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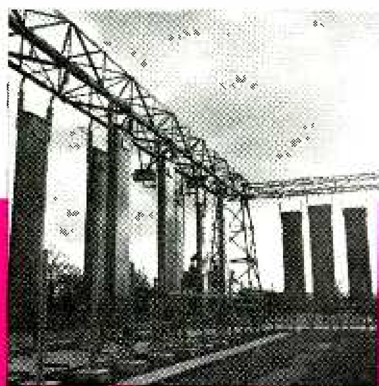

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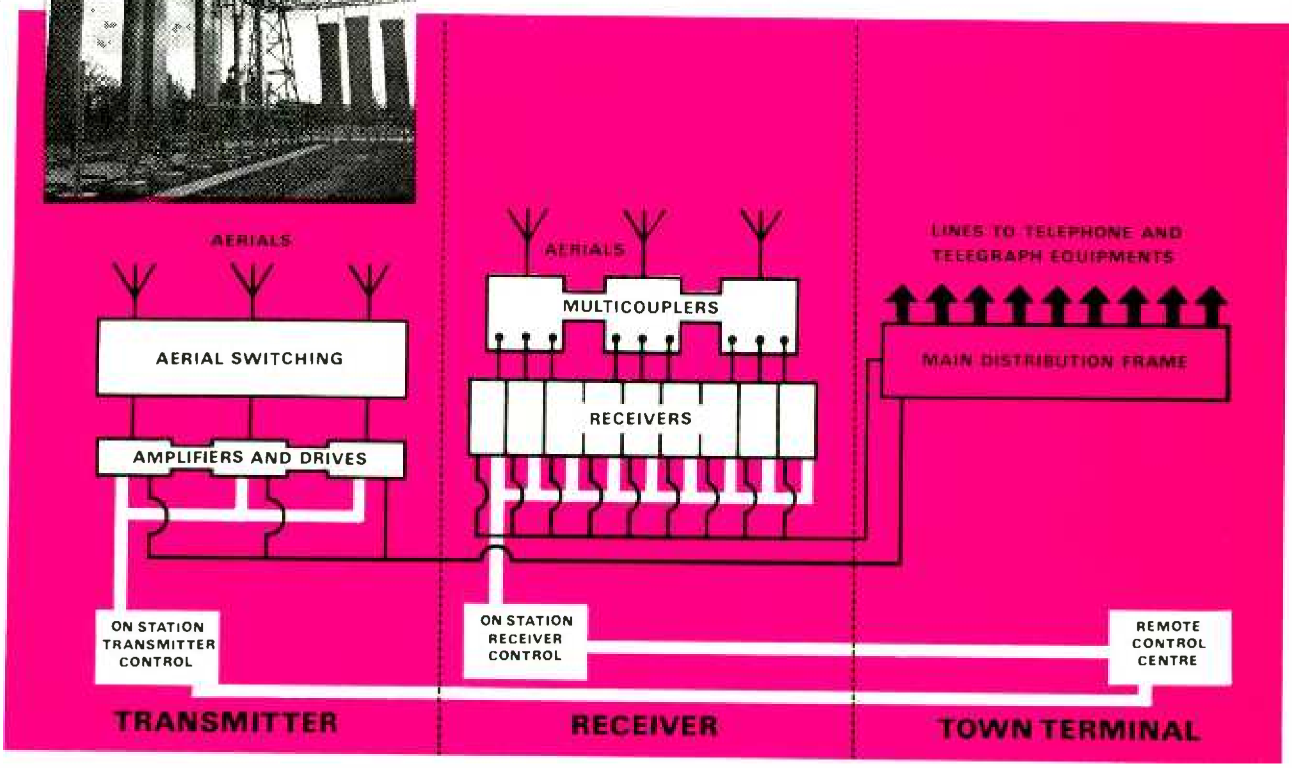

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This month's cover *shows the wideband helical aerial for u.h.f. television described in this issue.*

Contents

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Wireless World

The Wrong Prize

During an I.E.E./I.E.R.E./I.E.E.E. conference at Cambridge on electronics design, there was a discussion, led by a six-man panel, on the subject "Do R & D men make good managers?" Of course this question is one of those that at first sight seem intriguing (e.g. "Do computer programmers make good husbands?") but are bound to lead nowhere; but the discussion did serve to bring out an attitude about design engineers which is widely accepted though seldom stated openly or criticized. It seemed to be assumed without question that the natural road for an able design (or R & D) engineer to travel was towards management. This must be his ambition, his goal. There were frequent implications that the successful engineers were those who had "made the grade" into management, and that those who hadn't "made it" were to be pitied. The panel, a group of managers and directors (five engineers and one accountant), had that confident, self-satisfied air that plainly implied they considered *they* had made the grade. One or two even said so.

It is thus a characteristic of our industrial set up that the prize for being successful in one type of job is to be "promoted" into another type of job. The able craftsman is made into a foreman, and so on. In electronics this means that while you are a hundred per cent *certain* to lose a good design engineer, there is only a *possibility* that you will get a good manager in return. The dubious justification for this exchange is the hope that the total value of the good managers you do happen to get will outweigh the complete loss of the design engineers.

It does not seem to occur to anybody that good design engineers should be encouraged to stay in design, and continue to do the work in which they excel and which industry needs so badly, and that they should be rewarded accordingly. There is no reason why, in appropriate circumstances, a design engineer should not be paid as much as a managing director. (In small electronics firms they are often one and the same person anyway.) But such are the feudal traditions still clinging to British industry that certain types of jobs automatically have higher ranges of pay and prestige attached to them than others, and the only way for a good man to get his just rewards is to change the nature of his job. It derives, of course, from the historical link between management and private ownership. Fortunately, not only the communist countries but the Americans—with their concept of management as a particular class of job rather than the top of a hierarchy—are beginning to show that other systems of reward are possible.

Admittedly the design engineer in electronics is not in a strong position to demand more for himself. He has not yet achieved that aura of respectability and dullness possessed by his colleagues in "heavy" engineering which seems to be accepted as a guarantee of solid worth. One reason may be that a great deal of electronic circuit design has been achieved by experimentation on "breadboard" models, and this may have helped to create in the minds of administrators and boards of directors an impression of uninformed dabbling. As J. Murray of Edinburgh University said at the Cambridge conference, "Can we imagine the designer of a 275-kV transformer, even if it was the first that had ever been built, going through a lash-up stage on an ill-defined model with which he could tinker with file and blow-lamp?". However, as Mr. Murray later pointed out, the new responsibilities associated with designing integrated circuits (with their expensive processes and long production runs) may well alter the picture: "The integrated circuit era may well go down in industrial history as the era in which electronic engineers first learned to design efficiently."

A Helical Aerial for Bands 4 and 5

An alternative design to the usual Yagi array for use at u.h.f.

by E. H. Davies

The helical form of aerial does not differentiate between horizontal and vertical polarization to any significant degree over its bandwidth and while this may be a disadvantage in some areas it can have considerable advantages in others, particularly where polarization becomes modified by reflections of one form or another. It has been found, by practical experience, that the helical is much less prone to "flutter" effects, apparently due to this lack of differentiation.

A helical aerial is in use at the Bristol Technical College where it gives consistently good results on channel 63 from Oxford, a distance of 65 miles, without the use of a pre-amplifier. The signal level is of the order of 400 μV and it has been noticed that with considerable movement of the aerial in strong winds there is no noticeable effect on the picture, be it monochrome or colour. This particular aerial is a 10-turn helix and it has a gain of roughly 16 dB for an overall length of about 3 feet. The small dimensions provide possibilities for indoor use.

Construction of a helical aerial is a comparatively easy task for the enthusiast and a description of the form of construction used at Bristol will follow. However, in order to design an aerial for a particular area, one must first have suitable data and so a brief description of the operating principles and calculations required will be given.

Principle of the helical aerial

A wire, wound to form a helix with a circumference of one wavelength will radiate as a beam aerial, the radiation pattern being nearly circular. This type of radiation is called the "beam" or "axial" mode and it can exist over a relatively wide frequency range. Other modes of radiation can be obtained by having a helix circumference which is smaller than one wavelength, but only the axial mode is considered here, since it is most generally used in practice. In the axial mode the maximum field intensity is along the axis of the helix and the helix dimensions are relatively non-critical. The configuration shown in Fig. 1 is convenient in practice since it provides a termination to

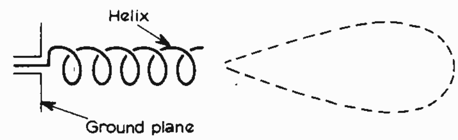


Fig. 1. Configuration of the axial-mode helical aerial. The ground plane diameter should be greater than half-wavelength.

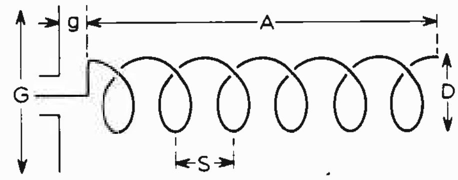


Fig. 2. Symbols used in this figure and in Fig. 3 to describe the aerial in the text are as follows:
D = diameter of helix, S = spacing between turns, L = length of one turn, α = pitch angle, N = number of turns, A = axial length (NS), G = ground plane diameter and g = distance of helix from ground plane.

a coaxial feeder and gives a unidirectional pattern.

A helix with its associated dimensions is shown in Fig. 2. It is fed by a coaxial feeder, the outer conductor of which is terminated at the ground plane screen and the inner conductor to the end of the helix. If, on a flat plane, one turn of the helix were to be unrolled, the triangle so produced relating the circumference, πD, the spacing S, the length of the turn L and the pitch angle α would be as shown in Fig. 3.

Dr. J. D. Kraus[1] (Ohio State University) has suggested an optimum design for the pitch angle as 14°(±3°) because within the vicinity of this angle the properties change least, producing beam widths of 30° to 60° at half-power points and impedances between 100 and 150 Ω. The actual aerial used by Dr. Kraus had a total length ($A + g$) of 1.65 λ and since $A + g = S(N + \frac{1}{2})$ where N is the number of turns and g is taken as $S/2$, the actual number of turns is six. The frequency range measured was 1.67:1 with a standing wave ratio better than 1.4 over the same range.

This optimum aerial compromised between directivity, power gain, terminal impedance and constructional difficulties. Constructional difficulties, obviously, tend to be reduced as the frequency is increased. Power gain can be increased slightly by adding more turns, provided an integral number is used, but the difficulty of supporting the helix, particularly at lower frequencies, and the added insulation required generally tends to offset the extra gain thus obtained. The helix will also work well with less turns than the optimum but with some loss of gain and broadening of the beam. With less than three turns the terminal impedance no longer remains constant and an adjustable match may be necessary. The beam width of a helix in the axial mode decreases inversely with the square root of the helix length in wavelengths. Thus the aerial gain is about 13 dB for six turns and 16 dB for ten turns.

Radiation pattern

The radiation pattern of a helical aerial using the axial radiation mode and designed for maximum directivity can be determined from:

$$E(\phi) = \sin\left(\frac{90^\circ}{N}\right)\left(\frac{\sin\frac{N\psi}{2}}{\sin\frac{\psi}{2}}\right)(\cos\phi) \quad ..\ (1)$$

where

N = number of turns of helix

ϕ = angle measured from axis of helix

$$\psi = 360^\circ\left[\frac{S(1-\cos\phi)}{\lambda} + \frac{1}{2N}\right] \quad ..\ (2)$$

S = spacing between turns in wavelengths.

From equation (1)

$E(\phi)$ is zero when $\sin\frac{N\psi}{2}$ is zero

$\sin\frac{N\psi}{2}$ is zero when $\frac{N\psi}{2}$ is 0°, 180°, 360°

For $N = 10$ this is when ψ = 0°, 36°, 72°, 108°, etc.,
For $N = 6$ this is when ψ = 0°, 60°, 120°, 180° etc.,
In addition $E(\phi)$ is zero when ϕ = 90°

* The Department of Electrical Engineering, Bristol Technical College.

Using equation (2) the minima and the alf-power points may be calculated for the iven wavelength.

The helical aerial has sufficient bandwidth o enable it to be designed for groups of .h.f. channels, in common practice with xisting u.h.f. aerials. The materials used onsisted of (mineral insulated) cable for the ielix, 18-gauge copper for the ground plane nd p.v.c. conduit for the helix supports. There were, of course, minor components uch as clips, self-tapping screws, etc., used. There seems to be no reason why a mesh round plane should not be used and also luminium strip for the helix. No doubt the hoice of materials will be influenced by vhat is readily available. It is worth noting, iowever, that m.i. cable is very suitable for he helix as it may be wound without fear of uckling. The helix shown in the photo-raph was wound on a powdered-milk tin is the tin happened to be the correct liameter for the frequency of the aerial.

Calculating the dimensions

Assuming that tubing of ¼ in (6 mm) liameter is used, this has a velocity factor of ibout 0.85. The following dimensions may be calculated:

$$\lambda = \frac{30{,}000 \times 0.85}{f} = \frac{25{,}500}{f}\text{ cm}$$

$$= \frac{836.4}{f}\text{ feet} = \pi D$$

$$D = \frac{25{,}500}{f} \times \frac{7}{22} = \frac{8{,}114}{f}\text{ cm}$$

$$= \frac{266.1}{f}\text{ feet}$$

$$S = \frac{25{,}500 \times 0.25}{f} = \frac{6{,}375}{f}\text{ cm}$$

$$= \frac{209.1}{f}\text{ feet } (S = \pi D \tan 14^\circ)$$

$$L = \frac{\pi D}{\cos 14^\circ} = \frac{25{,}000}{f} \times \frac{1}{0.97}$$

$$= \frac{26{,}280}{f}\text{ cm} = \frac{862}{f}\text{ feet}$$

$$g = \frac{S}{2} = \frac{3{,}187.5}{f}\text{ cm} = \frac{104.55}{f}\text{ feet}$$

where f is the frequency in MHz.

The diameter of the ground plane, G, is not very critical but a suitable dimension is $0.9\,\lambda$.

It seems a good procedure to mark the helix tubing at $\lambda/2$ intervals before winding since this provides a good indication for the positions of the clips used to fasten the helix to the supporting tubes. These clips can be attached by self-tapping screws. The number of turns used must be an integral number and the tubing at the ground plane end of the helix should be bent towards the axis of the helix at, or near, a right angle. This is important if the correct impedance is to be achieved. The spacing of the ground plane from the end of the helix also has a considerable effect on the impedance of the aerial and care must be taken. The supporting tubes may be fixed to the ground plane by any suitable means, for example, by threaded plugs.

Since the impedance of the helical aerial is about 130 Ω this may be matched to a 75-Ω feeder by a simple quarter-wave matching section as shown in Fig. 4:

$$Z = \sqrt{Z_1 \times Z_2} = \sqrt{75 \times 130} = 99\,\Omega$$

Using the same ¼ in tubing

$$0.25\,\lambda = \frac{6375}{f(\text{MHz})}\text{ cm}$$

long, the spacing between the tubes is given by

$$\frac{R_k}{276} = \log_{10}\frac{S\text{ (spacing)}}{R\text{ (tube radius)}}$$

for an open line (air dielectric).

Assume the characteristic impedance (R_k) of the section is 100 Ω, then

$$\frac{R_k}{276} = \frac{100}{276} = 0.362$$

being the $\log_{10}$ of $\frac{S}{R}$.

The antilog of 0.362 is 2.3 and the ¼-in tubes of the matching section would be spaced by $2.3 \times \frac{0.25}{2} = 0.29$ in $= 0.73$ cm.

A coaxial matching section may be used as an alternative. If a coaxial section is formed using a larger tube as an outer to the ¼-in helix tube continuation, with air spacing, then the tube diameter may be found using the formula:

$$\frac{R_k}{138} = \log_{10}\frac{R_o}{R_i}$$

where R_o is the space between the inner and outer conductors and R_i is the radius of the inner conductor. If a solid dielectric is used then the dielectric constant must be considered. A piece of low-loss coaxial cable may be satisfactory and such a section is shown in one of the photographs. The actual section was originally of 75 Ω impedance but was converted to 100 Ω by withdrawing the original inner and substituting a new inner of h.d. copper wire of 0.092 cm (0.036 in) diameter (20 s.w.g.).

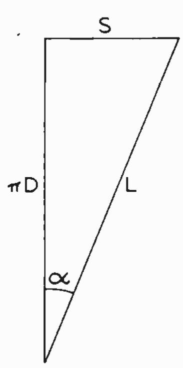


Fig. 3. The triangle produced by unrolling one turn of the helix.

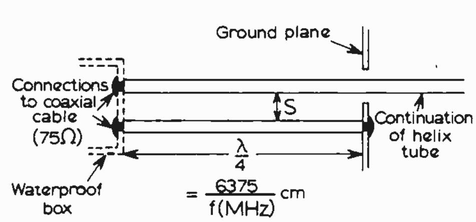
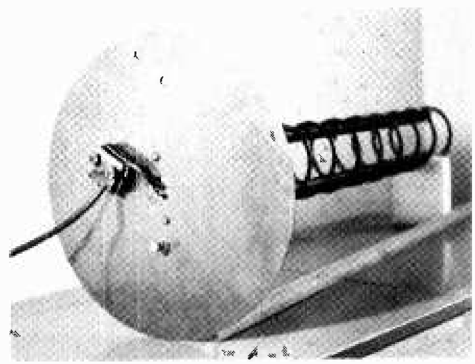


Fig. 4. Aerial output connection showing details for matching into a 75-Ω feeder.

Helical aerial prototype erected on site.



Back view of the helical aerial showing the position of the quarter-wave coaxial matching section and waterproof connection box.

Before mounting the aerial it is as well to consider its musical performance in wind and block the ends of supporting tubes. The helical aerial described may be wound in either direction for Bands 4 & 5 use and it may also be used in stacked arrays when, it is suggested, alternative winding senses are used. The use of stacked helical arrays requires, as with stacked Yagis, very careful matching.

The authors of this article wish to express their appreciation to the Principal of Bristol Technical College for his permission to publish.

REFERENCE

1. "Antennas", by J. D. Kraus. The McGraw Hill Book Co., New York, 1950.

