, the total harmonic distortion is 2%. Three inputs are available: microphone (at least 2 mV at 50 kΩ); tuner or pick-up (30 mV at 1 MΩ); and mixing (200 mV at 100 kΩ). The four variable controls are mixing level, playback gain, bass and treble—which is switched to provide recording level control. Recording level may be set prior to starting the tape in motion. The bass and treble controls are attenuation only.

Two models are so far available, the VR2 and VR4 (two- and four-track mono). A head output is provided on the VR4 (2 mV at 1 kc/s) which may be used in conjunction with a slide projector or for stereo playback, with the addition of a suitable amplifier. A supplementary loudspeaker may be used from an 8 Ω output and 2 V signal is offered at 10 kΩ.

Wow and flutter are quoted to be no greater than 0·15% at $7\frac{1}{2}$ in/sec and the s/n ratio is greater than 40 dB. The price of both models is 59 gn. The distributors are H. O. Thomas Electronics Ltd., of 67 Avenue Chambers, 4 Vernon Place, London, W.C.1.

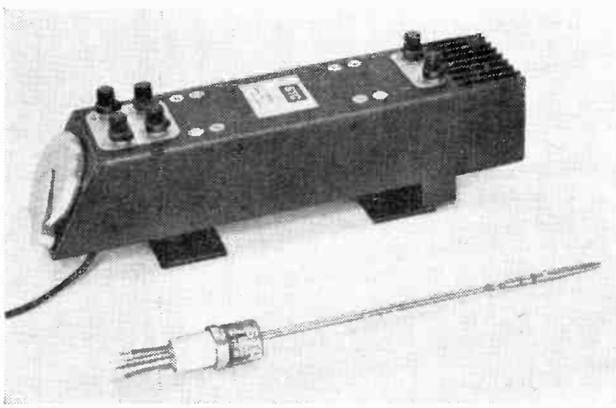
WW 305 for further details

Low-voltage T.W.T.

A NEW low-voltage travelling-wave amplifier has been added to the S.T.C. range of microwave tubes. Designated Type W7/5G, the new tube has a typical gain of 43 dB at a working output of 20 W; saturated output is 30 W. It is designed for operation in the 3.6 to 4.2 Gc/s range and is suitable for multi-channel equipment. A choice of waveguide connections are offered.

The address of Standard Telephones and Cables' valve division is Brixham Road, Paignton, Devon.

WW 306 for further details

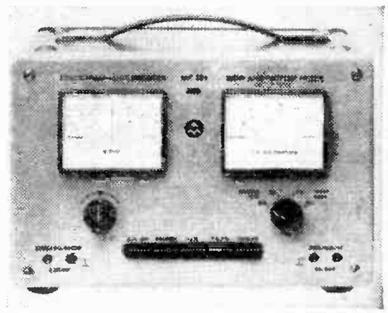


Wow and Flutter Meters

THE range of wow and flutter meters manufactured in Munich by Tech.-Phys. Lab. Dipl.-Ing. B. Woelke are now available in the United Kingdom through Lennard Developments Ltd., 7 Slades Hill, Enfield, Middx.

A general purpose instrument in the range is the Model ME 101. This is a solid state unit and contains an a.f. generator running at 3,150 c/s. Tone fluctuations between ±0.02 and ±2.5% can be read "linearly" or weighted as approximate peak values (to meet C.C.I.R. and D.I.N. specifications). The maximum drift indication (deviation of the mean value of the measuring tone from the theoretical value) is ±4.5%. Ancillary outputs are provided for driving an oscilloscope or a high-speed recorder (approximately 20 V pk-pk).

WW 307 for further details



Pulse Generator

MANY new features are claimed for the new Datapulse precision pulse generator now available from Dynamco Instruments Ltd., of Salisbury Grove, Mytchett, Aldershot, Hants. Among them are: rise times of less than 10 nsec, repetition rates adjustable from 0.5 c/s to 1 Mc/s, 50 V output into 50 Ω, and pulse delays up to 1 sec. Pulse durations range from 50 nsec to 10 msec.

Single and double pulse operation is possible with this instrument, designated Datapulse 107. Pulse delay, width and repetition rate accuracies are claimed to be better than 1% over the ambient temperature range 0° to 50° C. Each of these functions utilizes decade switching and 10-turn vernier dials, which allow a resolution of better than 1 part in 10^3 to be obtained. A direct reading amplitude control is employed in this solid state instrument and is claimed to speed setting-up and ensure repeatable tests. An oscilloscope is not required for stability monitoring or for setting-up.

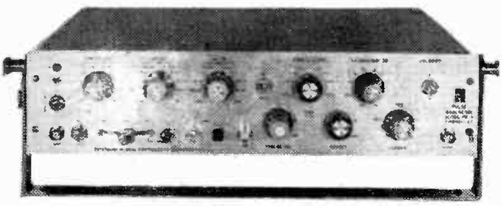
WW 308 for further details

HIGH-FREQUENCY PULSE GENERATOR

RISE times as fast as 5 nsec and pulse repetition rates of up to 50 Mc/s are features of the Model PG-4 pulse generator from Intercontinental Instruments Incorporated, of New York. This instrument is suitable for single and double pulse operation, and has single-shot facilities.

The frequency range in the single mode is 1 c/s to 30 Mc/s from the internal generators and this can be extended to zero frequency by external input. In the double pulse mode the repetition rate is from 1 c/s to 25 Mc/s; giving effective single pulse rates from 2 c/s to 50 Mc/s.

The main pulse output consists of delayed single or double pulses which can be either positive or negative, normal or inverted. The width of the pulses is adjustable from 10 nsec to 0.5 sec in eight ranges with continuous adjustment by means of a vernier control. The output circuits of the PG-4 are so arranged to allow the instrument to be used either as a current source with a high source impedance or as a voltage source with a 50 Ω impedance. In the current mode, the output is adjustable from 10 mA to 200 mA and can be supplied into load impedances from zero to 50 Ω, with source impedance greater than 1 kΩ. In the voltage mode, the output is adjustable from 10 mV to 10 V from a source impedance of 50 Ω. An off-set facility is provided for current and voltage outputs, and when used in conjunction with the polarity and inversion switches, allows full pulse positioning with respect to the baseline. The dimensions of the PG-4 are 3½ × 15 × 15 in and the price is £422, duty free. It is obtainable in the United Kingdom through Claude Lyons Ltd., 76 Old Hall Street, Liverpool, 3.



WW 309 for further details

Oscilloscope Tube

A NEW five-inch instrument tube designed for use with transistor circuits has recently been announced by the English Electric Valve Company, of Chelmsford, Essex. The deflection sensitivity of this tube, designated T98OH, is 2.7 V/cm in the x axis and 8 V/cm in the y axis. These figures can be improved if required by reducing the gun voltage.

Anode modulation plates are fitted and allow the beam to be cut off without any perceptible spot movement. The p.d.a. ratio is 12:1 and the writing speed is said to be "particularly good, traces at speeds of 10 m/μsec having been observed with the naked eye."

WW 310 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(s) 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.

V.H.F./U.H.F. TRANSISTORS

A NEW family of Total Planar transistors designed to operate on centre frequencies of 60, 200, 450 and 800 Mc/s has been announced by SGS-Fairchild Ltd., of 23 Stonefield Way, Ruislip, Middx. Each of these n-p-n devices—BFX18, 19, 20 and 21—features low feedback capacitances (C_{VE} = 0·6 pF max.), high gain and low noise figures, and good forward a.g.c. characteristics.

These devices are particularly suited for use in unneutralized amplifier and high stability oscillator circuits in v.h.f. and u.h.f. communications receivers. Brief details of the transistors measured at V_{CE} = 12 V and I_C = 2·5 mA are: BFX18, min. gain of 30 dB at 60 Mc/s; BFX19, min. gain of 18 dB at 200 Mc/s; BFX20, min. gain of 10 dB at 450 Mc/s; and BFX21, a min. gain of 8 dB at 800 Mc/s. Typical gain figures are 2 dB above the minimum figures quoted.

WW 311 for further details

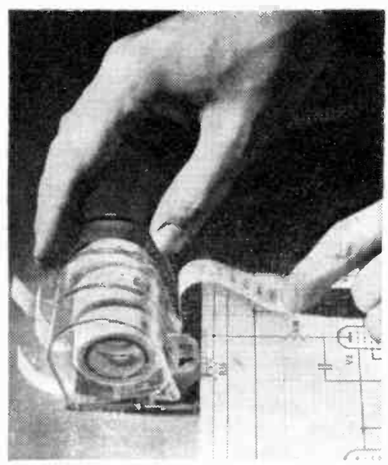
Instant Lettering

A RANGE of 120 different tapes of dry transfer lettering has been introduced by Letraset Ltd. especially for the electronics engineer. The range includes most common reference codes, numerical sequences and frequently used pre-set words.

In addition to the more obvious use—circuit drawings—these Letratapes may be used for marking printed circuit boards, chassis and front panels. Up to 500 symbols, that are heat resistant, are contained on each tape, which costs 6s. Plastic dispensers are available, price 1s 6d each.

The address of Letraset Ltd. is St. George's House, 195-203 Waterloo Road, London, S.E.1.

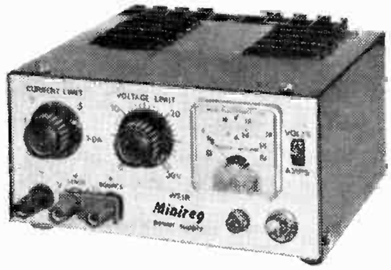
WW 312 for further details



Miniaturized Power Supply Units

A MAXIMUM output of 25 W is quoted for the 400 Minireg range of miniature power supply units made by Weir Electronics Ltd. of Durban Road, Bognor Regis, Sussex. The units measure $7\frac{1}{2} \times 3\frac{1}{4} \times 6\frac{3}{8}$ in and weigh 5 lb.

A continuously variable current limit control and a 1 % continuously variable voltage control are provided on the Model 401. The other unit in the range, the 402, is fitted with a nominal 0.3 % accurate voltage control with digital



readout. Remote programming and sensing facilities are included in both units, which may be operated in series and/or parallel arrangements.

Highlights from the specification include a maximum ripple of 200 μV pk-pk, regulation better than 0.05 %, an internal impedance of less than 10mΩ at 1 kc/s, and an output of up to 30 V with currents of up to 1.25 A at 25°C. In response to any change in loading conditions, the units will recover to within 50 mV in 50 μsec. Three binding posts are provided on the 400 range and allow them to be used as an 0.01 % current regulator; a pulsed voltage regulator (30 μsec rise time); temperature regulator; and as a power amplifier.