Noise in Transistor Circuits

1. Mainly on fundamental noise concepts

*by P. J. Baxandall** *B.Sc. (Eng.), F.I.E.E., F.I.E.R.E.*

An enormous amount of literature exists on the theory of random noise, the theory and practice of low-noise amplifier design, and measuring techniques involving noise. However, for most engineers and physicists not specializing on noise topics as such, the need is to extract from this mass of knowledge a certain minimum amount of basic theoretical and practical information, sufficient to enable the normal types of noise problem which arise in the course of electronic work to be understood and dealt with in an intelligent manner.

The aim in this article is to provide this minimum basic information in, it is hoped, an easy-to-assimilate form, and to quote, for the benefit of those desiring to delve a little more deeply, a few references which have been found particularly worthy of attention.

Gaussian Noise

The term "noise" has more than one technical meaning. For example, when computer engineers refer to "noise immunity" they are concerned mainly with the effects of unwanted but man-made interference caused by cross-talk between circuits in the computer, mains disturbances etc., and such "noise" does not have the full random properties of the really basic kind of "natural" noise which is inevitably present in all electrical circuits.

In this article, only truly random noise will be considered, i.e. noise generated by random processes such as the thermal agitation of electrons or the random arrival of charge carriers at the collector of a transistor.

In all normal circumstances met in the design of practical amplifiers, the noise voltages and currents have a Gaussian distribution of instantaneous amplitudes†. The exact meaning of this statement is shown in Fig. 1, and the associated theory leads to the two facts enumerated in the caption.

It is very important to bear fact (1) in mind when noise measurements are being made, for it means that an amplifier used to provide a noise output of x volts r.m.s. must be able to handle instantaneous voltages of values approaching $3x$ if significant errors due to overloading are to be avoided. This requirement is easily overlooked—for example, some mean-rectifier valve-voltmeters or transistor voltmeters do not have this signal-handling capacity and are therefore unsuitable for noise measurements.

Appearance of Gaussian Noise

In Fig. 2, the top three photographs on the left, taken under "single-shot" conditions, show white Gaussian noise‡ after passage through sharp-cutting *LC* low-pass filters with the cut-off frequencies indicated. In all three cases, the timebase speed is the same, i.e. 5 ms per square. (The gains were suitably readjusted to give a convenient size of waveform for clear photography.)

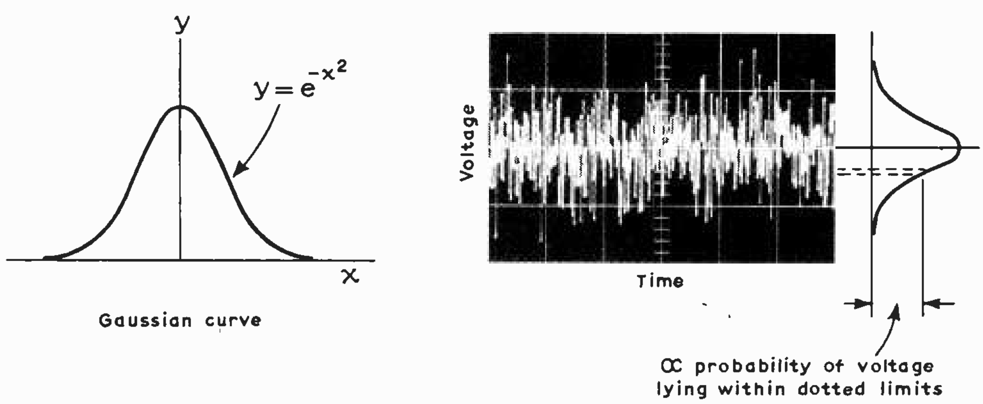
The top photograph on the right-hand side was obtained with the 600-Hz filter in operation, but with a 10 times slower timebase than that used for the 600-Hz picture on the left. It will be seen to have virtually the same appearance as the 6-kHz picture on its immediate left, which serves to emphasise that the appearance of such noise is controlled purely by the *ratio* of the timebase speed to the noise bandwidth and not by the *absolute* quantities involved.

The bottom photograph on the left was obtained by passing the wideband white noise through a 600-Hz noise-bandwidth circuit not having a sharp-cutting characteristic, but consisting of just a simple *CR* lag. This crude filter lets through, to some extent, quite high-frequency components of the noise, giving the picture a much "finer-grain" appearance than for the 600-Hz sharp-cutting filter whose output is shown in the picture immediately above it.

The bottom photograph on the right shows the appearance of white Gaussian noise after passing through a 1000-Hz selective circuit having a *Q*-value of approximately 23.**

Whereas white noise, as already mentioned, has a flat spectral density curve, i.e. equal mean squared noise voltage per unit bandwidth throughout the spectrum, the terms "pink noise" and "red noise" are sometimes used, particularly in electro-acoustic work. Pink noise has a constant mean squared noise voltage (or power) *per*

Fig. 1. Gaussian noise. Facts: (1) instantaneous voltage lies within ±3 times the r.m.s. voltage for 99·7% of the time; (2) using an ordinary mean-rectifier voltmeter (e.g. Avo), calibrated to read the r.m.s. value of a sine wave, we have: (r.m.s. noise voltage) = $2/\sqrt{\pi}$ × *(meter reading).*



† The Gaussian curve, or normal distribution curve, is basic to probability theory. Suppose we toss a penny 100 times and note how many times it comes up heads. We now repeat the experiment many times, each time noting the number of heads that come up. If we now classify the results of all these trials into groups, e.g. 30 to 35 heads, 35 to 40 heads, 40 to 45, 45 to 50, 50 to 55 etc., and plot the number in each group against the head numbers just mentioned, we obtain an approximation to a Gaussian curve. See reference 1, p. 14 and/or reference 2, p. 369.

‡ By "white" is meant, by analogy with white light, that the spectral density, i.e. the mean square noise voltage per unit bandwidth, is independent of frequency.

** The envelope of such a noise waveform, and therefore the output of a diode detector to which it is fed, does not have a Gaussian amplitude distribution—it can never have a negative value but can go without limit positively. The resulting unsymmetrical distribution of instantaneous values is called a Rayleigh distribution—see reference 2, p. 392.

octave, i.e. the mean squared voltage per unit bandwidth rises at 10dB/decade (3dB per octave) with falling frequency. (So-called flicker noise, excess noise, or "$1/f$" noise is of this type and is discussed later on.)

Red noise has an even greater low-frequency content, the mean squared noise voltage per unit bandwidth rising at 20dB/decade (6dB/octave) with falling frequency.

Fig. 3 shows examples of red noise—obtained by passing Gaussian white noise through a Blumlein integrator. For these pictures, unlike for Fig. 2, the system gain was left unaltered when switching from 6kHz to 600Hz bandwidth, and it will be seen that while reducing the bandwidth 10 times reduced the magnitude of the white noise voltage about $\sqrt{10}$ times, as expected, the effect on the amplitude of the red noise was very small—because the biggest components of the red noise are at very low frequencies.

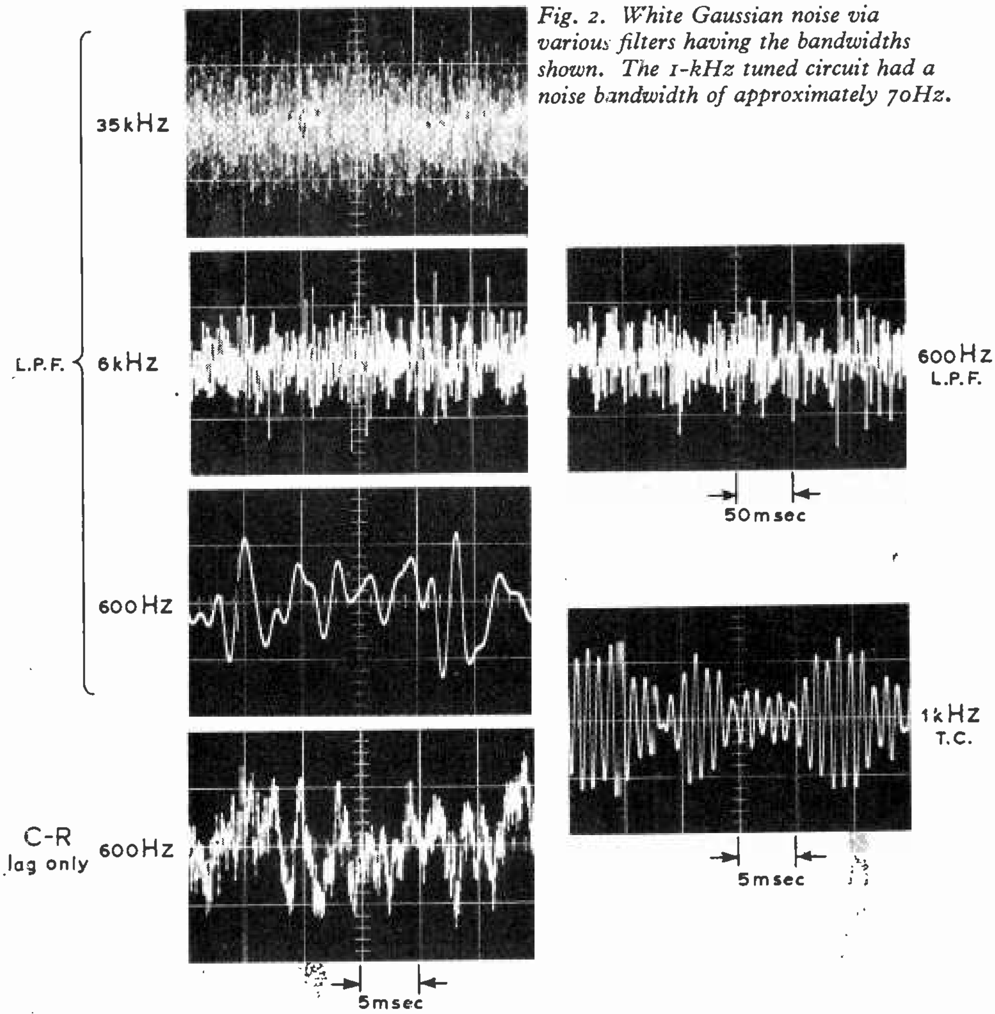


Fig. 2. White Gaussian noise via various filters having the bandwidths shown. The 1-kHz tuned circuit had a noise bandwidth of approximately 70Hz.

Correlation

The concept of "correlation" is used later in this article, and will now be briefly explained.

When two noise voltages are produced by two completely independent systems, they are said to be "uncorrelated". If we were to photograph their waveform, under "single-shot" conditions, on a double trace oscilloscope, the wiggles on one waveform would be found to have no particular tendency to coincide with those on the other.

Suppose we connect two noise voltage sources in series, as shown in Fig. 4, where v_1 and v_2 refer to the instantaneous values. Then, if the voltages are uncorrelated, it is easily shown that:

$$\overline{v_{tot}^2} = \overline{v_1^2} + \overline{v_2^2} \quad \ldots . \ (1)$$

(The bars signify "mean value of")

Since, by definition, the square of an r.m.s. value is the mean square value, equation (1) may be written in terms of r.m.s. values as follows:

$$V_{tot}^2 = V_1^2 + V_2^2 \quad \ldots\ldots \ (2)$$

from which:

$$V_{tot} = \sqrt{V_1^2 + V_2^2} \quad \ldots . \ (3)$$

(No correlation)

When two noise voltage waveforms are of identical shape, differing only in magnitude if at all, they are said to be 100% correlated. Thus v_1 and v_2 in Fig. 5 are 100% correlated. The v_3 waveform is an antiphase version of v_1 and v_2, of somewhat smaller magnitude, and is said to have 100% negative correlation with respect to the latter waveforms.

It is obvious that under the conditions of Fig. 5, simple addition or subtraction of r.m.s. values must apply, so that, instead of equations (2) or (3), we now have:

$$V_{tot} = V_1 + V_2 \ldots\ldots \ (4)$$

(100% positive correlation)

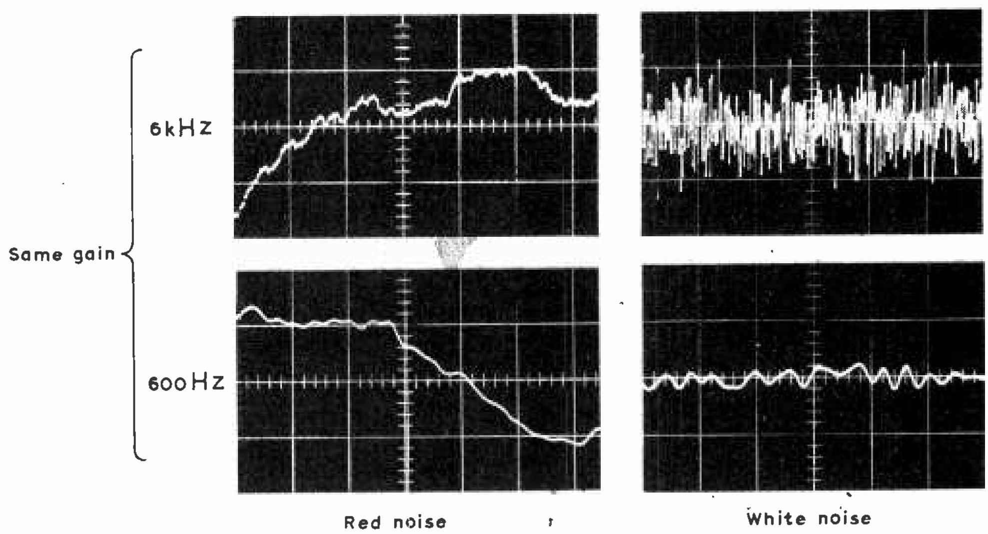


Fig. 3. Red noise and white noise. The time scale is 5ms per square in all cases.

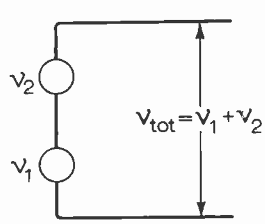
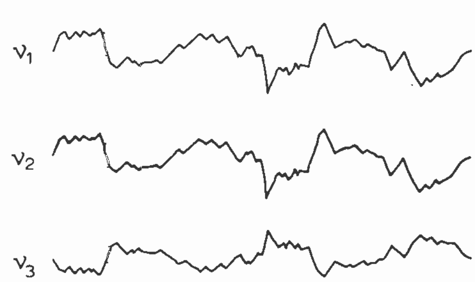


Fig. 4. (Above) Two noise sources in series.

Fig. 5. Voltages v_1 and v_2 are 100% correlated. The v_3 waveform has 100% negative correlation with respect to v_1 and v_2.



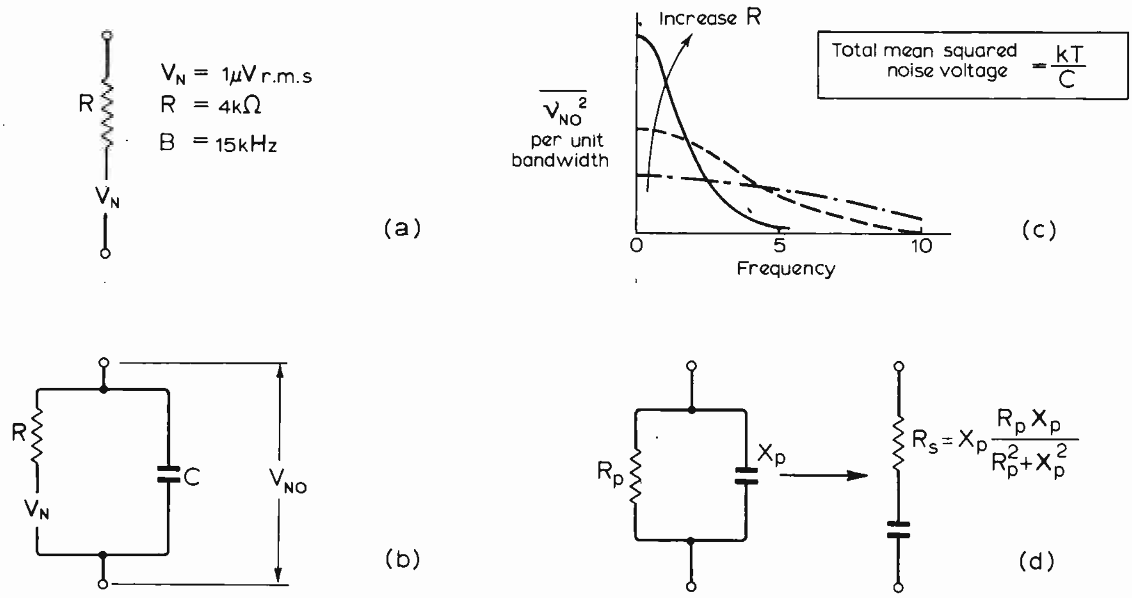
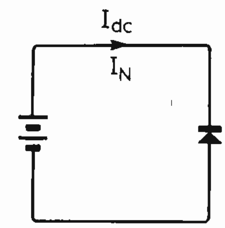


Fig. 6. Thermal agitation noise (Johnson noise).

Fig. 7. Shot-noise current, I_N, in a reverse-biased diode.



or $$V_{tot} = V_1 - V_3 \; . \; . \; . \; . \; . \; (5)$$

(100% negative correlation)

Two noise voltages which are only partially correlated often occur in practice, i.e. each contains some noise arising from a common source, but also contains some independently-generated noise. We then have:

$$V_{tot}^2 = V_1^2 + V_2^2 + 2\gamma V_1 V_2 \quad . \; . \; . \; . \; (6)$$

(General case)

where γ is called the *correlation coefficient* and can have any value between $+1$ and -1.

When $\gamma = 0$ (no correlation) it will be seen that equation (6) becomes the same as (2). When $\gamma = 1$ (full "in-phase" correlation), (6) becomes:

$$V_{tot}^2 = V_1^2 + 2V_1V_2 + V_2^2$$
$$= (V_1 + V_2)^2$$

or $$V_{tot} = V_1 + V_2$$

which is the same as (4).

When $\gamma = -1$ (full "antiphase" correlation), (6) becomes:

$$V_{tot}^2 = V_1^2 - 2V_1V_2 + V_2^2$$
$$= (V_1 - V_2)^2$$

or $$V_{tot} = V_1 - V_2$$

Thermal Agitation (or Johnson) Noise

This mechanism of Gaussian noise voltage generation occurs spontaneously in all resistors, or any other devices having resistive, or partially resistive, electrical impedance, and involves the random thermal motion of electrons.

The basic relationship, giving the noise voltage acting in series with a resistance R as shown in Fig. 6(a), is:

$$\left.\begin{array}{c} V_N = \sqrt{4kTRB} \\ (\text{or } \overline{v_N^2} = 4kTRB) \end{array}\right\} \quad . \; . \; . \; . \; . \; (7)$$

where: V_N = r.m.s. noise voltage in volts
k = Boltzmann's constant = 1.380×10^{-23} joules/°C
T = Absolute temperature in °K
R = Resistance in ohms.
B = Effective bandwidth in Hz over which the noise is measured.

Equation (7) is often called Nyquist's formula. The background to its discovery in 1928, and ways of deriving it, are discussed in the pages following page 385 of reference 3.

To facilitate rapid determination of approximate noise voltages, it is worth committing to memory a set of values such as those shown in Fig. 6(a), which apply to room temperature conditions.

The Nyquist formula is actually a very fundamental one, being applicable to mechanical systems as well as electrical ones. Thus, if we have a viscous mechanical resistance which is constrained to have no velocity between its ends, the Nyquist formula enables us to calculate the random mechanical force developed. It may be used, for example, to calculate the random motion imparted to a capacitor microphone diaphragm by the viscous damping present[4].

The Nyquist formula predicts that an infinite resistance should generate an infinite noise voltage, yet there is no evidence of this happening in practice! This is not because the theory is in any way wrong, but simply because of the inevitable presence in practice of stray capacitance. Thus any practical resistor and its associated wiring inevitably looks more like a resistor and a capacitor in parallel, as shown in Fig. 6(b). As we increase the resistance, we increase V_N, but, at any finite frequency, we also increase the attenuation of V_N produced by the R-C circuit. Except at low frequencies, the increase in voltage attenuation (approx. $\propto R$) more than outweighs the effect of the increase in V_N ($\propto \sqrt{R}$), and the noise voltage obtained at the terminals thus varies as shown in the graphs of Fig. 6(c).

The value of V_{NO} (Fig. 6(b)) may be calculated in either of two ways. The first way is to calculate V_N from the Nyquist formula, and then determine, at any given frequency, the attenuation of V_N produced by the CR circuit.

The second way is to determine, at the given frequency, the series combination of R and C which is equivalent to the original values in parallel, using the formula shown in Fig. 6(d). The noise voltage at the terminals is then simply that given, according to the Nyquist formula, by the series resistance R_s. Both methods give, of course, exactly the same answer.

The above methods enable us to calculate the noise voltage, or the mean square noise voltage, in a small band of frequencies centred on any given frequency. However, because of the filtering action introduced by the shunt capacitance, the noise output is quite finite even if considered over an infinite bandwidth, and it is of practical interest to calculate this total noise output.

The total mean square noise output voltage of the Fig. 6(b) circuit may be obtained, using either of the above methods, by integrating the noise output (mean square) in each small bandwidth from zero to infinite frequency. If this is done (and the integration is not difficult) it will be found that the answer is independent of R, which is equivalent to saying that the areas under the several curves shown in Fig. 6(c) are all the same. The total mean squared noise voltage turns out, in fact, to be equal to kT/C, and this simple result may also be obtained by equating the mean thermal noise energy per degree of freedom, $\frac{1}{2}kT$, to the mean energy, $\frac{1}{2}CV^2$ stored in the capacitor.

An important practical consequence of the above matters is that, in low-noise amplifiers designed to operate from capacitive signal sources, such as capacitor microphone amplifiers or TV camera head amplifiers, the shunt resistor value in the input circuit must be made very *high* to keep the noise at signal frequencies down to an adequately low value—it is desirable to make the value much higher than mere considerations of frequency response would demand.

To conclude this section on Johnson noise, it is worth noting that whereas the Nyquist formula is usually given in the rm of eqn. (7) already mentioned, it may : rearranged to give the short-circuit noise ırrent of a resistor instead of the openrcuit voltage; the formula then becomes:—

$$\left.\begin{aligned} I_N &= \sqrt{4kTB/R} \\ \text{r} \quad \overline{i_N{}^2} &= 4kTB/R \end{aligned}\right\} \quad \ldots . (8)$$

hot Noise

In devices such as thermionic valves, ːmiconductor diodes, and transistors, one f the mechanisms of noise generation is nown as shot noise, and involves the fact ıat the output current is not smooth and ɔntinuous but is the sum of numerous small ulses caused by the passage within the evice of discrete electronic charges.

When plenty of reverse bias voltage is pplied to a semiconductor diode as shown ı Fig. 7, the magnitude of the current uctuation which constitutes shot noise is iven by††:

$$\left.\begin{aligned} \overline{i_N{}^2} &= 2qI_{dc}\,B \\ (\text{or } I_N &= \sqrt{2qI_{dc}\,B}) \end{aligned}\right\} \quad \ldots\ldots (9)$$

† This is sometimes known as the Schottky ɔrmula—an amusing instance of a man having a ame peculiarly well suited to his work! The basic erivation of this formula is discussed very clearly in eference 2, page 200.

where: q = electronic charge
$= 1.60 \times 10^{-19}$ coulomb.
I_{dc} is in amps.
B is in Hz.

For equation (9) to apply, three fundamental conditions must be satisfied:

(a) All the carriers must have the same charge.

(b) The frequency range of interest must be small compared with the reciprocal of the transit time across the vacuum or semiconductor junction—otherwise the shape and duration of each pulse becomes significant.

(c) The motion of any one charge carrier must be statistically independent of the motions of the other charge carriers.

In addition, the frequency band over which the noise is measured must be high enough to avoid a significant contribution from flicker effect, and the bias voltage must be well below the breakdown voltage—otherwise excessive noise of a "spiky" nature will occur.

While the above conditions are sufficient to ensure that the noise will be white, a further condition must be satisfied if the noise waveform is to have a Gaussian distribution of instantaneous values, viz:

(d) A large number of charge carriers must arrive during a period equal to the reciprocal of the system's bandwidth.

(This last condition is normally very fully satisfied, since one milliamp corresponds to the arrival of about six thousand million electrons every microsecond! However, the noise output from a photomultiplier tube may cease to be Gaussian at exceedingly low light intensities because of failure to satisfy condition (d).)

To give some physical insight into these matters, an experimental system was set up, and gave the waveforms shown in Fig. 8.

Normal Gaussian white noise, as illustrated in Fig. 1, was fed at high level to a limiter circuit with trigger action, so that the output voltage made traversals between the two limiting values every time the input noise waveform crossed zero. Waveform (a) was obtained with an input noise bandwidth of 6 kHz, waveform (b) being with the bandwidth reduced to 600 Hz.

Waveform (c) is as for (b), but a 100 μs a.c. coupling has been introduced. For waveform (d), a biased-off amplifier stage was inserted, capable of passing only the positive peaks of the previous waveform.

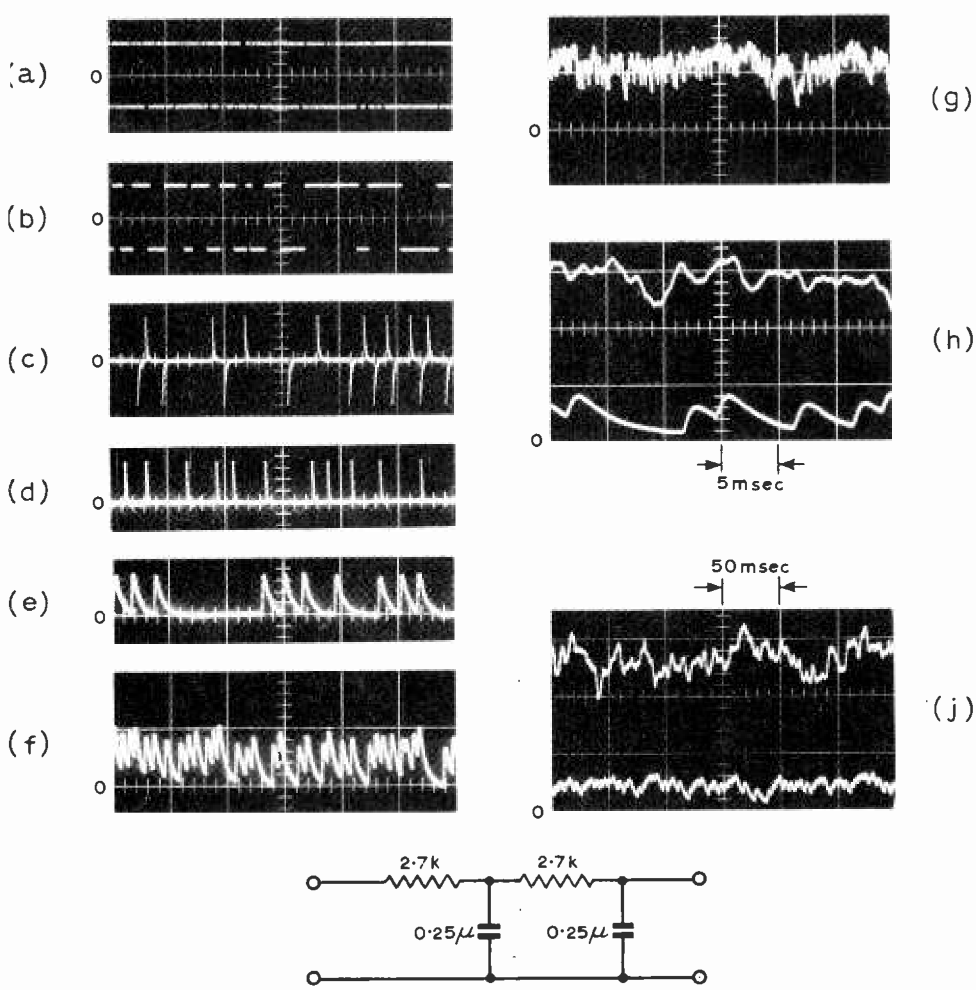
Waveform (d) is seen to consist of randomly-timed uni-directional impulses of constant magnitude‡‡, and may be taken to represent the output current of a device exhibiting shot noise and operating at an extremely small current. (A waveform like this can be obtained from a photo-multiplier tube, as already mentioned.)

In practice, the output load resistor of a device exhibiting shot effect is likely to have a significant amount of stray capacitance across it—this is represented in Fig. 8(e), for a shunt capacitor value giving a time-constant of 0.6 ms.

In waveform (f), the bandwidth of the input noise has been increased from 600 Hz to 2000 Hz, giving a correspondingly larger mean number of pulses per second. It will be observed that an output pulse now frequently occurs before the effect of the previous one has died out, and that the mean d.c. level has risen noticeably.

In waveform (g), the input noise bandwidth has been further increased, to 6 kHz. The fine detail in this waveform is due, of course, to the individual pulses, but it is evident that there is an increase in the low-frequency random variations also. It was mentioned that, in real life, a very large number of pulses normally occurs in a time equal to the reciprocal of the maximum frequency reproduced, so that the fine detail due to the pulses themselves will not then be seen. An attempt to simulate this state of affairs is shown in (h), where the simple filter shown has been inserted at the c.r.o. input to attenuate the high-frequency components. The two waveforms in (h) both have their zero at the bottom of the picture, and were obtained with noise bandwidths of 400 Hz and 3 kHz at the input to the limiter. It will be seen that the filtering action is not severe enough to remove evidence of the pulses themselves from the lower trace, but has almost done so in the upper trace, which consequently looks almost like normal Gaussian noise. For waveform (j), also for 400 Hz and 3 kHz input bandwidth, the capacitors in the *CR* filter shown were increased to 0.5 μF each,

Fig. 8. Waveforms illustrating shot-noise principles. The zero-levels are marked "0". All waveforms except (j) have a time scale of 5ms per square. A filter of the form shown was inserted before the c.r.o. for waveforms (h) and (j)—see text.



‡‡ While this is white noise (up to a certain frequency), it is far from having a Gaussian distribution.

and the timebase is ten times as slow. It is now seen that the noise amplitude increases as the mean current increases, and that even the lower trace shows some semblance of a Gaussian distribution.

(Note: In waveform (e), it will be seen that the sharp vertical edges of the pulses are all of substantially equal heights, whereas in (f), and to an even greater extent in (g), this is not always true. This is a defect of the system very hastily rigged up, and occurs because, at high mean pulse rates, a negative-going pulse (see waveform (c)) sometimes occurs so soon after a positive-going one that it prevents the unidirectional pulse (see (d)) generated from the positive going pulse from having as large an area as it should have. This defect, however, does not invalidate the general conclusions.)

The Schottky formula, i.e. equation (9), may be used to determine the shot-noise current in a semiconductor diode to which a constant d.c. voltage of either polarity is applied, *provided the diode current is virtually all reverse current or all forward current.* Referring to the diode equation below, this means one of the terms "A" or "B" must dominate. However, when the applied voltage is very small,

$$I = \underbrace{I_0 (e^{qV_{dc}/kT}}_{A} - \underbrace{1)}_{B} \quad . . . (10)$$

the two terms are of the same order, and then each will contribute its own separate component of shot noise. Since the two components are uncorrelated, the total shot noise current is given by:

$$\overline{i_N^2} = 2qBI_0(e^{qV_{dc}/kT} + 1) \quad . . (11)$$

In particular, when $V_{dc} = 0$, the above equation shows that we get equal contributions from the two terms, giving:—

$$[\overline{i_N^2}]_{V_{dc}=0} = 4qI_0B \quad . . . . (12)$$

Now by differentiating equation (10) above with respect to V_{dc}, it is easily shown that:—

$$I_0 = \frac{kT}{qr_o} \quad . . . . . (13)$$

where r_o is the small signal a.c. resistance of the diode with zero d.c. voltage applied.

Hence equation (3) above becomes:—

$$[\overline{i_N^2}]_{V_{dc}=0} = \frac{4kTB}{r_o} \quad . . . . (14)$$

This, as one would expect, agrees with equation (8), the Nyquist formula for the short-circuit Johnson noise current from a resistance, and indeed points the way to one method for proving Nyquist's formula.

A further interesting fact easily deduced, is that if a semiconductor diode is forward biased, so that the forward shot noise component dominates, then the mean squared noise current in the diode (if biased by a fixed voltage), or the noise voltage across the diode (if biased by a fixed current), is of only half the magnitude which would apply for a resistor having a value equal to the diode a.c. resistance.

That a device can produce *less* noise than pure Johnson noise, yet have a purely resistive impedance, may seem very surprising at first sight; but it should be noted that a diode passing current is receiving energy and is not in thermal equilibrium—thus violating a basic assumption on which the theory leading to the Nyquist formula is based. (Another situation giving less noise than would be predicted by the Nyquist formula is when we obtain a low resistive impedance at the input of an amplifier by means of shunt negative feedback via a high value of feedback resistor—this resistive input impedance is also unusually noise-free.)

If we feed a diode with steady d.c. from a high voltage supply via a high resistance, there cannot be any appreciable shot noise current, so the charge carriers must traverse the diode junction at regularly spaced time intervals. It would seem a fair question, however, to ask how the carriers inside the diode know they must behave in this noise-free manner! The answer, of course, is that the voltage across the diode develops a random noise fluctuation of just the right magnitude to make the carriers arrive at a constant rate. This effect is somewhat similar, in essence, to the "space-charge smoothing" effect in a thermionic diode in which the available emission from the cathode is much greater than necessary for supplying the anode current. A cloud of electrons, or space charge, forms near the cathode, and movements of this space charge under the influence of the anode current charge carriers affects the velocities of the latter in such a way that they arrive at the anode with less randomness of timing than would be the case if there were no space charge.

In semiconductor diodes, under normal circumstances, there is no space-charge smoothing, and "full shot noise", as given by the Schottky formula***, is obtained. The main complicating factor in practice is flicker noise, but this will be discussed later.

REFERENCES

1. "Fluctuation Phenomena in Semi-Conductors" by A. van der Ziel. Butterworths Scientific Publications, London (1959). This is mainly concerned with transistor noise theory, and includes a chapter on flicker noise. There is a short summary (10 pages) of mathematical methods—probability, correlation, etc.—but the book gives little information on circuit design aspects.

2. "Information Transmission, Modulation, and Noise" by M. Schwartz. McGraw-Hill (1959). This book, though fairly advanced, has the great virtue for engineers of using only the simple sort of mathematics most of us can understand! Chapter 7, on Statistical Methods, is an excellent summary of many important ideas. Noise in a.m. and f.m. radio systems is discussed very clearly. The section on semiconductor noise (13 pages) is a brief but useful summary.

3. "Frequency Analysis, Modulation and Noise" by S. Goldman. McGraw-Hill (1948). This is another very good book, which deals with some of the thermodynamic fundamentals of noise much more fully than the above two references. (It also has a very full and clear treatment of Fourier principles for steady-state and transient analysis of radio problems.)

4. "Noise in Condenser Microphones" by A. G. T. Becking and A. Rademakers. *Acustica*, Vol. 4. No. 1, p. 96. (1954).

*** The shot noise formula is usually given in the form shown in Fig. 5, i.e. $I_N^2 = 2qI_{dc}B$. If, however, the device giving shot noise is fed with constant current, then the shot noise voltage across it is given by:—$e_N^2 = 2qI_{dc}B \times r^2$, where r is the small-signal a.c. resistance of the device.

Improved 525/625 TV Standards Converter

One major drawback of the B.B.C.'s existing television standards converter* for converting American 525-line pictures to British 625-line pictures—a black border round the displayed picture—has now been overcome, as viewers of the Mexico Olympic Games programmes will have seen. A new type of electronic converter, developed by the B.B.C. Research Department, has been put into operation at the B.B.C. Television Centre, London, and this redistributes the information from the American 525/60-field p.s. pictures into European 625/50-field p.s. picture format in a different and more complex manner.

The redistribution is achieved partly by an "interpolator" which, from the 525/60 input signal, produces a new set of lines together with an extra 50 lines during each input field, and puts into these "empty" 50 lines (100 for a complete picture) signal information obtained by interpolation. The process involves filling in information between adjacent lines of an input field, and in order to derive the correct signal values to be interpolated one television line must be temporarily stored until the next arrives. This is done in ultrasonic delay units of one-line delay time. There is also signal interpolation between adjacent lines of a picture, and this requires ultrasonic stores of one-field delay time.