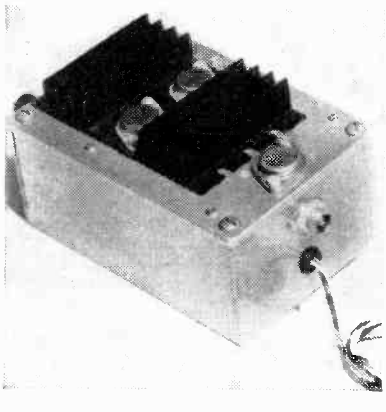
The standard unit (401) costs £39 10s and the 402 unit £44 10s.

WW 314 for further details

TRANSISTOR POWER AMPLIFIER

CAPABLE of delivering 21 V r.m.s. into any load impedance over 12 Ω is the new solid state voltage amplifier from Bradmatic Ltd., of 338 Aldrige Road, Streetly, Sutton Coldfield, Warks. Designated Type MA30, this amplifier is particularly suitable for driving electrostatic loudspeakers and can be used in many other applications, as the voltage generated across the output terminals is hardly affected by the load impedance. The manufacturers do, however, recommend a minimum load impedance of 12 Ω to ensure that the safe current rating of the output transistors is not exceeded.

Seven transistors are employed in this amplifier. The first two receive a.c. and d.c. negative feedback, the a.c. feedback being varied to alter the input sensitivity. Only d.c. feedback is provided to the driver stage, which comprises three transistors. Input impedance at the standard sensitivity (100 mV r.m.s.) is 10 kΩ. Frequency response at 15 V r.m.s. output is within 3 dB from 10 c/s to 17.5 kc/s with an output impedance of 15 Ω and up to



24.5 kc/s with an infinite load impedance. Distortion at 1 kc/s is less than 1% with a 30 W output.

Overall dimensions of the MA30 are 4×4×7 in and the weight is $3\frac{1}{4}$ lb. Retail price is £14. A power supply unit (PP30X2) suitable for driving a pair of these amplifiers is available for stereo working. Retail price of this unit is £11.

WW 313 for further details

Low-cost, High-frequency Transistors

TWO low-cost, epoxy encapsulated silicon planar transistors designed for high-frequency applications are now available from Jermyn Industries Ltd., of Vestry Road, Sevenoaks, Kent.

The transistors, 2N3662 and 2N3663, feature a typical circuit gain bandwidth product of 19.7 dB at 200 Mc/s. The V_{CBO} for the 2N3662 is 18 V, and 30 V for the 2N3663. Collector current for both devices is 25 mA. Typical gain bandwidth product is 1,200 Mc/s.

In quantities of one hundred, the 2N3662 costs 8s and the 2N3663 8s 6d. Both devices are manufactured in the United States by General Electric.

WW 315 for further details

Tunnel Diode Mixers and Amplifiers

SEVERAL tunnel diode mixers and amplifiers, made in the United States by Reindel Microwave Incorporated, are now available in the United Kingdom through Wessex Electronics Ltd., Royal London Buildings, Baldwin Street, Bristol, 1.

Mixers for the S, C and X bands are included in the range. Advantages claimed for these mixers when compared with conventional devices, include a typical i.f. impedance of 60 Ω and a temperature range of −50° to +100°C. As an example of the mixers, the Model 1MA covers the frequency range 300 Mc/s to 3 Gc/s, requires no d.c. bias, has a noise figure of 7 dB and suffers little change in performance with variations in local oscillator power variations. The specification limits are from −3 to −20 dBm. Weight of this device is 1.5 oz.

The amplifiers contain an improved circuit featuring low noise, easy diode replacement and smaller size. These amplifiers may be terminated in unmatched loads and even under these conditions they will retain their stable gain and phase characteristics. Models with four or five port circulators are available, the latter providing an additional 30 dB isolation at the amplifier output port. Specification details include a frequency range of 1 to 7 Gc/s, standard bandwidth of 10% or 400 Mc/s, minimum gain of 15 dB, maximum noise figure of 5 dB, and a maximum gain variation of 1 dB. Power requirement is 10 mA at 1.5 V d.c. and saturation power level is −15 dB

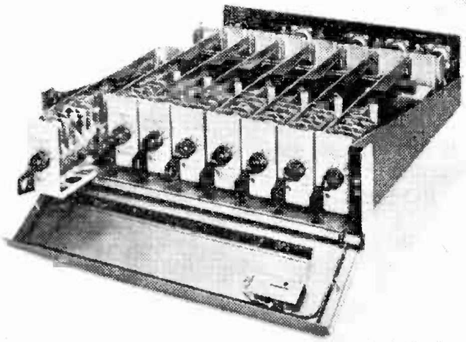
WW 316 for further details

D.C. AMPLIFIER

A MEDIUM-PRICED d.c. amplifier Type 1-163 has been added to the range of signal conditioning equipment made by the Consolidated Electrodynamics Division of Bell and Howell Ltd., of 14 Commercial Road, Woking, Surrey. It is a low-gain device and has been designed to drive high-frequency light-beam galvanometers. The frequency response is ±0.5% from d.c. to 10 kc/s and ±3% to 20 kc/s. Voltage gains from 1 to 20 are possible with this amplifier. Other features include an input impedance of 2 MΩ and a ±10 V, 10 mA output.