Since each input field already has its full complement of lines the generation of 50 extra lines means that occasionally two separately interpolated lines occur simultaneously. The output of the interpolator is therefore fed into a unit called the main store which re-times the lines so that they emerge in a continuous train, and this process of re-timing results in the expansion of each "American" field by 3⅓ms to the full time of a British field (20ms). In the final displayed picture it is not possible to point to particular lines and say that these are the "extras" because in fact the interpolated signal information is distributed over the entire picture.

The earlier standards converter entailed the use of an intermediate video tape recorder because the American/British field frequency ratio is not the integral ratio of precisely 6:5 required by that converter but actually 59.94:50. In the new machine this problem has been avoided in the timing system, which allows a non-integral ratio to exist between the input and output field frequencies, so that now direct "live" standards conversion is possible.

*Colour TV Standards Converter", *Wireless World*, Oct. 1967, p.476.

Filling the Light-Radio Gap

Classical and quantum techniques for generating sub-millimetre waves described at MOGA 68 conference, Hamburg.

Although we have always known, theoretically, that light and radio waves are both forms of electromagnetic radiation, the two bodies of technique, optics and radio engineering, have hitherto been self-contained and isolated from each other. The coming of the laser radically changed the situation, in that here was a device producing radiation in the optical region of the spectrum that was coherent in the same manner as radio transmissions. Initially the two classes of generator were still far apart in the frequency spectrum, but now, with r.f. techniques producing shorter and shorter wavelengths and lasers generating longer and longer wavelengths, the two have finally met in the middle—in that interesting region known as the far infrared by optics people and sub-millimetre waves by radio people. Indeed, to judge from information presented at the recent MOGA 68 conference in Hamburg* they have not only met in the middle but overlapped, as shown in the chart below. While F. K. Kneubühl, of the Eidgenüssische Technische Hochschule, Zürich, was talking about an iodine cyanide gas laser operating at wavelengths extending up to 0.774mm, in another session B. B. Van Iperen, of Philips Research Laboratories, Eindhoven, was describing a new type of klystron tube, incorporating a frequency multiplier, for producing wavelengths as short as 0.46mm. (Note that although the "l" in laser comes from "light", the word laser is now generally applied to all devices producing photons by atomic energy-level transitions—quantum electronic devices—whether the resulting radiation is visible or not.)

If the mere closing of the gap in the spectrum were not enough to demonstrate that the radiations from the two classes of generator were identical, some of the other work described at Hamburg certainly was. For example, M. A. Pollack, of NASA, U.S.A., outlined a technique for mixing the output of a 147.7GHz klystron oscillator plus frequency multiplier with the 118μm wavelength radiation from a water-vapour laser (frequency about 2500GHz), to obtain a beat frequency which was amplified by an i.f. amplifier and displayed on a c.r.o. The mixing of the "optical" and radio waves was done in a gold electroformed waveguide structure containing a specially made point-contact diode constructed from silicon semiconductor and an electrochemically formed tungsten point. As Mr. Pollack spoke of the extremely critical, delicate contact needed in this device one was inevitably reminded of the catswhisker crystal detector of half a century ago, working in a somewhat different frequency band. The object of these NASA experiments has been to measure the frequency and investigate the coherence of the sub-millimetre laser radiation with a view to its possible applications in space.

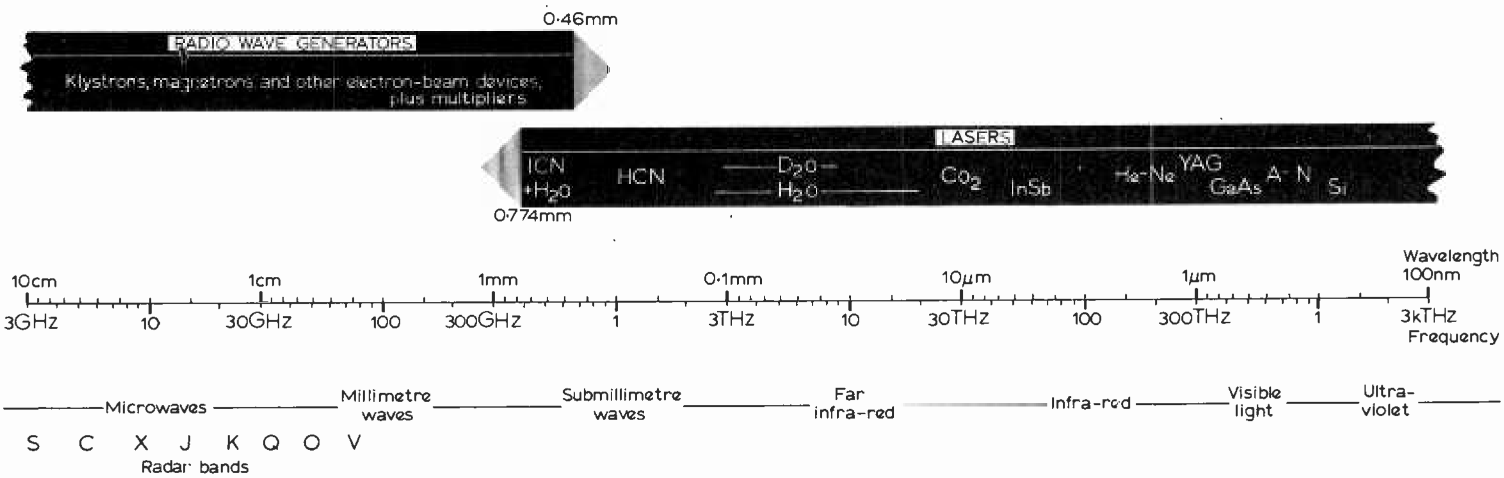
Pollack also mentioned an experiment in which oscillations from microwave electron tubes were shown to have harmonics in the "optical" (far infrared) region. It had been demonstrated, by mixing the 47th harmonic from a 70GHz klystron with the 11th harmonic from a 300GHz carcinotron and observing the beats that a frequency of about 3000GHz (0.1mm wavelength) was present. Working from the opposite direction, a Russian scientist at the conference, E. G. Solovier of the U.S.S.R. Academy of Sciences, described experiments in heterodyning the outputs of two lasers to obtain a difference frequency in the microwave radio band—actually 20GHz. An even lower difference frequency, in the X band (7-12GHz), was claimed to have been achieved by optical mixing in a single laser, in a paper by H. Inaba and T. Hidaka of Tohoku University, Japan. Here the difference frequency was produced from components of the radiation of a ruby laser, and the ruby rod of the device, 60mm long and 6.8mm in diameter, acted not only as the active medium for stimulated emission but also as a dielectric microwave cavity for the difference frequency. The X band signal was detected by a microwave superheterodyne receiver through a coupling iris in an end plate of a waveguide supporting the ruby rod.

Just as different methods of generation can now be used to obtain a given frequency in the sub-millimetre/far-infrared region so can different techniques of detection be employed for that frequency, and what were specifically either "radio" or "optical" methods are no longer confined to these traditional fields. Pollack's use of a point-contact diode for laser radiation was one example, while the output of Van Iperen's 0.46mm klystron was detected with a Fabry-Perot interferometer† and a Golay cell.‡

* The 7th International Conference on Microwave and Optical Generation and Amplification, Hamburg, 16th-20th September.

† Resonating device using facing mirrors to enhance a given wavelength—as in lasers.

‡ Gas cell in which infrared energy is absorbed and detected as temperature and pressure changes.



Although the work described at Hamburg was mainly research, interest in the sub-millimetre/far-infrared region is not entirely academic, as there are possibilities for use in communication, radar and navigation. In terms of hardware it offers something between the long range and large aerials of radio equipment and the extremely high resolution and compact size of optical systems. The main problem is the high absorption of radiated energy at these wavelengths in the earth's atmosphere—between 1mm and 50μm there are about 150 water vapour absorption lines in the spectrum. But of course for space travel applications this problem does not arise. Perhaps the main incentive for further work is the enormous information carrying potential of this region. As can be seen from the chart on the previous page, the bandwidth available in the sub-millimetre region alone—270GHz—is nine times as great as that of the whole radio spectrum below it.

A further report from the MOGA 68 conference will deal with the increasingly important field of solid-state devices for operation at microwave frequencies.

Optical Communications

Practical devices operating within the visible part of the electromagnetic spectrum

Optical communications techniques are based on the use of electromagnetic radiation in frequency bands which fall within the visible spectrum, for carrying transmitted information. Because light frequencies are very high, an optical system which used the whole gamut of the visible spectrum could accommodate 100 million television channels or 1000 times as many voice channels, so that the transmission of light could provide the solution to the overcrowding of broadcast transmissions and telephony in the radio frequency bands. A further advantage is that light can be radiated in very narrow beams, making it possible to employ separate systems physically close to each other without mutual interference.

Optical transceiver made from ordinary binoculars.

At the Ministry of Technology's Signals Research and Development Establishment, Christchurch, Hants, work has been carried out on optical communications for military purposes, since this method is virtually undetectable by enemy observation and the information cannot be tapped. There is no extraneous radiation from the light beam as there would be, for example, from a copper conductor, and the information can only be received at the point to which it is directed. A number of military developments using optical communications have recently become unclassified, and S.R.D.E. are now actively interested in their industrial and commercial applications. Some activities have been sponsored by one or two companies who are now manufacturing similar devices for sale on the civilian market.

Although a number of practical systems are already a reality for short-distance communication, and suitable light sources and detectors exist, there is still a problem of transmitting light from place to place. Transmissions through the atmosphere become impaired in poor visibility conditions, during fog, rain or snow and in extreme cases may fail completely. To provide an optical path which is unaffected by weather conditions, a proposed method is the use of a narrow glass fibre, through which the light is passed, clad with a glass sheath of lower refractive index to ensure that the light is guided along the centre core. Overall diameter of the glass fibre is approximately 0.01 cm and the bandwidth, which is dependent on the type of construction used, can be greater than 10^3MHz. 200 separate fibres can be packed into a diameter of 0.25cm. Optical glass at present available has attenuation in excess of 200dB per km but attempts are being made to make suitable glass and fibre with the desired minimum attenuation of 70dB/km. Gallium arsenide lasers are suitable as a light source, because the glass fibre attenuation is at a minimum at the gallium arsenide laser radiation wavelength of 0.9μ and also because these devices can be modulated directly, while silicon photodiodes, which operate in the near-infrared region, can be used as detectors. Ideally though, the system has to have a more efficient light source and improved detector performance before it becomes a practical proposition. Also the light source and detector devices should be of sufficiently small physical dimensions to enable them to be fabricated into the ends of the glass fibre during manufacture. This would eliminate subsequent alignment of these devices with the light beam, leaving only conventional electrical terminations to be made. For communications over longer distances, repeater amplifiers could be inserted between lengths of glass fibre.

The rate of progress in developing communication systems which rely on light propagation in glass fibres is determined mainly by the rate at which the problems of manufacturing fibre from glass with the required properties can be resolved. Work has been carried out on two types of fibre. One is described as a single-mode or waveguide fibre which is capable of providing only 3 or 4 modes of transmission. It has a bandwidth of approximately 10,000MHz over 1km and is most suitable where very wide-band single-channel systems are required, such as for inter-connecting computers or for very wide-band data handling. In the alternative type, multi-mode fibre, hundreds of transmission modes are possible, but with a much smaller band-width (approximately 5MHz over 1km). This type of fibre is more suitable for use where a number of separate channels of information are required, such as for television conference facilities, although each fibre in a multi-core assembly of, say, 200 fibres, requires its own light source and detector. The second fibre type is the one chosen for detailed study by S.R.D.E.

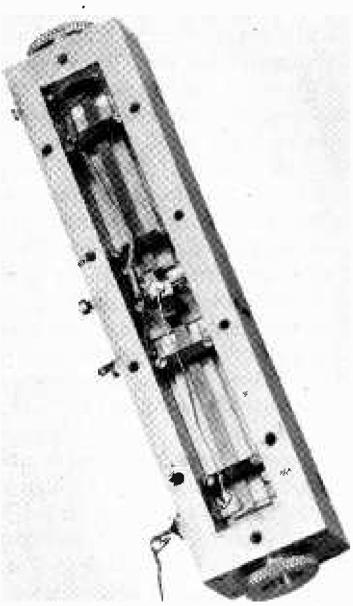
The prospect of using wide-band glass fibre cable in opto-electronic systems that would replace conventional copper telephone cable systems has been enhanced by a recent announcement by the Post Office Research Station, Dollis Hill, London, that raw materials necessary to make the required high-quality glass are now available.

Modulation of the light so that it will carry information is another difficulty and at S.R.D.E. the simple amplitude modulation used in previous optical links has been abandoned in favour of a sophisticated pulse frequency modulation system operating at a p.r.f. of 20kHz. Speech is converted into the pulse-coded electrical signals and these are amplified to drive a room-temperature GaAs laser. The emitted pulses of infrared light are transmitted along the length of glass fibre, detected by a photodiode and subsequently converted back into speech.

One commercial piece of equipment designed for modulating a laser light beam is produced by Elliott Brothers of, Camberley, Surrey. Called optical modulator EOM/727, it comprises the modulation unit proper, which is inserted in the path of the light beam, and a solid state electronic control unit, connected to the modulator by a flexible lead. Described by Elliott's as an amplitude modulating system, it causes information to be imposed on the light beam by varying the angle of polarization as the beam passes through the modulator unit. A calcite prism is used in the modulator. A feature of the system is the low drive voltage used, 150V at 0.63 micron, which makes possible the use of transistor circuitry. Previous types, of American origin, have required drive voltages of up to 8kV. The modulator operates from 220-240V a.c. mains and has a bandwidth of 6MHz. It is suitable for use with a laser beam in communication or display systems and was seen at S.R.D.E. modulating a 625-line television signal onto a laser beam which was then demodulated and fed to a monitor receiver.

The physics department of Essex University has been investigating opto-electronic communications over a distance of five miles with carbon-dioxide lasers. It is reported that a very high degree of reliability could be achieved over distances of up to 20 miles using this method. What is said to be the most powerful pulsed carbon dioxide-laser in the world has just been installed at the University. This is a 70ft system with an instantaneous peak output of 250kW.

Laser beam modulator unit.



Among the optical equipment recently put on show at S.R.D.E. was an audio two-way link-up via two pairs of specially adapted, but otherwise normal binoculars over a distance of about 150 yards. One eye-piece was used as the transmitter and the other as the receiver, with a gallium arsenide lamp source emitting a narrow infrared beam and a photodiode as a detector. The equipment can be hand-held and aligned by using the binoculars in the usual manner. These transceivers have a moderate range, requiring a line-of-sight path with good weather conditions. Applications might include building construction and surveying. The pairs of binoculars must be aligned within 0.5 deg and when this requirement is fulfilled, normal conversation is possible between two people wearing only a lightweight headset and mouthpiece combination.

A practical domestic application for glass fibre cable is in motoring—a road-light failure warning system which transmits light from a tail light cluster via a fibre-optic link to a monitor in the car.

Designing Circuits for Integration

Contrary to earlier ideas, it is now quite possible for electronic equipment designers to design their own integrated circuits, in collaboration with the i.c. manufacturers who will actually produce the devices. At an I.E.E./I.E.R.E./I.E.E.E. conference in Cambridge, D. R. Hester of Plessey outlined what sort of demands are made on the outside engineer if he wishes to make use of the facilities for "i.c. custom design" provided by a manufacturer. First of all he must be prepared to undergo a period of training with the i.c. manufacturer, and in the case of Plessey this would probably be a course of three months, working on a specific circuit project. In the actual process of design the trainee has to work within (a) the component characterization data resulting from the manufacturer's process, (b) a set of "worst case" limits on the component data, and (c) a set of layout rules, including such parameters as the distances necessary between junctions to allow for diffusion and photoengraving misalignment.

What Mr. Hester considered the most significant constraint on the designer was that he had to be prepared for a restricted use of the "breadboard". The reduced lead lengths and header capacitances within a semiconductor chip, said Hester, often made it impossible to simulate an integrated circuit accurately in breadboard form, and so it was necessary to determine the circuit performance by calculation. Furthermore, the calculations had to be correct. Once an i.c. chip had been made its components were fixed, and the cost in time and money of correcting a mistake was quite significant.

It had been found best to proceed as far as possible with a paper design, using computer-aided design techniques whenever they were available. The next step was to simulate the circuit as nearly as possible in breadboard form, using active components provided by the i.c. manufacturer and conventional passive components. The performance of the breadboard would be predicted, and then measured to check the accuracy of the design theory. Modifications to the breadboard and the calculations would then be carried out until the designer was confident that he understood his circuit, when he would be in a position to predict the performance of his i.c. for comparison with the specification.

Hester warned that the designer had to calculate in advance the effects on his circuit of the parasitic capacitances within a chip, and the resistance of the aluminium interconnections etc. Some circuits, particularly for high speed or high frequency applications, were critically dependent on the chip layout, and it had always been necessary to ensure that the responsibility for chip layout would be borne by the designer himself rather than by, say, the mask-making department or the drawing office.

One implication of this demand for more thorough initial design, said Hester, was, of course, that it took longer and cost more, although this was not necessarily the wrong place to invest in engineering effort. It had been found, for example, that a design team might fall well behind schedule for "A" model circuits, and yet easily catch up during the "B" model phase, for most circuits went unaltered into the "B" model equipment. The photoengraving masks would have been completed and so the circuit could be put into production quite quickly.

Northern I.E.A. show?

An exhibition, which might well become the Northern counterpart of the London Instruments Electronics and Automation Exhibition was held in Manchester at the end of September. Organized for the past 17 years by the Institution of Electronics, it has grown from a small instrumentation exhibition held at a college to a sizable show embracing the whole field of electronic components, instruments and controls. About 60 exhibitors participated and several of them have not been seen at a London show.

The four-day exhibition, which was opened by Dr. Jeremy Bray, joint Parliamentary Secretary, Ministry of Technology, included a series of lectures and demonstrations. Among the speakers was T. D. Towers, of Newmarket Transistors, who gave a series of three lectures on semiconductor surface mounting devices; K. J. E. Burge, of Wyvern Organs, who, with J. P. Mitchell, described and demonstrated an electronic organ; A. M. Martin, of International Rectifier Co., who gave several lectures including one on developments in high-power fast turn-off diodes and thyristors; and A. J. Barnes (Texas Instruments) who dealt with digital i.cs.

A number of products were on show for the first time and some of these will be dealt with in subsequent issues.

Electronics at Farnborough

A glance at some of Britain's latest avionic equipment

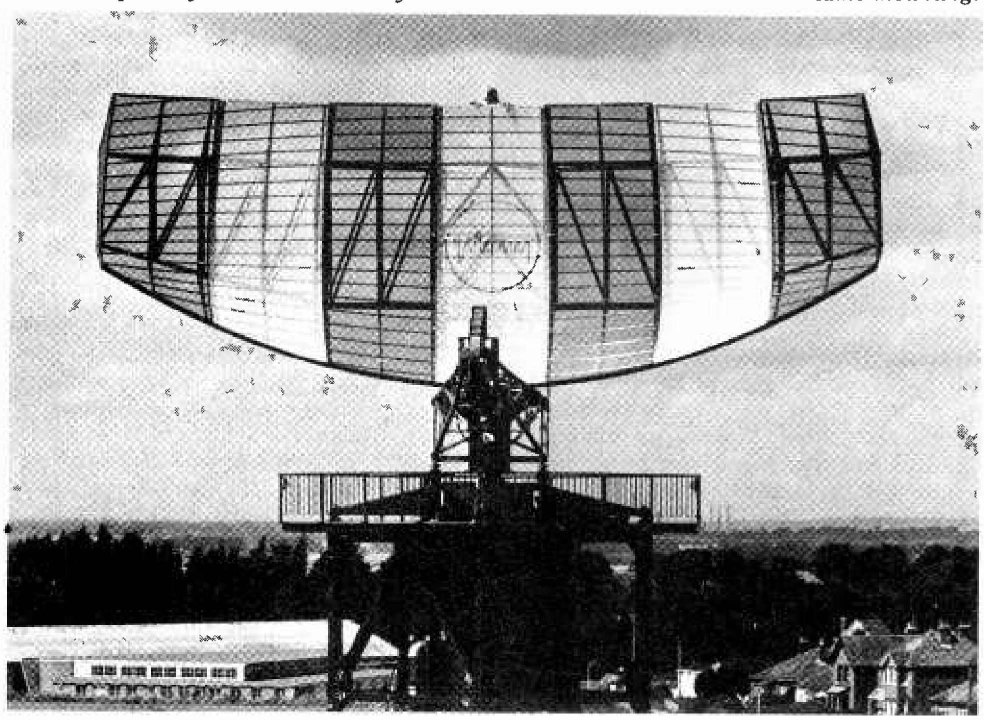
Farnborough has been described as the shop window of the British "avionics" industry and the most valuable show to exhibitors as far as orders are concerned. The adverse weather conditions immediately preceding the opening did little to dampen the enthusiasm of visitors from 120 countries in spite of the fact that the airfield rapidly became a sea of mud. Some amusement was caused by the television report of a fish captured on the main runway—presumably on a "cross country" from the nearby canal.

Radar

Described as the big brother of the Plessey AR-1 recently installed at Farnborough the company introduced a new large primary radar known as the AR-5. Operating in the L band (23cm) the AR-5 has a maximum range of 200 nautical miles providing coverage up to 80,000 ft. A moving target indicator (m.t.i.) system is incorporated which allows only echoes from moving targets to be displayed thereby eliminating clutter caused by stationary objects—buildings, parked aircraft and the like. (Potted spec.: wavelength—23cm; p.r.f.—350p.p.s.; rotation rate—≏8 r.p.m.; noise factor—3.5dB.)

Marconi were showing the S600 modular radar system which was announced recently. Modules available enable 5.5, 10 and 23cm radars to be built up for a wide variety of fixed-station and mobile civil and military applications. Taking the SG54 as an example; this is a 23cm surveillance radar system intended for air traffic control. In order to reduce clutter an m.t.i. system is incorporated and, in addition, two beams are used. Two separate radiators share the same reflector and are arranged to produce beams that are displaced from each other in the vertical plane. The radiating elements share a common receiver via a fast-acting r.f. changeover switch. The changeover is made in every interpulse period at a predetermined range, typically 15 nautical miles. The technique is claimed to reduce clutter significantly because at short range, where clutter is worst, signals are derived from a beam having little gain at low elevation angles. (Potted spec.: frequency—1250 to 1365MHz tuneable; peak power—2MW; pulse length—1.5 to 5 μs; p.r.f.—250 to 850p.p.s.; noise figure 2.5dB.)

The AR-5 primary radar. A secondary radar scanner can be attached to the same mounting.



The latest version of the Cossor s.s.r transponder, type SSR2100, which is fitted to the *Concorde* prototypes, was shown. This makes extensive use of integrated circuits in the processing and i.f. sections. Coding and decoding is performed by two digital shift registers operating in parallel from two phases of a crystal controlled clock generator. Built-in logical redundancy ensures that in the event of an i.c. failure the system still replies with 50% fidelity to 80% of the received interrogations. Cossor have just received an order for this transponder from the Ministry of Technology. Although full details of the order have not been revealed it is understood that the equipment will be for use in Royal Air Force aircraft. (Potted spec.: Tx frequency—1.09MHz; Tx power output—500W; Rx frequency—1.03MHz; reply codes—12 information pulses with 4096 possible combinations; temperature range — −26°C to +55°C, convection cooling.)

The Plessey PTR446 s.s.r. transponder was also on show. An order worth £1M was recently announced for this equipment by the Ministry of Technology. Group Captain E. Fennessy, managing director of the Plessey Electronics Group, said that he expects an international market for s.s.r. equipment of £4M over the next five years.

Secondary radar ground installations were shown by Plessey, Cossor, and Marconi-Elliott. The aerial for the Plessey system is arranged so that it can be mounted atop the previously described AR-5 aerial. The Marconi-Elliott system is called "Challenger" and allows for two distinct modes of operation —active and passive. In the active mode a ring marker placed over the aircraft plot on the radar display causes the identification and height of the aircraft to be displayed. In the passive mode all aircraft plots are eliminated from the screen with the exception of the one the controller is interested in. This is achieved by making the system respond only to the identification code assigned to the wanted aircraft.

Solartron's selective moving target indicator equipment was displayed. This limits the effects of tangential fade when m.t.i. is used for the suppression of ground radar returns. The s.m.t.i. was fitted to a video map in the Solartron mobile demonstration unit which was fed from Farnborough's AR-1 radar.

Expanded polystyrene granules being poured into a mould at the components group of Plessey during the manufacture of radar absorbent material. After processing the material will absorb radiation from 0.75 to 30GHz.

Video signals processed by the s.m.t.i. were then distributed to other stands. The s.m.t.i. equipment is being installed at the new West Drayton air traffic control centre and at Heathrow.

Ekco displayed the weather radar for *Concorde* (described in the article "Electronics in Concorde", March 1968 issue), a smaller weather radar—type E90—for feeder line and executive aircraft and a new tactical radar. The latter is fitted to *Wessex* Mk III helicopters and will also be fitted to the Westland *Sea King* when it enters service. In addition to displaying primary returns from targets with ranges up to 50 nautical miles, the equipment also displays secondary radar signals from aircraft in the vicinity equipped with transponders and range and bearing of sonar contacts are also shown. Primary and secondary returns can be displayed separately or simultaneously in any one of three modes, conventional p.p.i., ground stabilized or ground stabilized with offset.

Coincident with the Farnborough display Ferranti announced an order from the Netherlands Government Purchasing Office acting on behalf of the Department of Civil Aviation for a radar simulator. The equipment, which is worth £100,000, is to be installed at a training school for approach and area radar controllers at School Airport, Amsterdam. The simulator, which is based on the FM160b miniature digital computer, will simulate the movements of up to 30 aircraft within the Amsterdam region and will represent one approach radar and one long-range radar.

Navigation

The type 5 lightweight automatic h.f. direction finder exhibited by E.M.I. is a commercial version of an equipment designed for military use. The loop aerial, a capacitive goniometer, employs a matching method which uses a wideband tuning technique and an aerial sense pre-amplifier that allows the aerial to be mounted at virtually any distance from the receiver. The receiver employs a crystal-controlled local oscillator and uses frequency synthesis to cover the operating band. (Potted spec.: frequency range—100kHz to 3MHz, sensitivity 25μV/metre, accuracy $\pm 2°$ at 25μV/metre.)

A moving map display from Marconi, AD670, when used in conjunction with associated computer, indicator and controller forms a complete aircraft navigational system. The system accepts inputs from ground or self-contained aids and provides aircraft position outputs on a counter and on the back-projected moving map. Outputs are also available for feeding an automatic pilot directly and for correcting an inertial or heading reference stabilized platform. Marconi also displayed a v.o.r./i.l.s. navigation system, type AD270, which receives and processes instrument landing system glide path and localizer signals.

The Decca DANAC is claimed to be the simplest pictorial display navigation system yet devised, as the setting up operation has been reduced to pushing a single button. The complete equipment consists of a Mk.15 receiver, DANAC computer, control box and self-setting display head type 966. Aircraft position is superimposed on a moving roller-chart, pilot involvement being reduced to setting the aircraft's starting position on the display. Decca also showed the type 72 doppler as specified for the Anglo-French *Jaguar* and the type 71 which has been ordered by the Swedish navy. A new Loran, type ADL22 was also exhibited.

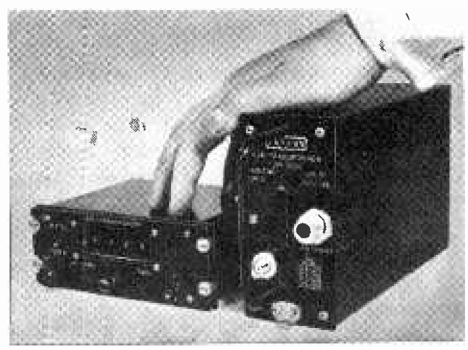
A mini-doppler, type AD510, first shown at the German air show earlier this year was to be found on the Marconi stand. Intended for use in helicopters and small aircraft for up to supersonic speeds the equipment consists of two units, an aerial unit measuring 30.5 × 30.5 × 10cms and an electronics unit housed in a short $\frac{3}{4}$ ATR case.

Instrumentation

An equipment from Elliott Automation will enable a check to be made on the accuracy of both airborne and ground automatic landing installations. A number of sensors of various types located along the line-of-flight allow a record to be made of the progress of an aircraft engaged in landing from a height of 60m to a point about 1,400m past the runway threshold where nosewheel steering is initiated. Before the runway threshold a landing aircraft passes in "view" of a number of photoelectric sensors which are arranged in such a way to make it possible to compute the aircraft's approach, lateral and vertical speed, height and position. Geophones (seismic detectors) located at strategic positions along the flight-path register the touchdown point, bounce and give an idea of the severity of the impact. Infra-red detectors at intervals down the runway allow the progress of the aircraft to be recorded and give information on speed and position relative to the centre-line. The outputs of all the sensors are fed to a central processor which produces a punched tape containing all the relevant data for analysis by a general purpose computer. Interlocking facilities are such that signals due to aircraft taking off, low velocity vehicles and over-flying birds or aircraft are ignored. Although the equipment has been ordered for use at the Blind Landing Establishment at Bedford it is a matter for some conjecture as to whether other airfields will consider the equipment necessary. On the Elliott stand, rather hopefully, a chart showed how the system could be installed at Heathrow.

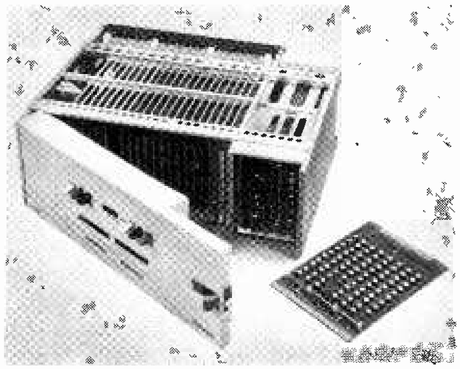
Talisman is the name of an infra-red line scan equipment that is installed in a reconnaissance pod developed by E.M.I. The pod, housing Talisman and other equipment, will be fitted to the F4M *Phantom*. Infra-red radiation depends upon the temperature and the emissivity of an object. Thus any target whose temperature or emissivity differs from its surroundings may be detected, even if, in the latter case, the temperatures are the same. In Talisman strips of ground are scanned by mirrors driven by an air turbine. The mirrors are focused on to a bank of infra-red sensors the outputs of which feed light sources so that the information can be recorded on film.

The radiation detector designed by A.W.R.E. for *Concorde* and now being manufactured under licence by S. Davall and Sons Ltd. was on show. The system detects the ionizing and neutron radiation that could be expected to be found in the cabin of an aircraft cruising at high altitude and displays this on an indicator. The indicator also houses two small lights which signify "alert" and "action" conditions. In addition an output is provided that activates the master and audio aircraft central warning



The SSR 2100 miniature transponder from Cossor.

Moving map display from Marconi.



Ferranti FM1600B Computer.

Capacitance bridge for aircraft use from Thorn-Bendix. Range is from 1 to 1000pF with an accuracy of ±1%.

systems should "action" conditions be encountered.

Up to 300 parameters can be sampled at rates from 32 per second to 2 per second in the PV740 aircraft integrated data system from Plessey. Information from various sources within the aircraft is digitized and either recorded in the aircraft or transmitted directly to ground via a radio link. In this way a complete record of the performance of all the aircraft systems can be kept throughout their operating lives.

Other equipment and components

Plessey Electronics Group announced a combined u.h.f./v.h.f. airborne transceiver known as the PTR377. The equipment, which has been developed by the Radio Systems Division, is specified as standard equipment for the *Jaguar* and *Harrier* aircraft and the Anglo-French helicopters. It operates over the 100 to 156MHz and the 225 to 400MHz bands and provides radiotelephone communication on a.m., data transmission on f.s.k. and homing in azimuth at both v.h.f. and u.h.f. If required, it can be adapted to r.t. operation on f.m. All frequencies are derived from a single highly stable crystal controlled source. The resultant frequency stability over an ambient temperature range of −55 to +70°C permits operation at 25kHz channel spacing up to 400MHz. Channel spacing is normally 100 kHz for data and 50 or 25kHz, preset or switchable, for r.t. The PTR 377 provides up to 7,000 channels in the u.h.f. band and 2,240 in the v.h.f., any one of these 9,240 channels being selectable by the flight deck control unit on decade selection knobs. Alternatively, single switch selection of 19 preset channels anywhere in the range is provided. Two of these would be the international distress call frequencies of 121.5 and 243MHz, for which completely independent guard receivers are incorporated in the transceiver.

A v.h.f. transceiver operating between 117.95 and 135.975MHz using 25kHz channel spacing with facilities for single channel voice operation, the air traffic control signalling system and reception of ground stations using multi-carrier techniques was shown by Marconi. The equipment, type AD170, employs a control unit that will be able to control more than one transceiver using memory circuits.

A range of connectors from Amphenol, incorporating r.f. suppression networks in the pin contacts was shown for the first time at Farnborough. They have an insertion loss of 30 to 70dB over the frequency range 40MHz to 1GHz and are rated at 3A d.c. maximum.

A flight line test set for evaluating the performance of i.l.s. v.o.r. equipment was shown by Cossor. The test set, type CRM588, provides outputs at the localizer and glide path frequencies, 108.1 and 334.7MHz, and at the v.o.r. frequency, 108MHz, with an accuracy of ±0.0035%. A marker at 75MHz ±0.005% is also incorporated. Separate modulation controls for the localizer and glide path carriers are provided so that equipment associated with the i.l.s. system can also be checked.

Announcements

'Audio and Acoustic Measurements' is the title of a 12-lecture course to be held on Thursday evenings from October 24th at The Northern Polytechnic, Holloway Road, London N.7. Fee 3 gn.

A course of six **lectures on integrated circuits** (logic and linear applications), will be held at Twickenham College of Technology, Egerton Road, Twickenham, Middx, on Wednesday evenings commencing November 6th. Fee £4 10s.

£4½M, 1,000 mile **submarine telephone cable** capable of carrying 640 (3kHz) conversations is to be laid between Palo, near Rome, and Estepona, south-west of Malaga in Spain. Equipment for the new link will be manufactured and installed by Standard Telephones and Cables Ltd., of London. The new system, designated MAT I, will incorporate a microwave link from Estepona to the terminal at Conil in Spain where the fifth transatlantic cable (TAT 5) will also terminate. Another microwave link will connect the MAT I/TAT 5 Conil terminal with Sesimbra in Portugal, the European landfall of the South Atlantic cable (SAT I) from Cape Town (now 50% complete) and of the U.K.-Portugal cable, both of which contracts have been entrusted to S.T.C.

Technograph Printed Circuits Ltd. and AGA Aktiebolag have entered into an agreement in which a British patent relating to the manufacture of **multilayer printed circuits** will be exploited.

A joint statement has been issued by the Solartron Electronic Group and the Miles Group announcing that the two companies are to collaborate in the design and manufacture of **flight simulators** and other civil and military training systems.

Racal Electronics have announced the formation of a British based company, **Racal-Milgo Ltd,** to manufacture and market Milgo Series 4400 Data Modems, in association with the Milgo Electronic Corporation, of Miami, U.S.A.

Microwave Associates Inc. have acquired Huggins Laboratories of California, U.S.A., manufacturers of low-power t.w.ts. Huggins has been re-named Microwave Associates (West) Inc., and will be represented in Great Britain by Microwave Associates Ltd., Cradock Road, Luton, Beds.

Microwave Instruments Ltd., of Park Lane, Shiremoor, Northumberland, have been appointed U.K. representatives for Custom Materials Inc., Chelmsford, Massachusetts, U.S.A. specialists in **low-loss dielectric materials.**

Cosmocord Ltd., Eleanor Cross Road, Waltham Cross, Herts, have appointed Transatlantic Electronics Inc. of Hicksville, New York, as their marketing agents for the United States.

The Sound Division of Peto Scott Ltd., Addlestone Road, Weybridge, Surrey, will in future handle all **Pamphonic** audio products.