Various cases are available for carrying one or more Type 1-163 units; an eight-unit case is illustrated.

WW 317 for further details



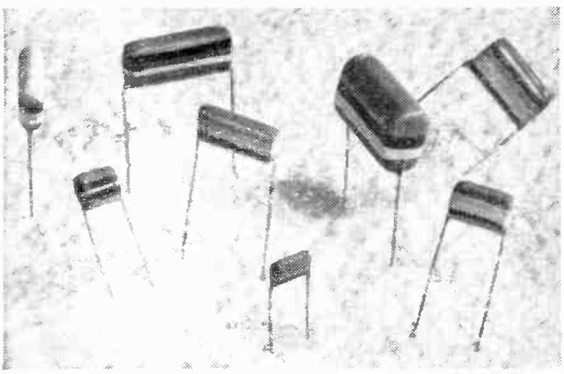
250V WORKING POLYESTER CAPACITORS

THE C280 series of foil capacitors made by Mullard's for the radio and television industry now covers a capacitance range 0.01 to 2.2 μF—in 15 preferred values, at 250 V d.c. working. Previously the upper capacitance value was 0.22 μF and the d.c. working voltage was 30 V.

Specification details include a ±20% tolerance for values of 0.1 μF and below, and ±10% tolerance for values above 0.1 μF. A.C. working voltage is 160 V r.m.s. (50 c/s), insulation resistance is 10,000 MΩ/μF and temperature range is from −40°C to +85°C. Size varies from 12.5 × 10 × 4 mm to 30 × 22.5 × 14 mm according to value.

At present these capacitors are available only to setmakers.

WW 318 for further details

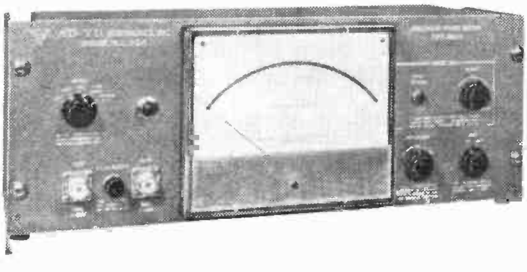


PRECISION PHASE METER

DIRECT reading of phase angle between two signals without either amplitude or frequency adjustments over the frequency range 8 c/s to 500 kc/s is possible with the Model 406H precision phase meter from Ad-Yu Electronics Inc. of New Jersey. This instrument, which is a development of 405H, has an accuracy of ±0.3° or ±2% to 40 kc/s. An analogue output signal, which varies in direct proportion to phase, is provided to facilitate phase plotting.

The price of the Model 406H is £311 (excluding duty). It is available in the U.K. through Livingston Laboratories Ltd., Greycaines Estate, Bushey Mill Lane, North Watford, Herts.

WW 319 for further details



800V Power Transistor

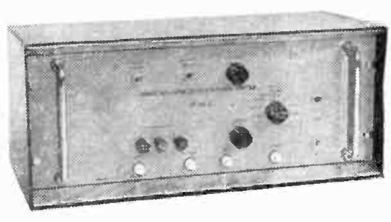
A RANGE of high-voltage silicon n-p-n transistors made by the Industro Transistor Corporation, of New York, is announced by the U.K. distributors, Lectropon Ltd., of Kinbex House, Wellington Street, Slough, Bucks. One of the devices in the range is the TRS 8015, which has a V_{CBO} of 800 V and a 15 W dissipation at 25° C case temperature. This device is housed in an MD-14 outline case and costs—in small quantities—about £20.

Medium power devices in TO-5 encapsulations include the TRS-7014S which has a V_{CBO} of 850 V and a 5 W dissipation at 25° C case temperature.

WW 320 for further details

Phase-sensitive Detector and Phase Shifter

A SINGLE unit containing a phase-sensitive detector and a phase shifter using high-frequency silicon transistors is announced by Brookdeal Electronics Ltd., of Myron Place, Lewisham, London, S.E.13. Very low d.c. drift is a feature of the phase-sensitive detector, allowing the instrument to be used at very low signal levels. This reduces the risk of overload by noise signals and allows the unit to be used with an untuned amplifier. A neon lamp is, however, provided on the front panel to indicate overload conditions. Another neon indicator is provided to show if the reference voltage amplitude is correctly adjusted. The output of the detector is suitable for driving a pen recorder or an external meter.

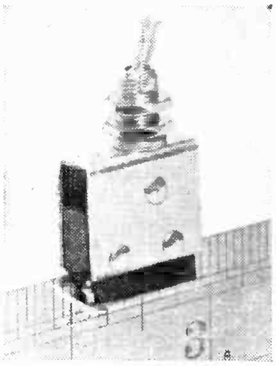


Phase correction of up to 180° is possible with the phase shifter. Over the whole phase range the voltage output of the unit does not vary by more than 1 dB for a given input voltage. Other details include an input impedance of 30 kΩ, an output impedance of less than 1 kΩ, a maximum output voltage of 2 V r.m.s., and a frequency coverage of either 10 c/s to 100 kc/s or 30 c/s to 300 kc/s.