The Mitsubishi Electric Corporation have appointed Ultra Electronic (Components) Ltd., Microelectronics Division, 35-37 Park Royal Road, London N.W.10, to handle the range of **Melco integrated circuits.**

F.W.O. Bauch Ltd., Holbrook House, Cockfosters, Barnet, Herts., have been appointed sole U.K. agents for Wilhelm Albrecht GmbH of Berlin, manufacturers of sound recording equipment for use with 16, 17.5 and 35mm magnetic film.

EMI Electronics has been awarded an order worth £500,000 by the Italian engineering company Radionica SpA for four **outside broadcast vehicles** and studio equipment for the Libyan State television service. Each vehicle will be equipped with four EMI image orthicon monochrome cameras to be used at Tripoli and Benghazi.

The Ministry of Technology has placed an order valued at almost £350,000 with the Solartron Electronic Group for the supply of three **check-out systems** for the British Black Arrow Satellite programme. Two of these systems will be automatic and under digital computer control, the third will be manual.

An order valued at almost £2M has been placed with Pye T.V.T. Ltd. for **television studio and transmission equipment** to be sited in Seoul and Pusan, Korea.

Erie Electronics Ltd., have moved their London office from 1 Heddon Street, W.1, to Bilton House, Uxbridge Road, Ealing, W.5. (Tel: 01-579 2041).

The Great Northern Telegraph Works have changed the company name to **GNT Automatic A/S.** The address of the London office remains at 5 St. Helens Place, E.C.3. (Tel: 01-588 5040).

Granger Associates Ltd., the U.K. subsidiary of Granger Associates, Palo Alto, California, U.S.A., are moving from Walton-on-Thames to Brooklands Road, Weybridge, Surrey.

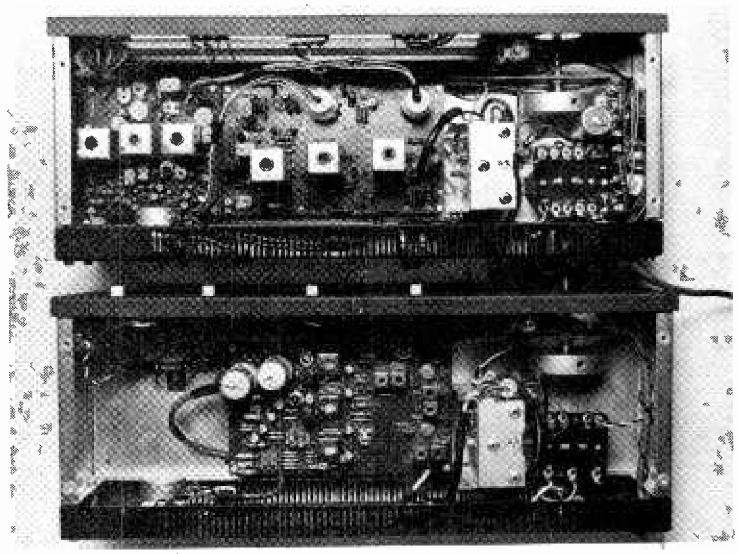
Nuclear Data Inc., of U.S.A., have announced the commencement of their own U.K. sales and service organization at Rose Industrial Estate, Cores End Road, Bourne End, Bucks.

The Aircraft Equipment Department of **Ferranti Ltd.** are to transfer their Research and Development Section, located at South Hill Park Manor, Bracknell, Berks., to new laboratories at the Department's headquarters in Moston, Manchester.

S. W. Ward & Co., the London based **TV aerial installation** company, have moved from Lambert Mews, N.12, to 143 High Road, N.11. (Tel.: ENT 0077).

Teknis Ltd., have transferred their Sales Department from the Head Office at Slough to Teknis House, 31 Stoke Road, Guildford, Surrey.

F.M. Tuner Using Integrated Circuits



Construction of the FM200IC integrated circuit tuner (lower chassis) compared with that of an earlier Truvox tuner, FM200, using discrete components throughout.

Two integrated circuits are used in the latest f.m. tuner to come on the market. They provide the functions of i.f. amplification and f.m. demodulation, and, as can be seen from the simplified schematic, Fig. 1, the only external components they require are tuned transformers, decoupling capacitors and a small number of resistors. The makers of the tuner, Truvox Ltd., say that the use of i.cs has enabled them to provide a standard of performance that would cost a great deal more —mainly in the assembly and testing processes of manufacture—if discrete components had to be employed. (The price of the new tuner, which includes a stereo decoder and has an f.e.t. front end, is expected to be in the region of £60.)

Both of the integrated circuits are R.C.A. linear types housed in 10-lead TO-5 packages. The first, type CA3012, is a wide-band amplifier with built-in power supply regulation, corresponding to the first part of Fig. 2 up to terminal 5. It consists of three direct-coupled differential-amplifier stages in cascade, each of the first two stages being an emitter-coupled amplifier and an emitter-follower. (The terminal numbers of the device correspond with those in Fig. 2—terminals 6, 7 and 9 being unused.) This amplifier, which provides the high gain of 65dB at the 10.7MHz i.f. is preceded by a single-peak tuned i.f. transformer and followed by a double-peak tuned transformer, the two together giving the required almost flat frequency response (±0.5dB) over the i.f. nominal bandwidth of 300kHz. The circuit of the second integrated circuit, type CA3014, is shown in Fig. 2. It comprises a three-stage direct-coupled amplifier-limiter cascade, a power regulating system, components of an f.m. ratio detector, and a Darlington-pair output stage. The ratio detector components work in conjunction with an external tuned phase-shift transformer as shown in Fig. 1. Normally ratio detectors and discriminators use large-value capacitors to obtain peak rectification from the detector diodes, but since capacitors of this size could not be included in integrated circuits they have been dispensed with and instead average detection is used with a substantially resistive load.

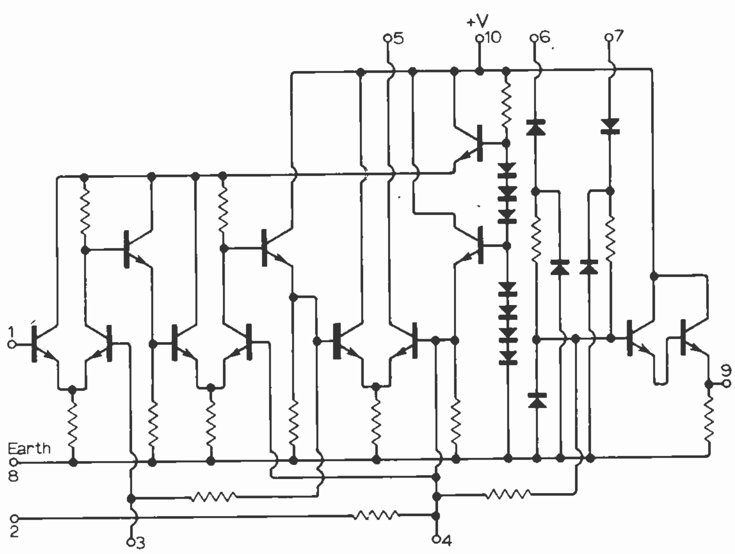
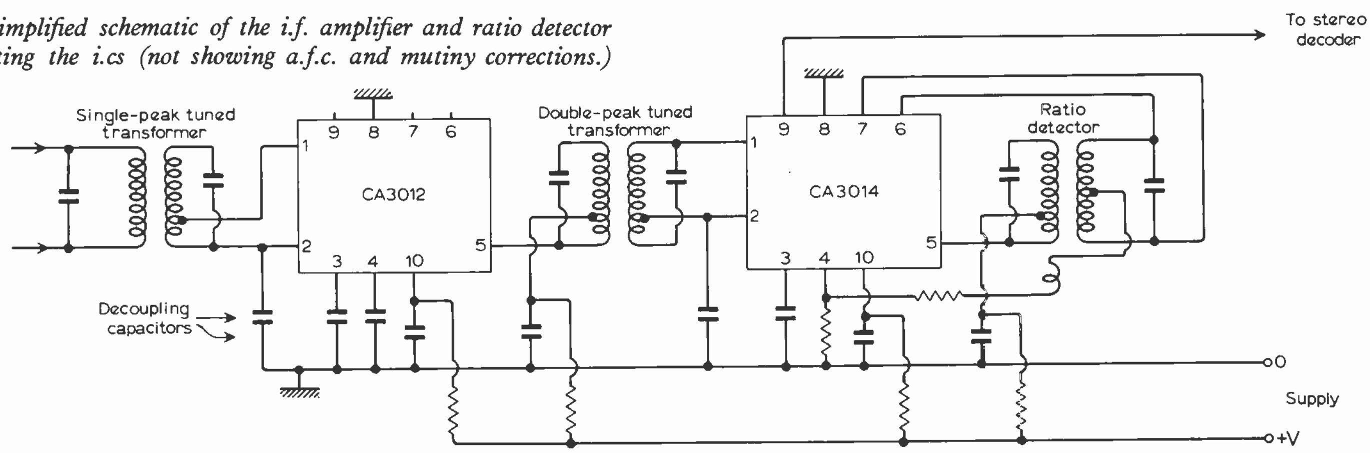


Fig. 2. Circuit of R.C.A. integrated circuit CA3014.

A notable performance advantage obtained through the use of integrated circuits is the good a.m. rejection, which is as high as 50dB. Sensitivity of the tuner is 2.0 μV for 30dB quieting (I.H.F.M. spec.); i.f. rejection is 85dB and image rejection (119.4MHz) is 55dB. Stereo separation is 30dB at 1kHz. Audio frequency response is ±1dB from 20Hz to 15kHz.

Fig. 1. Simplified schematic of the i.f. amplifier and ratio detector incorporating the i.cs (not showing a.f.c. and mutiny corrections.)



Personalities

F. E. Jones, M.B.E., D.Sc., F.R.S., managing director of Mullard Ltd., has been appointed Visiting Professor in the Department of Electronic and Electrical Engineering at University College London, where he will introduce undergraduate students, by lecture and discussion, to "some of the exciting challenges of the modern electronics industry". Dr. Jones has been with Mullard since 1956 prior to which he had been 16 years in the scientific civil service. After graduating at King's College, London, in 1940 he joined the Telecommunications Research Establishment. He was appointed an M.B.E. in 1945 for his work on the blind-bombing system "Oboe". For the last four years of his Government service Dr. Jones was deputy director (equipment) at the Royal Aircraft Establishment, Farnborough.

Robert J. Clayton, O.B.E., M.A., F.Inst.P., managing director of G.E.C.-A.E.I. Research Ltd., is the 1968/69 chairman of the I.E.E. Electronics Division. Mr. Clayton, who is 53, took the natural-sciences tripos at Cambridge University, specialising in physics, and in 1937 joined the General Electric Company research laboratories. He was for some time manager of the group of G.E.C. applied-electronics laboratories and later deputy director of the company's Hirst Research Centre. In 1961 he was appointed general manager of GEC (Electronics), becoming managing director in 1963. Mr. Clayton, who has been

R. J. Clayton

managing director of GEC-AEI Research since the amalgamation of the two companies, has been a member of the electronics research council of the Ministry of Technology and is chairman of its communication committee.

John H. Westcott, D.Sc.(Eng.), Ph.D., D.I.C., professor of control systems in the centre for computing and automation at Imperial College, London, is the new chairman of the I.E.E. Control and Automation

Professor J. H. Westcott

Division. Professor Westcott, who is 48, interrupted his apprenticeship with the British Thomson-Houston Company to attend London University, where he received a B.Sc. degree in electrical engineering in 1941. On completion of his apprenticeship he was seconded to the Radar Research & Development Establishment, Malvern, to work on auto-follow radar. In 1946, he returned to the University to undertake research on the theory of servo-mechanisms at Imperial College, and during 1947-48 he studied the work of Norbert Wiener on filters at the Massachusetts Institute of Technology. After obtaining his Ph.D., he joined the staff of the electrical engineering department at Imperial College, where he was professor of electrical engineering before occupying his present chair. Dr. Westcott has been founder director of three companies, and chairman of Feedback Ltd. since 1958.

Gerald W. Boulton, Dynamco's chief engineer, instrumentation, has been appointed to the board as technical director. He joined the company in 1962 after spending ten years with the Bristol Aircraft Corp., where in addition to development work on electronic instruments he lectured in the Corporation's Technical College. Dynamco, of Chertsey, also announce the appointment of **David E. Taylor,** M.I.E.R.E., to the board, as sales and marketing director. He has been the company's sales manager since 1962 prior to which he was with Solartron.

M. W. Hefferman, senior engineering lecturer at the Thomson Foundation Television College, Glasgow, since 1965, is leaving to become engineer-in-charge of the newly formed Mass Media Centre in Addis Ababa, Ethiopia. During 1964/5 Mr. Hefferman, who is 46, was chief engineer of Gibraltar Television having previously been chief television engineer in Cyprus and chief engineer of the Western Nigerian Radio-vision Service. **William Kirkwood** has been promoted to senior engineering lecturer at the College in Glasgow where he has been on the staff since 1966, prior to which he was with the B.B.C.

T. W. Straker, M.Sc., Ph.D., F.I.E.E., has joined Standard Telephones and Cables Ltd. as executive director of the Radio Group. Based at New Southgate, North London, he will assume responsibility for S.T.C's activity in avionics and radio communications. Born in New Zealand, Dr. Straker came to England in 1946 after receiving an M.Sc. degree from Canterbury University. Following research work at the Cavendish Laboratory, Cambridge, on the ionospheric propagation of radio waves, he received a Ph.D. in 1950. He then spent five years in Ottawa with the Radio Physics Laboratory of the Canadian Defence Research Board, and three years as defence research liaison officer with the Canadian Joint Staff in London, before joining the Marconi Company's Research Laboratories. In 1961 he became manager of the Radar Division and since 1965 has been general manager, telecommunications.

Dr. T. W. Straker

G. D. Speake, M.A., director of research in the Marconi Company since 1965 has succeeded Dr. T. W. Straker as the company's general manager, telecommunications, responsible for the five divisions covering space communications, broadcasting, radio communications, line communications,

G. D. Speake

and mercantile marine equipment. Mr. Speake, who is 49, graduated in physics from St. Catherine's College, Cambridge, and after service in the Technical Branch of the R.A.F. spent four years as instrument manager of I.C.I. before joining Marconi in 1950. From 1960 until 1965 he was deputy chief of research.

Clive Barwell has been appointed head of Mullard's Industrial Electronics Division in succession to **C. F. Machin,** who will for some time be taking charge of Mullard Incorporated in the United States prior to assuming new responsibilities in the company. Mr. Barwell was previously head of Mullard's Central Marketing Services Division.

Ronald F. Russ, managing director of Bell & Howell Ltd., Consolidated Electrodynamics Division, has been appointed international vice-president in the Electronic Instrumentation Group of Bell & Howell. In his new capacity, Mr. Russ will control the operations of the Group's three subsidiary companies in Britain, Germany and France. He will also continue in his position as managing director. Mr. Russ who is 42, began his career shortly after the war at the Royal Aircraft Establishment, Farnborough. In 1953 he joined the Research Department of the B.B.C. where he became a member of the team working on the development of the Corporation's first video magnetic tape recorder. Prior to joining Bell & Howell's subsidiary, Consolidated Electrodynamics Corp. (U.K.) in 1961, he was with Solartron.

H. E. Godfrey, who has joined Decca Radio & Television as marketing manager, was with Philips Electrical for 21 years. For the last seven years he was commercial manager of the radio and television division.

News of the Month

Paper transistors

The era of the tear out, disposable, transistors and paste together, pull out, amateur constructional projects is upon us. In "News of the Month" June 1968 in a report on the Thick Film Technology conference held at Imperial College, London, we described work that was being carried out with GAD (Graphic Active Device). Now Westinghouse Electric International have released details of a range of experimental transistors that can be printed on paper, plastic and aluminium foil.

The applications for such devices are numerous, toys, hobby kits, novelties, teaching aids, low-cost industrial apparatus. In the data storage field perhaps the full circle will be completed and once again data will be stored on paper, only not with ink, but with transistor circuits.

At the present time Westinghouse have succeeded in printing, by metal evaporation and not with ink, 600 transistors in a space the size of the average postage stamp and rolls of 13,000 transistors have been produced. There appears to be no limitation to the length of rolls that can be used, so the possibility exists of printing, testing and encapsulating circuits as one long continuous process. In this way, it is stated, a single machine could manufacture 50 million thin film circuits a year—the mind boggles.

To date Westinghouse say they are some time away, several years perhaps, from a commercial product. However, the future in this field certainly looks exciting.

Microwave Computers

Digital computers with arithmetic units operating at pulse repetition frequencies in the microwave region are a possibility arising from work by H. L. Hartnagel of Sheffield University. At the MOGA 68 conference at Hamburg (see also page 393) he described a technique for making fast logic elements from Gunn-effect diodes, by which pulse durations "shorter than 50 psec" can be obtained. The justification for this work is, of course, that the junction capacitance of conventional semiconductor devices places a limit on the frequency at which present solid-state logic elements will operate. In Dr. Hartnagel's Gunn-diode elements the leading edge of the pulse consists of the sudden drop of current when an electric-field domain is formed, while the trailing edge of the pulse is the termination of the current drop that occurs when the travelling domain reaches the anode end of the diode and is discharged. Thus the length of the diode determines the pulse duration. So far Hartnagel has made diodes with lengths ranging from 600μm down to 140μm, but he claims that they can be made 5μm long or ever shorter, to obtain the 50ps pulse duration referred to. Gunn-effect pulse regenerators, AND and OR gates, comparators, inhibitors, one-bit memory elements and an analogue-digital converter were described. In answer to criticisms that the Gunn logic elements had a greater current consumption than conventional semiconductor elements, Hartnagel said it was envisaged that the technique would be restricted to the central processing unit of digital computers.

London's educational television service

The first 300 schools and institutes in the Inner London Education Authority's educational service received their first broadcasts on September 12 when the system was officially inaugurated. When the remaining 1,000 schools are brought into the network over the next year ETV London, as the service is called, will probably be the largest closed-circuit television system in operation in the world.

The first establishments to receive ETV are in the Tower Hamlets and Islington areas. The cable network is expected to carry up to seven channels when the system is in full swing and extension to nine channels is possible should the extra capacity ever be required. From 1969 two of the channels will be used to relay B.B.C. and I.T.A. educational programmes; one is reserved for the Universities of London, polytechnics, and colleges; and the remainder will be for programmes made at the ETV centre in the former Laycock School at Highbury.

The welded outer conductor coaxial cables carrying the signals from the ETV centre are being laid by the Post Office in existing telephone cable ducts. Repeaters which amplify and equalize the signals are interposed every 500 to 800 yards and are installed in telephone exchanges and manholes. The d.c. power supply to energize the repeaters is fed along the same coaxial cable as carries the signal, in much the same way as submarine cable repeaters are powered. The nine carriers employed are spaced so that the total composite signal falls in the 40 to 140MHz band. Some wired television networks feed the sound at a.f. along separate pairs of wires. Here this is not the case as the 625-line signal is relayed with f.m. intercarrier sound in the same form as transmitted by the B.B.C.

A supervisory system operates in the following way: a pilot signal is transmitted throughout the network from the send terminal to repeaters installed in each school. The school repeaters reply with another tone which is routed to the nearest telephone exchange. Should the return tone not be received an alarm is automatically actuated.

The receivers in the schools have been built to an Inner London Education Authority specification by Decca Radio and TV Ltd. They have a better-than-domestic sound and vision response, good overall picture linearity and incorporate black-level clamp circuits. The production studio is equipped with three E.M.I. image orthicon cameras and a training studio has three Marconi vidicon cameras.

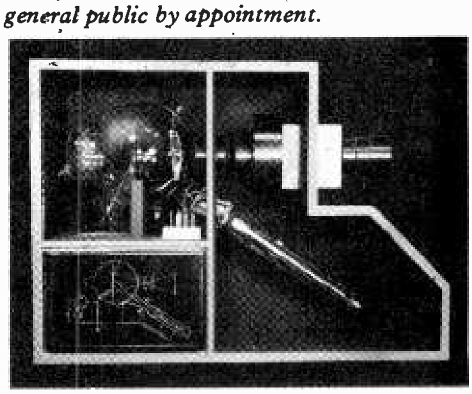
Olympic Games via ATS III

Overseas television coverage of the Olympic Games from Mexico City will be handled through the Applications Technology Satellite III following the recent failure of the Intelsat III launch vehicle. The use of the satellite was made possible under a contingency agreement between the National Aeronautics and Space Administration and the Comsat Corporation in case Comsat lacked sufficient satellite capacity.

ATS III was launched in November 1967 as one of a series of satellites to carry out experiments in the useful applications of space technology in communications, meteorology and navigation. It is in synchronous orbit over the Atlantic.

The video part of the composite television picture will be transmitted from Mexico's earth station to Goonhilly via ATS III. Back-up stations are at Etam—West Vancouver,

This example of the first successful electronic TV camera tube developed by Isaac Shoenberg and his associates at E.M.I. is one of the exhibits in the Television Gallery opened at the I.T.A. headquarters last month by Earl Mountbatten. The Television Gallery was built to provide a centre of information about television with a non-technical approach specially for the layman. It is located at the I.T.A., 70 Brompton Road, London S.W.3, and is accessible to the general public by appointment.



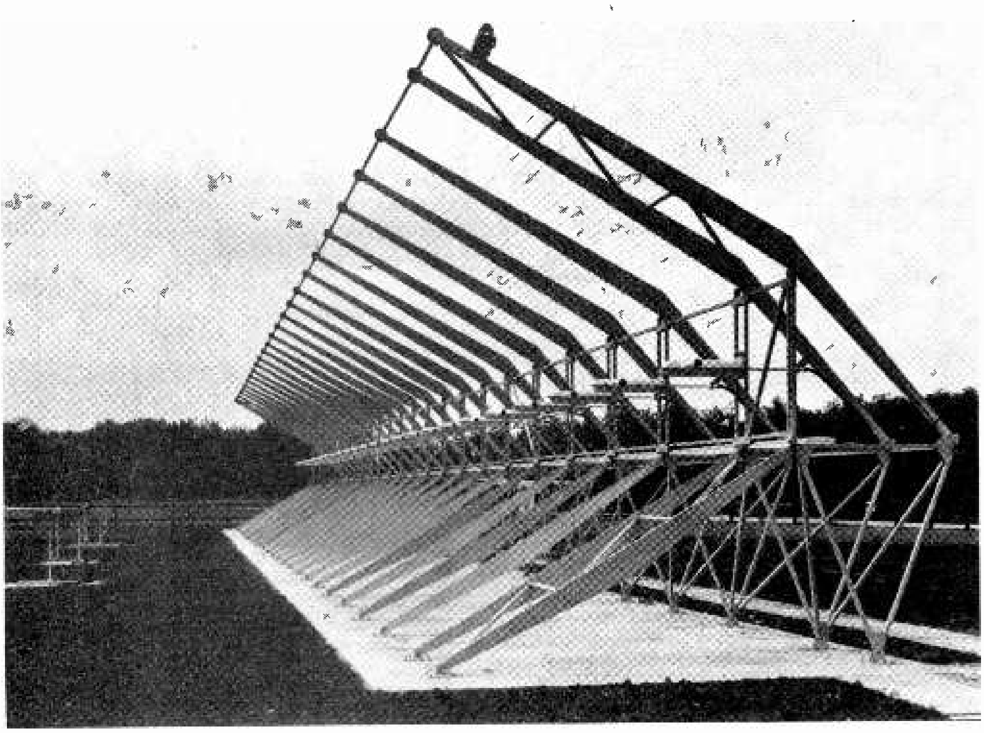
and Raisting—West Germany. The sound part of the signal will be carried along land lines from Mexico to the Canadian earth station at Mill Village, Nova Scotia, and from there via Early Bird to Europe where the sound and vision signals will be matched.

In addition, the signal will be carried by landlines to a transportable earth station located south of San Jose, California, to be relayed, via Intelsat II in orbit over the Pacific, to Japan and other eastern countries.

British consortium lands £13M avionic contract

A consortium of six British electronics and electrical companies, called Irano-British Airports Consortium, has won a contract for electronic equipment worth £13M to be used in the modernization of the civil airports in Iran. Under the terms of the contract the consortium will supply radars, instrument landing systems, telecommunications equipment, airfield lighting, service vehicles and other aviation aids to be installed at some 20 airports in Iran over the next five years. The companies in the consortium and the products they are supplying are as follows: Coubro and Scrutton Ltd—aerials, masts and towers, fire protection and rescue equipment and miscellaneous stores; G.E.C. Overseas Services Ltd—airfield lighting with control equipment, emergency generators and distribution equipment, and telephone systems; Marconi Company Ltd—primary and secondary radar, radar display systems, test equipment; Pye Telecommunications Ltd—air traffic control and flight information desks, u.h.f. links, and a microwave data link; Redifon Ltd—point-to-point communications links, m.f. radio beacons and beacon monitor receivers; S.T.C.—instrument landing systems, v.h.f. beacons, automatic direction finding equipment, distance measuring equipment and a teleprinter centre.

An instrument landing system localizer aerial of the type being supplied to Iran. The aerial forms part of the STAN 37/38/39 I.L.S. equipment.



Audio Fair, 1969

Next year's London Audio Fair will not be held in the Spring, nor will it be at the Hotel Russell. The Fair organizer, C. Rex-Hassan, announcing this at the end of the recent Northern Audio Fair in Harrogate, said that it may be held in the Autumn probably in an exhibition hall. It is envisaged that small demonstration rooms would be built for each exhibitor. Unless this can be done, and done with effective sound proofing, then the Audio Fair will loose its biggest appeal—being able to hear demonstrations—and it will become just another *exhibition* of equipment.

ESRO I launched

Now called Aurorae, ESRO I was successfully launched on October 3rd from Western Test Range, California, and is in an orbit very close to the planned one. Early reports suggest that all satellite systems are working normally. The satellite, which is stabilized along the earth's lines of magnetic flux, will study Auroral phenomenon.

Faraday lecture tour

The 40th Faraday lecture tour, organized by the Institution of Electrical Engineers, will start on November 26th and finish on March 27th 1969. This year's lecturer is Peter E. Trier, Director of Research and Development, Mullard Ltd, with Edward T. Emms, Head of the Mullard Central Application Laboratory, as deputy. This year's subject is microelectronics and will take the Faraday lectures usual form—providing a "popular" introduction to the subject.

The lecture will be given at: Swansea—Nov. 26; Bristol—Nov. 28/29; Sheffield—Dec. 10; Manchester—Jan. 20/21; Liverpool—Jan. 23; Birmingham—Feb. 3/4; Leicester—Feb. 6; Portsmouth—Feb. 11; London—Feb. 27/28; Bradford—Mar. 12; Newcastle—Mar. 25; Edinburgh—Mar. 27. A ticket is necessary to gain admission and these may be obtained from local organizers, however, in case of difficulty contact the Institution of Electrical Engineers, Savoy Place, London W.C.2.

Rugged battery

A battery developed by the American National Aeronautics and Space Administration has successfully withstood a simulated planetary landing involving extreme conditions of heat and shock.

First, to satisfy N.A.S.A. planetary quarantine requirements, the battery was subjected to 24 hours of heat sterilization at 112°C. Then the battery was dropped from a helicopter hovering at 250ft onto an asphalt surface, a shock of some 2,500g. Moments later the battery was supplying power to instrumentation and radio equipment.

The battery has eight cells using reinforced silver and zinc electrodes and a potassium hydroxide electrolyte. Irradiated polythene is used for the electrode separators and polyphenylene oxide for the cell cases. The battery, which has an 80W/hr capacity, measures about 20 x 10 x 10cm.

Eighteenth International Apprentice competition

Nominations are being accepted for the 1969 International Apprentice Competition until December 15th this year. The aims of the competition are to raise the standards of skill and craftsmanship and to promote greater understanding and friendship among those taking part by providing an opportunity for the exchange of ideas and experiences. It also provides an opportunity for comparing the training standards of other countries with our own. Other countries taking part are Belgium, Holland, Italy, Japan, Spain, Switzerland and West Germany. The British entry is being organized by the City and Guilds of London Institute, 76 Portland Place, London WIN 4AA.

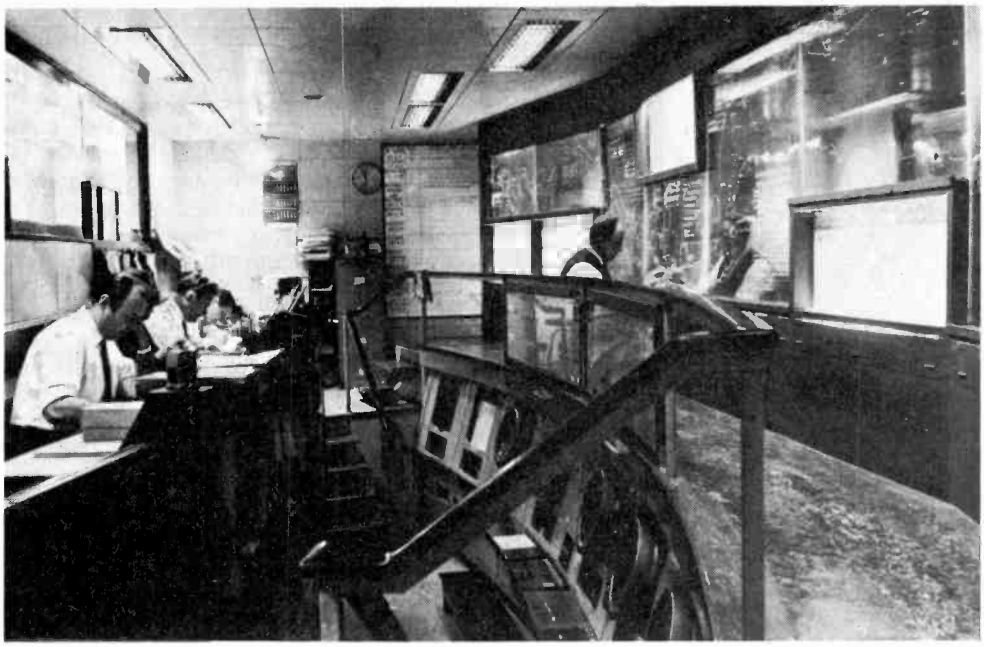
The number of candidates any firm can nominate depends on the number of employees at that firm. Candidates do not have to be indentured apprentices so full-time students can apply.

The competition will be held in Belgium in July 1969; selection tests will be held between January and April 1969.

In all 29 trades will be represented including industrial electronics and TV servicing.

Small shipboard terminal for Skynet

A programme of research has been started at the Admiralty Surface Weapons Establishment at Portsdown to develop a small shipboard terminal for use within the defence satellite communications system Skynet. The



Duty personnel at work in the Thames Navigation Service operations centre at Gravesend, nerve centre of the Port of London Authority's Thames radar survey, which, it was recently announced, is to be extended to cover the river as far upstream as Dagenham. Two existing Decca marine radar stations cover an area from Southend pier up to Gravesend and these are to be supplemented by two more installations at Broadness and Crayfordness. The new stations will be unmanned and will be provided with duplicate equipment. Microwave links between the radar towers and the operations centre were provided by Ferranti Ltd. Plans are in hand for further radar coverage of the river as far up as Tower Bridge.

programme is known as project SCOT (Shipboard COmmunications Terminal). In the first instance the terminal will handle one telegraph and one supervisory channel only.

A provisional specification lists a 1m diameter aerial housed in a 1.5m spherical radome and a transmitter power output of 1kW. Because of the light weight of the aerial system (50-100kg) it can be mounted on a mast and, therefore, will not suffer much from screening by the super-structure; unlike the 2m deck mounted aerial already specified for Skynet. It is possible that the SCOT project could be stretched to accommodate voice traffic, but a larger aerial would probably be required. It is expected that the SCOT terminals will cost in the region of £100,000 each as against about £270,000 for the 2m terminal.

Explorer 38 progress report

The 38th satellite in the explorer series, described in "News of the Month" September 1968, has been declared an unqualified success by the National Aeronautics and Space Administration. On September 30th the aerials were extended to 600ft each (150ft short of their maximum) giving the satellite a total span of over 1,200ft. Later it is expected that the aerials will be fully extended after the behaviour of the spacecraft in its present condition is evaluated.

French amateur television convention

It was announced at the recent amateur television convention organized by the British Amateur Television Club that a similar event organized by French amateurs is to be held in Armentières on April 19-20th 1969. Readers wishing to know more about this event should contact: C.F.T.A., 13 Rue de Bellevue, 75, Paris 19.

At the British convention, which was attended by 150 members, I. J. P. James, who led the team which developed the E.M.I. 2001 colour camera, agreed to become the new president of the club following the conclusion of N. Watson's successful term of office.

Eurocontrol contract

An international three-company consortium formed in 1963 has won a £4M contract for radar display and associated computing facilities for the Eurocontrol's Maastricht, Netherlands, air traffic control centre. The three companies are Plessey Radar (U.K.), C.S.F. (France) and AEG-Telefunken (Germany). Details of the equipment are not yet available but more information should become available later on this year when the details of the contract are finalized.

R.E.A. Annual Awards

Awards for 1968 given by the Radar & Electronics Association at their annual dinner in London last week went to Dr. Eric Eastwood, C.B.E., "for his outstanding contribution to the radar and electronics industry", and to John Gilbert, of Northern Polytechnic, "for his service to the Association in connection with the student branch". First, second and third prizes for the best students of the year were won by B. A. H. Jones (Portsmouth College of Technology), S. W. Soysa (Northern Polytechnic) and Miss J. M. Greaves (University of Kent at Canterbury).

Guest of honour at the dinner was Mr. John Stonehouse, Postmaster General. During his speech Mr. Stonehouse paid tribute to the work being done at Goonhilly, Europe's receiving point for the Mexico Olympics transmissions, and to the B.B.C. for their latest television standards convertor.

British company to build East African earth station

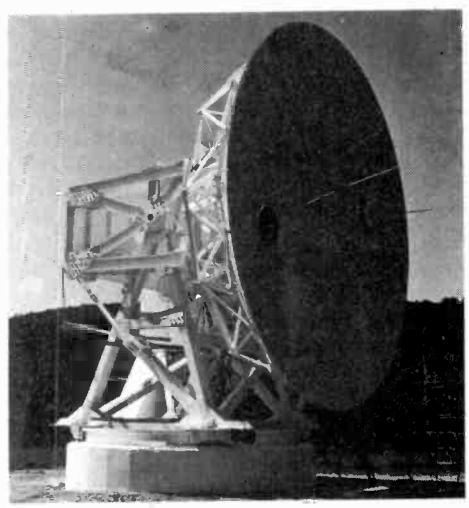
After considering tenders from America, Britain, Italy, Japan and the Federal Republic of Germany the board of the East African External Telecommunications Company Ltd has conditionally awarded the contract for building a satellite earth station to the Marconi Company. The contract will be placed with Marconi subject "to detailed negotiations regarding the finalization of the overall contract terms".

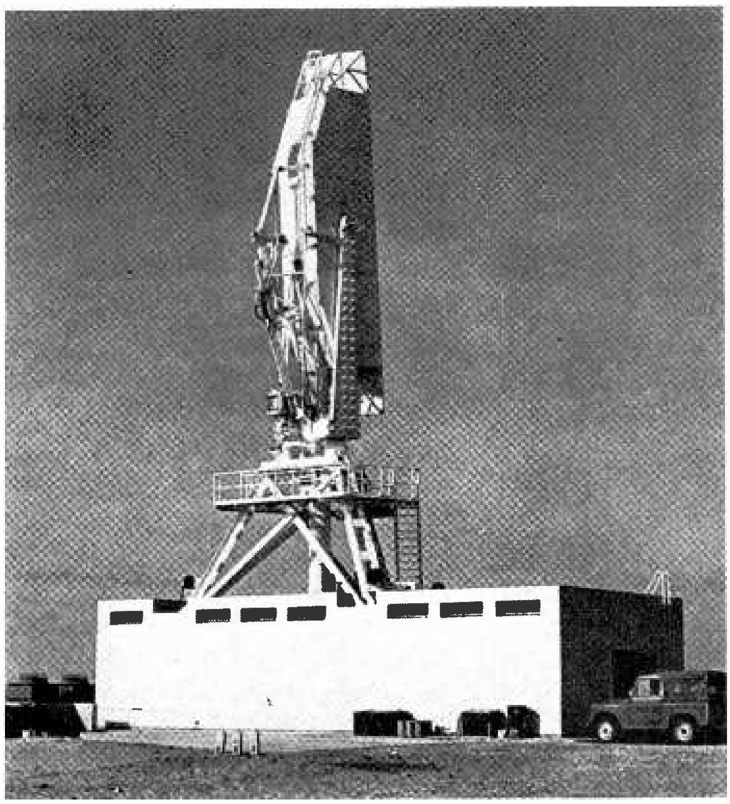
The earth station, which will work in the Intelsat system, is to be built at Mount Margaret in the Rift Valley, Kenya.