The combined unit can be supplied in several forms; for bench or 19-in rack mounting.

WW 321 for further details

SMALL TOGGLE SWITCH



A SUB-MINIATURE, two-position toggle switch is being made by Plessey's under licence from the Illinois Tool Works Incorporated, of Chicago. Single and double-pole versions (designated 79-4800 series) are available from the Electromechanical Division of the Plessey Component Group, New Lane, Havant, Hants. Both types have the same electrical characteristics as the Type 19 microswitches (also made under licence) and each have the same overall width of 0.78 in. Back-of-panel projection, including tags, is $\frac{7}{8}$ in and the mounting bush diameter is 3/16 in.

WW 322 for further details

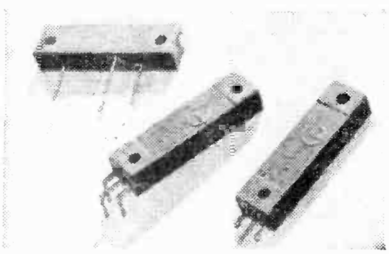
Trimmer Potentiometers

A NEW range of rectangular trimmer potentiometers is now available from Reliance Controls Ltd., of Sutherland Road, London, E.17. Three models are offered, the Type CW 90 which has standard end lugs, the Type CW 91 with printed circuit end terminations, and the Type CW 92 with printed circuit "belly" pins.

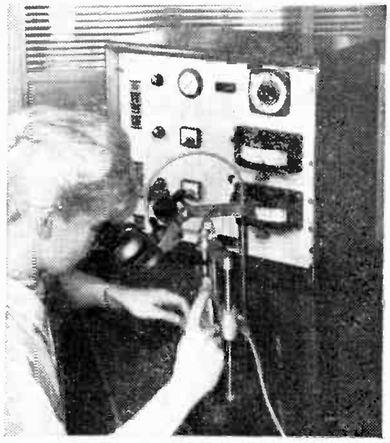
The resistance range is from 10Ω to 50 kΩ and the temperature range is from −40 to +100°C. Temperature coefficients of 20 p.p.m. are claimed for the majority of the resistance range.

A fully sealed version will be available in the near future.

WW 323 for further details



Bonder for Micro-electronics



A HOT-GAS bonding machine for use in the manufacture of microcircuits has been developed by G. V. Planer Ltd. It is designated Type B400 and utilizes a fine high-temperature jet to effect the bond.

The gas stream of nitrogen or a mixture of nitrogen and hydrogen is heated electrically at a thermostatically controlled temperature, which can be varied up to 400°C. The flow rate of the gas is controlled by a pressure regulator and the duration of the gas stream is adjustable—by a pre-set control—up to 15 sec. A number of interchangeable nozzles are available allowing the jet diameter to vary from 0.01 to 0.1 in.

A thermostatically controlled heated substage, with micromanipulator position control, is provided to support the components to be bonded. A vacuum pump is used to hold the component during the bonding operation and a pair of vacuum tweezers are provided for very small components. Placing of the components to be bonded is simplified by means of an integral binocular microscope.

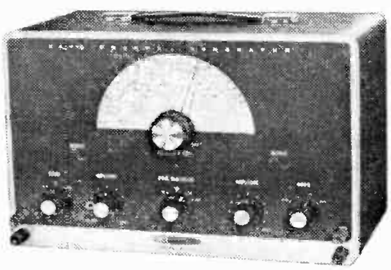
The address of G. V. Planer Ltd. is Windmill Road, Sunbury-on-Thames, Middx.

WW 324 for further details

20 c/s—1 Mc/s SIGNAL GENERATOR

SINE- AND SQUARE-WAVE outputs are available either separately or simultaneously from the new signal generator being produced by Daystrom Ltd., of Gloucester. Called the Heathkit Model IG-82U, this instrument covers the frequency range 20 c/s to 1 Mc/s and should be of particular interest to the service engineer.

Features of this generator include an



output of up to 10 V pk-pk, a distortion figure of better than 0.5% from 20 c/s to 20 kc/s sine wave, and a rise time of less than 0.15 μsec. Separate continously variable attenuators are provided for the sine wave and the square wave outputs, with a coarse switched attenuator operating on both outputs. This switch offers three ranges: 0 to 0.1 V, 0 to 1 V and 0 to 10 V.

The overall dimensions of the Model IG-82U are $8\frac{1}{2} \times 13 \times 7$ in; weight is 16 lb. In kit form the instrument costs £24 10s and assembled £36 10s.

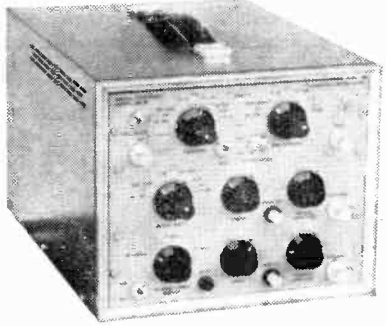
WW 325 for further details

Texas Instruments

THE first instrument to be made in Britain by Texas Instruments Ltd., of Manton Lane, Bedford, is the Model 6613 pulse generator. This is an Anglicized version of the original American instrument (p. 588, Nov. 1964).

Although Texas Instruments have now formed a British marketing organization, B. & K. Laboratories Ltd., of London, who were previously the exclusive U.K. distributors, will continue to market Texas instruments.

WW 326 for further details



The Tail Wags the Dog

EVERY once in a while there comes a moment in life —a kind of "draw the curtains, Willie's dead" moment —when one leans upon the hoe and looks back over the years that the locust hath eaten.

Such an occasion calls for the rapid erection of a wailing wall and a beating upon the breast; one realizes in that instant that the prophet Haggai had his finger absolutely on the pulse when he remarked "Ye have sown much, and bring in little; ye eat, but ye have not enough . . . and he that earneth wages, earneth wages to put it into a bag with holes." (I think Haggai must have been a Section Leader in the labs of his day.)

Whenever you do happen to succumb to such morbidity (and it happens to all of us, although mercifully not often) my advice is to wrap yourself around a couple of tranquillizers immediately, or before you know what has hit you, you will start asking yourself seditious questions like "Why was I ever born?" or (getting down to detail) "What's wrong with modern research?"

The first is plainly unanswerable except from the biological facet. The second—well, now that it has reared its ugly head let's drag it out in the open and then perhaps it won't bother us again.

A loaded question

What's wrong with modern research? For a start, the question is as loaded as the one which asks "Do you beat your wife often—yes or no?" Of course there's nothing wrong with it. I mean, you've only got to think of the tremendous benefits it has brought to realize that. As an instance, thanks to modern science, we now enjoy a tip-top world communication service which enables you to start worrying yourself silly over crises the moment they happen. Contrast your luck with that of poor old great grandad, who, lacking our amenities, would never have heard of them at all.

Think with grateful thanksgiving of the technological travail which alone has made possible such rich emotional experiences as "Coronation Street" and "Juke Box Jury." Thanks to our own industry, countless millions of little electrons are being made to jump through hoops every second of every day in order to make life meaningful. Be proud then, that we each play our humble part; you in your small corner and I in mine.

So, away to the saltmines with those reactionaries who assert that although there has been a tremendous eruption of scientific knowledge over the past century, there has been no comparable cataclysm—indeed, not even the faintest burp —of wisdom to teach us how best to use it. It was irresponsible chatter like this which landed Galileo right up to his telescope in trouble.

But enough of this dangerous ground. The Editor, in the words of Robert Hooke's directive to the Royal Institution, has oft-times warned me against meddling with Divinity, Metaphysicks, Morals, Politicks, Grammar,* Rhetorick or Logick (although it seems to me that this leaves precious little else except Sex, and he won't let me meddle with that, either).

Personally, I think that the question is not so much that of what is wrong with modern scientific research as what was wrong with it in the bad old days before it became rationalized. For example, take the old-timers like Muschenbroek, Galvani, Volta *et al.* Look what happened when they made some fundamental discovery. Instead of acting sensibly by hugging it tight to their chests until they had dreamed up a commercial use for it and then slapping a patent on it sharpish, what did they do? Why, they broadcast the news around to all and sundry, with never a bean for their trouble.

And then there was that chap Faraday: If only he had had the acumen to have kept his lips buttoned he could have bought the Bank of England to keep his small change in. Oersted, Ampère and Ohm, too—all tarred with the same brush—and all they got for their trouble was to have electrical units named after them. And, as all the world knows, that doesn't feed five starving kids and keep up the instalments on the bedroom suite.

One would have thought that Teutonic common sense would have kept Heinrich Hertz on the rails. But no! There he was, with the only radio transmitter and receiver in the world in his hands and he seems not to have had the gumption to put a Morse key and a patent on them.

Even when wireless telegraphy did get going, nobody seemed to realize that there was gold in them thar undulations. Instead, there was a screwy idea abroad that the main function of wireless was to save lives at sea, and, of course, there was no percentage in that. Even when the British War Office tried to get the whole thing going along the right lines by offering a development contract for its adaptation to the remote detonation of mines, there were no takers. Just how stupid can you get?

Dedication

In those penurious days, only dedicated lunatics, after graduation, turned aside from the havens of lecturing or teaching to go into what is now called electronics research. Who else but a lunatic would want to spend his days—and nights—in a cold, draughty shed stuck out in the middle of nowhere? Who but a lunatic would count himself lucky if he managed to scrounge a few bits and pieces to make himself some test equipment? Who but a lunatic would go into a job knowing that it was at the top of the charts for the old chopper at the first inkling of a falling market?

And not only did these chaps research, they also developed their brain-children, built them and, like as not, installed them. The peculiar thing is that, although completely ignorant of the benefits of time and motion study, systems analysis and data processing, they somehow managed to get a job done in about one-tenth of the time it would take today. Just fluked their way through, I suppose.

It wasn't until the thermionic triode became a reasonable performer that the new day dawned. For the triode begat sound broadcasting, public address systems, electronic gramophones, electronic recording, talking pictures, television, tape recording, radar and what-have-you, and the gold rush was on. Then came the show-down with Hitler to stoke up the situation with fat Ministry contracts, and after that there was precious little nonsense talked about research for the benefit of mankind.

*Except inadvertently!—Ed.

Yesterday, research was the tail-end Charlie of the electronics industry. Today the tail wags the dog. No longer is it the poor relation of the Universities; it is at last located in its rightful place, in industry and in Ministry establishments, and the wishy-washy pure research of yore is for Squaresville. Applied science is now the thing, operating according to a law which states that the amount of money spent on a given research programme is strictly proportional to the profit which may be ultimately expected from it. Human nature being what it is, this means that the concentration of research effort is usually inversely proportional to the intrinsic worth of the end product.

This law, then, is the philosopher's stone which, over the years has transformed the electronics research Cinderella into a glamorous princess. Its operational elegance lies in the fact that, despite the base-over-apex redistribution of values, it has involved no radical change of outlook in the engineering mind. As Gertrude Stein might have said (but didn't) "A problem is a problem is a problem," and an engineer gets his kick from solving problems; whether his solution goes into a guided weapon or a heart pacemaker is not particularly relevant; it's the solving of the problem that counts.

Reactionary movement

Naturally, we have not quite reached Utopia, as witness these deplorable hallucinations of futility we all get at times. We also have in our midst a small hard core of reactionaries who actually elect to research in fields such as medical electronics where there is patently no bonanza to be gained. We must, somehow, make these misguided souls realize they're letting the side down.

Small as it is, it would be a grave mistake to underestimate the danger in the existence of this reactionary movement. Heading it is—and I name him without hesitation—Dr. Vladimir Zworykin, who for many years has been responsible for putting the bread and butter in our mouths by his inventions, notably the iconoscope, the kinescope, the electron multiplier and the electron microscope. He, as director of the Medical Electronics Center at the Rockefeller Institute and Chairman of the Professional Group on Medical Electronics of the I.E.E.E., is putting all his efforts (and they are formidable) into the encouragement of research into electronic means of fighting disease and is actually looking to industry for practical support. We must, without doubt, keep a close eye on Dr. Zworykin if we are to maintain electronics safe for puerility.

FEBRUARY MEETINGS

Tickets are required for some meetings: readers are advised, therefore, to communicate with the secretary of the society concerned

LONDON

2nd. I.E.E., I.E.R.E., I.E.E.T.E., & Television Soc.—"Modern applications of closed circuit TV" by V. J. Cooper at 5.30 at I.E.E. Savoy Pl., W.C.2.

2nd. I.E.R.E.—"The electron beam in electronics research and production" by Dr. M. A. Champney at 6.0 at 9 Bedford Sq., W.C.1.

2nd. B.K.S.T.S.—"Helical scan videotape recorders" by F. Morrison at 7.30 at Central Office of Information, Hercules Road, S.E.1.

8th. Radar & Electronics Assoc.—"Medical electronics and life before birth" by Dr. C. N. Smyth at 7.0 at the R.S.A., John Adam St., W.C.2.

9th. I.E.E. & I.E.R.E.—"The Manchester digital traffic simulator" by Dr. F. G. Heath at 5.30 at Savoy Place, W.C.2.

9th. Soc. of Environmental Engrs.—"Transducers for instrumentation" by F. E. Duffield at 6.0 at Imperial College, Mec. Eng'g Dept., Exhibition Rd., S.W.7.

9th. I.E.R.E.—"Trutrack — a new approach to low side thrust transcription arms" by A. R. Rangabe at 6.0 at 9 Bedford Sq., W.C.1.

9th. S.E.R.T.—"Colour television systems" by J. S. Sansom at 7.0 at the London School of Hygiene and Tropical Medicine, Keppel St., W.C.1.

9th. B.K.S.T.S.—"Mellotron sound effects system" by Eric Robinson and F. C. Brooker at 7.30 at Central Office of Information, Hercules Road, S.E.1.

10th. I.E.E.—Faraday Lecture "Computers, control and automation" by P. D. Hall at 6.0 at the Central Hall, S.W.1. (The lecture will be repeated at 6.0 on the 11th for students.)

10th. Television Soc.—"The independent television news service" by G. Cox at 7.0 at I.T.A., 70 Brompton Rd., S.W.3.

16th. B.K.S.T.S.—"The ionic loudspeaker for the reproduction of high frequencies" by A. E. Falkus at 7.30 at Central Office of Information, Hercules Rd., S.E.1.

17th. I.E.E.—Discussion on "The 'literary explosion'—what can be done about it?" at 5.30 at Savoy Pl., W.C.2.

23rd. I.E.R.E. & I.E.E.—Discussion on "Medical stress induced by audio and visual hazards" at 6.0 at 9 Bedford Sq., W.C.1.

25th. Television Soc.—"The use of test line signals for remote monitoring of picture quality at unattended transmitters" by D. J. Parkyn at 7.0 at I.T.A., 70 Brompton Rd., S.W.3.

ABERDEEN

23rd. I.E.E.—Discussion on "Teaching and learning—improving efficiency" at 7.0 at Robert Gordon's Institute of Technology.

BIRMINGHAM

16th. Television Soc.—"Eidophor large-screen colour television" lecture-demonstration by Peto Scott at 7.0 at Brodcasting House, Carpenter Road, Edgbaston.

25th. I.E.E.—"Is laboratory work really necessary?" by Dr. K. R. Sturley at 6.15 at the University of Aston.

BOLTON

24th. I.E.R.E.—"Problems in computer design" by Dr. F. G. Heath at 7.0 at the Technical College.

BOURNEMOUTH

23rd. I.E.R.E.—"Measurement and effects of voltage transients on aircraft systems" by M. Rose at 7.0 at the Municipal College of Technology and Commerce.

BRIGHTON

15th. I.E.R.E.—"Electronic technique in electro-physiology" by D. E. Budgen at 7.30 at the College of Technology.

23rd. I.E.E.—"Circuit calculations using analogue computers" by R. A. Rathmell at 6.30 at the College of Technology.

BRISTOL

8th. Television Soc.—"Video storage for standards converters" by E. R. Rout at 7.30 at the Royal Hotel, College Green.

16th. I.E.R.E. & R.Ae.S.—"Current trends in civil aircraft electronic equipment" by H. Hill at 7.0 at the Engineering Laboratories at the University.

CAMBRIDGE

24th. I.E.R.E. & I.E.E.—"Transistor audio equipment" by P. J. Baxandall at 8.0 in the Engineering Dept., the University.

CARDIFF

9th. I.E.R.E.—"Colour television" by Prof. G. N. Patchett at 6.30 at the Welsh College of Advanced Technology, Cathays Park.

18th. Television Soc.—"Television lighting" by T. Moncrieff at 7.30 at the Royal Hotel.

CHELMSFORD

28th. I.E.E.—"Appleton's contribution to radio science" by J. A. Ratcliffe at 6.30 at the Lion and Lamb Hotel.

CHIPPENHAM

15th. I.E.E.—"Telemetry, the present position and future trends" by R. E. Young a 6.0 at the Westinghouse Brake & Signal Co. Ltd.

DUBLIN

17th. I.E.E.—"Some advances in automatic control" by Dr. J. L. Douce at 6.0 at the Physical Laboratory Extension, Trinity College.

DUNSTABLE

24th. I.E.E.—"Rocket sounding of the ionosphere using low-frequency radio-wave techniques" by Dr. T. R. Kaiser at 6.30 at the College of Further Education.

EDINBURGH

8th. I.E.E. & I.E.R.E.—"Radar—present position and future trends" by Dr. E. V. D. Glazier at 6.0 at the Carlton Hotel, North Bridge.

15th. I.E.E.—"Electronic circuits—past, present and future" by G. King at 6.15 at the Carlton Hotel, North Bridge.

GLASGOW

7th. I.E.E. & I.E.R.E.—"Radar—present position and future trends" by Dr. E. V. D. Glazier at 6.0 at the University of Strathclyde.

22nd. I.E.E. & I.E.R.E.—Open discussion chaired by Dr. W. G. Stephens at 6.0 at the University of Strathclyde.

HORNCHURCH, ESSEX

8th. I.E.R.E.—"Semiconductors in nuclear radiation monitoring" by G. D. Smith at 7.0 at the College of Further Education.

LOUGHBOROUGH

17th. I.E.R.E. & Brit. Computer Soc.—"Numerical problems of optimal control" by Prof. C. Storey at 6.15 at the College of Technology.

MALVERN

21st. I.E.R.E. & I.E.E.—"Some aspects of space research in the U.K." by R. Dalziel at 7.30 at the Winter Gardens.

MANCHESTER

7th. I.E.E.—Discussion on "The implementation of the Industrial Training Act" at 6.15 at the Renold Building, College of Science and Technology.

8th. I.E.E.—"Medical electronics round the world" by Dr. W. Hill at 6.15 at the Renold Building, College of Science and Technology.

NEWCASTLE

2nd. S.E.R.T.—"Emphasis on design" by R. H. Joyce at 7.15 at the Charles Trevelyan Technical College, Maple Terrace.

NORTHAMPTON

24th. I.E.E.—"Programmed learning" by Sqn. Ldr. I. K. Davies, at 6.30 at the Plough Hotel.

NOTTINGHAM

22nd. I.E.E.—Faraday Lecture "Computers, control and automation" by P. D. Hall at 7.15 at the Albert Hall.

PORTSMOUTH

16th. I.E.E.—"Flight data recording" by W. T. Eastwood, R. Parsons and B. R. Davis at 6.30 at the College of Technology Anglesea Rd.

SALFORDS, SURREY

2nd. I.E.E.—"Electronic exchanges" by L. R. F. Harris at 7.30 at the Mullard Research Laboratory.

SHEFFIELD

3rd. I.E.R.E.—"Semiconductors in industrial instrumentation" by F. W. Addams at 7.0 at the Dept. of Electrical Engineering, the University.

SOUTHAMPTON

8th. I.E.E.—Faraday lecture "Computers, control and automation" by P. D. Hall at 6.30 at the Guildhall (Students' lecture at 2.30).

15th. I.E.E.—"Novel fixed stores for electronic telephone exchanges" by G. P. Rodgers at 6.30 at the Lanchester Theatre, the University.

23rd. S.E.R.T.—"Flight simulation" by General Precision Systems at 7.30 at the College of Technology, East Park Terrace.

STOKE-ON-TRENT

22nd. S.E.R.T.—"Television studio equipment" by B. Yates at 7.30 in the Physics Block, College of Technology.

SWANSEA

17th. I.E.E.—"Radio meteorology" by J. A. Lane at 6.0 at the University College.

TORQUAY

15th. I.E.E.—"Connections in electronic circuits" by G. W. A. Dummer at 7.0 at the South Devon Technical College.

WOLVERHAMPTON

9th. I.E.R.E.—"Medical electronics" by Dr. G. K. Rose at 7.15 at the College of Technology.