Black Arrow Contract

The Ministry of Technology have awarded a number of contracts for provision of electronic equipment and planning and integration services for the Black Arrow X3 spacecraft to GEC-AEI (Electronics) Limited. The contracts include responsibility for design and development of the v.h.f. telemetry and telecommand system, the p.c.m. data acquisition system, and power supply stabilization, control and storage units. Other work is also being undertaken in connection with experiments on board the satellite. All these systems will be engineered and manufactured at Portsmouth. Integration aspects include the assembly of all electronic sub-systems with the structure, followed by systematic testing for compatibility with the launcher and with the ground stations. Following environmental testing of the equipment complete systems tests will be carried out. Other companies contributing towards the construction of the X3 satellite include BAC,

The picture shows Canada's first earth station for domestic satellite communication at Bouchette, Quebec. The 30-ft station is expected to become fully operational this month (October 1968) and will withstand winds of up to 140m.p.h. and remain operational in 82m.p.h. gales.





The photograph shows a Marconi S244 long range height-finding radar installed at Kuwait airport. The radar was fitted as part of a £2.8M contract awarded to a consortium led by Marconi and N. V. Philips Telecommunicatie Industrie.

who are designing and building the spacecraft structure according to the original R.A.E. concept, and Ferranti, who are supplying solar cells for mounting by Ernest Turner Ltd.

Southern a.t.c. has touchwire control

A computer touchwire input system has been ordered from Marconi by the Ministry of Technology for use in the flight plan processing system (f.p.p.s.) intended for the new Southern England air traffic control centre at West Drayton, near Heathrow. The f.p.p.s. will consist of three Marconi Myriad computers and 74 touchwire input/display systems.

Basically the touchwire system, originally developed by the Royal Radar Establishment, consists of two units—a mask that fits over a c.r.t. display and a logic control unit. Wire contacts are fitted into the lower part of the mask and are so arranged that a finger touch on any contact results in a unique code being transmitted to the computer. Associated with each contact is a window in the mask which allows computer-generated messages in the form of data on aircraft movement information to be seen by the operator. Aircraft controllers simply touch the contact beneath the window which is displaying the required information to input that information to the computer. Each of the displays for West Drayton has 24 windows, although 32 can be provided should they be required.

Marconi also supplied, as part of a £1M contract, a touchwire system for use in the Eurocontrol Experimental Air Traffic Control Centre at Bretigny, near Paris.

The West Drayton control centre will handle military as well as civil traffic and as such will play a part in the new defence installations to be built in eastern England. The new installations will be known as Standby Local Early Warning and Control (SLEWC) Centres. In a joint contract Marconi and Elliott are to supply £2M worth of electronic equipment for these centres.

Marconi's contribution will be in radar displays and a wide range of equipment to integrate the new centres with Britain's existing early warning system. Elliott will supply the computer power in the form of the 920C microminiature computer and all the necessary software.

Microwave system for Scotland

Equipment worth over £1M is to be provided by Standard Telephones and Cables to the G.P.O. for a scheme to link the Western Islands of Scotland with the mainland. Certain links in the Orkney and Shetland Islands and others connecting remote points on the mainland also form part of the contracts. In all, thirty-six separate microwave 'hops' are involved, varying in length between 5 and 33 miles, with a total route mileage exceeding 600. Each of the links will be capable of carrying 300 two-way telephone conversations, although many will carry 24 only.

For over-water paths and in other cases where specular or multipath reflections cause fading a space diversity system will be provided. Using space diversity techniques the signals from two receiving aerials are combined at s.h.f. and automatic control circuits operating from a rotary phase shifter ensure that the signals combine in phase.

The first links to come into service will be from Dunoon to Rothesay and Greenock and the scheme will be completed in the summer of 1971.

I.T.A. u.h.f. network order

Transposer equipment valued at nearly £700,000 has been ordered from Plessey by the I.T.A. The transposers receive a television signal on any channel within bands IV and V, change its frequency and re-transmit it after amplification so that areas which normally would not receive a good signal from the main transmitter can be adequately served. The order is for 30 transposers, 18 of which will operate at 1kW (peak sync.) and the rest at 200W.

Underwater navigation research scheme

A working party on underwater technology set up by the National Research and Development Council some months ago revealed a need for the development and design of a number of underwater navigation systems. Subsequent talks with Decca have resulted in a joint study programme between the N.R.D.C. and the Decca Systems Study and Management divisions that will be concerned with underwater position fixing, navigation and homing.

Colour television sales

A recent report from the British Radio Equipment Manufacturers' Association shows that colour television receiver deliveries during the first during the first seven months of the year amounted to 72,000. Adding on last year's deliveries gives a grand total of 103,000.

An error occurs in the advertisement of Radford Laboratory Instruments in this issue. In the specification for the distortion measuring set read "30dB down to 45Hz" instead of "3dB down to 35Hz".

The photograph shows the television camera developed by the Aerospace Division of the Westinghouse Space Center, Baltimore, Maryland, which will be used by the first American astronauts to land on the moon. The camera, which makes extensive use of integrated circuits, has been designed to operate under the poor lighting conditions encountered during the lunar night.

1968 Radio Hobbies Exhibition

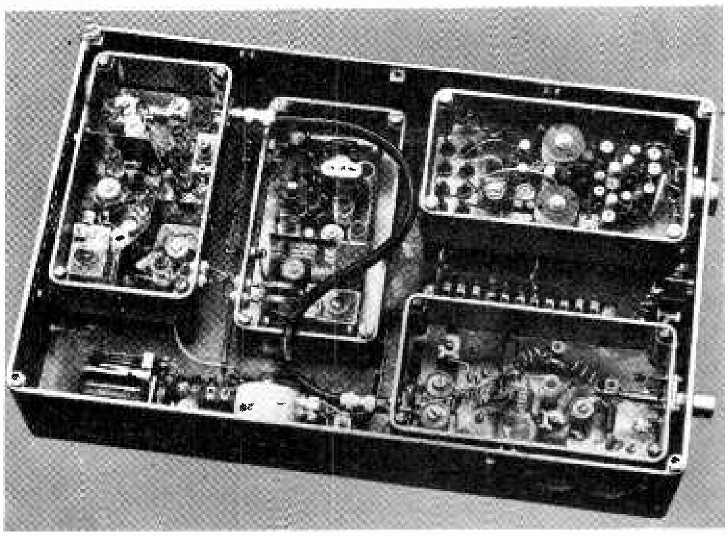
A display of professional equipment for amateurs.

Organized by the R.S.G.B. for radio amateurs and held at the Royal Horticultural New Hall, London, October 2-5, the 1968 International Radio Engineering & Communications Exhibition was one of mixed aspirations. A quite small representation of manufacturers and agents, but including the major kit suppliers, were displaying their products. Only one overseas standholder was present and the foreign products displayed by agents were mainly established Japanese and American imports, the impression being that the international billing is more of an invitation to encourage foreign firms to take part than an implication that they were already there.

All three military Services, and this year the Diplomatic Wireless Service as well (of which more will be said later) were there, primarily for the purpose of offering bait to potential recruits. The G.P.O., which clearly has been troubled by complaints of interference on television receivers from amateur transmitters, had a different objective and took a stand where they demonstrated their recently introduced method of measuring the output power of s.s.b. modulated transmitters and showed examples of equipment modifications which could be used to alleviate interference. Also there was the usual flood of literature from clubs, magazines and equipment makers.

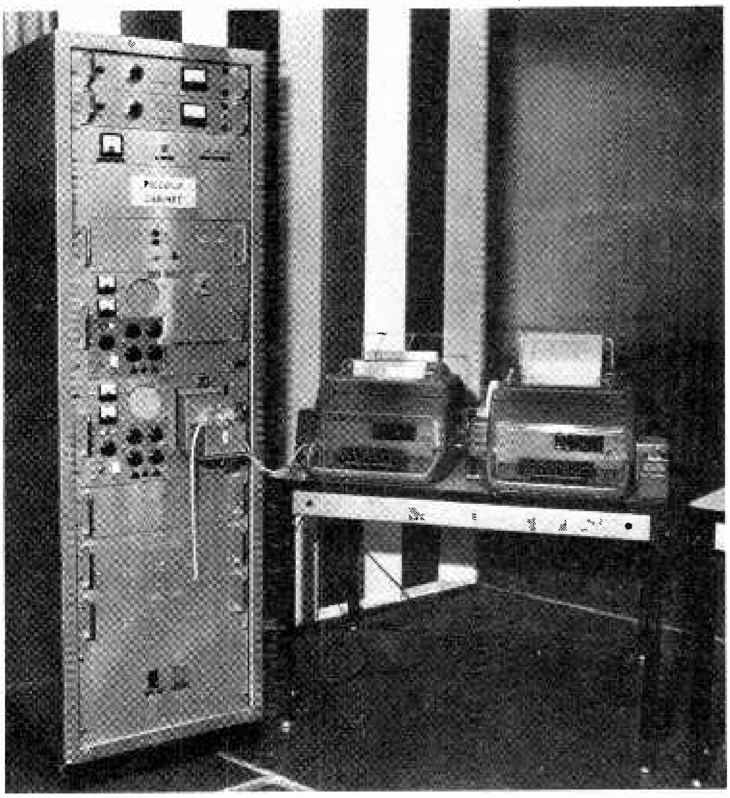
The radio amateur, besides being as devoted to his hobby as other men are to theirs, as like as not also earns, or intends to earn, his living in the radio industry so that any subject with a radio connotation is a source of interest to him. It may well be therefore that the apparently diverse sowings of the exhibitors each struck fertile ground at some time during the three days. However, in case the visitor wondered by this time what he had come to see, the answer was to be found in what surely should be regarded as the nucleus of the exhibition, the display of equipment constructed by R.S.G.B. members. Home construction is, for many, what amateur radio is all about. Some 16 items were shown in this section and all were built to a very high standard. The item which won the Horace Freeman Trophy for the most original piece of equipment was a solid-state 70cm f.m. transmitter constructed by S. F. Weber (G8ACC) of Wimbledon, London. It employs a germanium transistor crystal oscillator with a 5th overtone 108MHz crystal, followed by silicon transistors used as doublers and straight-through amplifiers. The oscillator is frequency-modulated by a varactor diode which provides 2.5kHz deviation at 432MHz with maximum audio frequency input.

Turning again to the Diplomatic Wireless Service, an organization which has grown from war-time origins when normal communication channels between Government and overseas missions were cut, its prize exhibit was a new radio telegram system called "Piccolo" which is currently replacing hand Morse systems. The Piccolo system can provide inter-continental communication using a modest r.f. power (500W) output and it has very good noise immunity. Messages from an ordinary teleprinter keyboard are fed to the system on a 5-unit



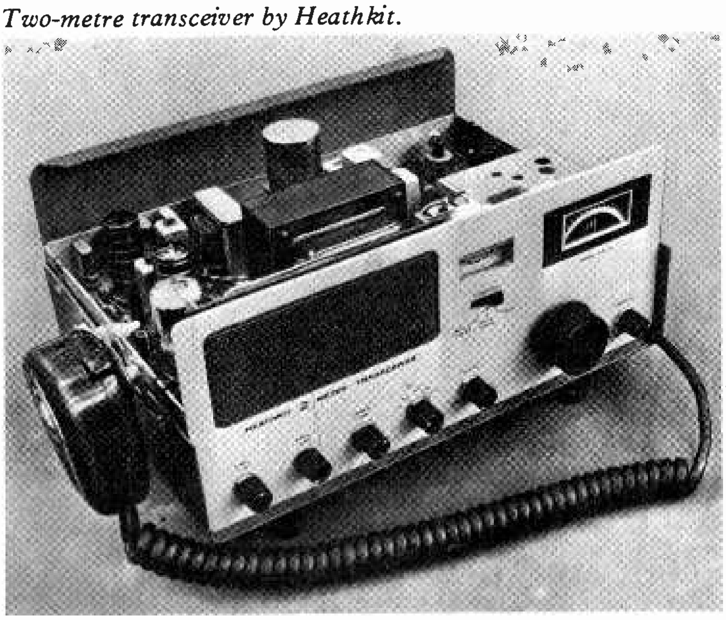
Solid-state transmitter trophy winning entry by S. F. Weber.

Piccolo telegram system shown by the Diplomatic Wireless Service.



K.W. Atlanta transceiver for 10-80m and a.c. power unit.

Two-metre transceiver by Heathkit.



punched tape which is read by five GaAs cells in conjunction with five associated photo-electric detectors. At this stage each 5-unit code is converted into a single tone representing one letter of the alphabet, six more tones representing teleprinter functions. The tone frequencies range from 330 to 650Hz, spaced 10Hz apart. Messages are transmitted at frequencies up to 30MHz in an a.m. single-sideband mode. At the receiver the tone signals are applied to resonators which act as enhanced Q filters, and are converted through a shift register into suitable pulses to drive a teleprinter. Transmitter and receiver frequencies are controlled by a synthesizer with a stable 1MHz crystal oscillator source. The system will operate at speeds up to 100w.p.m. and is said to provide solid copy when noise exceeds the signal amplitudes by 4dB. It derives its name from the musical sound made by the demodulated signal.

Returning now to the commercial products, the most striking feature was the compactness of the equipment generally and a tendency towards one-unit stations. The transceiver type of set was much in evidence mostly in hybrid form and carrying a daunting price tag. Going on the air using set pieces seems nowadays to involve big spending. K.W. Electronics, for example, presented their "Atlanta" transceiver designed for operation on all amateur bands from 10 to 80 metres at a cost of £250. It can be operated in s.s.b., a.m. and c.w. modes and has a p.e.p. input of 500W. Carrier suppression is better than 50dB. Valves are used throughout except for the single v.f.o. transistor and solid-state a.c. power supply. A d.c. power unit is available at an additional cost of £42. The Atlanta measures 27 x 14 x 33cm. Another transceiver with an almost identical specification to the K.W. Atlanta was the Swan 500C. In appearance, the Swan and Atlanta are so similar that one could be mistaken as being a mirror image of the other. Like the Atlanta, the Swan 500C comes complete with a.c. power unit but is even more expensive at £328. It was being shown by Radio Shack Ltd. of London. Top price for a 10-80 metre transceiver belongs to the Hallicrafter SR2000 marketed by Electroniques. The transmitter has a 2000W p.e.p. input capability and at £495 the transceiver is claimed to be the Rolls-Royce of amateur radio, though "certainly not the cheapest transceiver on the market."

Approaching the far end of the hall visitors were confronted by a stand of the Army's 82nd Signal Squadron displaying a Heathkit HW-32, 20m 200W transceiver and power unit beside a notice which read—"For 15 days in camp with 82 Signal Squadron TAVR (Territorial Army Volunteer Reserve) you could buy this complete rig." So, for those despairing of ever finding sufficient money to start their own communications centre, here was an easy way after all, but as the HW-32 costs about £80, this would make the Army pay worth about £5 7s a day. (There must be a catch somewhere.) A new transceiver by Heathkit for 2 metre operation was model HW-17, which employs 15 transistors in a double superhet circuit and electronic transmit/receive switching. Transmitter power output is 8-10W and optional crystal-controlled or v.f.o. operation is provided for. The HW-17 is suitable for fixed or mobile working and has a built-in loudspeaker. Frequency coverage is 143.2 to 148.2MHz and the dimensions of the case are 35.5 x 22 x 15.5cm. Price of the basic transceiver is £69 2s.

Among the aerial and aerial accessory displays was an ingenious mobile whip aerial mounting assembly which allows the aerial to be fixed to a vehicle even if access is available only from the outside. After drilling a $\frac{5}{8}$in clearance hole in the skin of the vehicle, the end of the insulated mounting is dropped through the hole and pushed to one side allowing a plastics locating plate to sit flush on the vehicle body. Tightening-up on a brass locknut fixes the mounting and earths the aerial outer to the vehicle chassis. This device was shown by Bantex Ltd., who also make whip aerials embedded in glass fibre.

Tailpiece (for radio amateurs who cannot afford to buy equipment): Two "stations" who met personally at the exhibition were seen to be exchanging Q S L cards. Against the entry on the cards for mode of communication was written, "two-way visual".

30-watt Amplifier Modification

Operation from a single supply rail

by Arthur R. Bailey *M.Sc. (Eng.), Ph.D., M.I.E.E.*

The 30-watt amplifier circuit published in the May 1968 edition of *Wireless World* utilized two power supplies and a non-polarized output capacitor. By suitable modifications to the circuit it is possible to use a single 60-volt supply rail and use a more standard polarized output capacitor. The overall cost then is appreciably reduced as compared with the original circuit. Also if it is contemplated to use a stabilized power supply, only one stabilizer has to be built.

The modifications are as follows:

1. The 0 and −30-volt amplifier connections are strapped together. This common connection goes to the negative side of the 60-V rail, and the previous +30-V lead goes to the positive side of the 60-V supply.
2. The output capacitor is now a 2000μF 50V d.c. electrolytic with its positive side connected to the amplifier output.
3. The feedback resistor R_8 is replaced by a 1.5-kΩ 1-W type, and its associated resistor R_7 is increased to 68 ohms.
4. To maintain d.c. balance in the amplifier, R_6 is increased to 10kΩ and R_4 to 22kΩ.
5. Owing to the changes produced in 4 above, C_2 is now 10μF and 12 volts d.c. working.

The d.c. conditions are now adjusted by the potentiometer P so that the amplifier side of the output capacitor C_7 is exactly half-way between the two supply lines in potential. The amplifier performance is not affected appreciably by these modifications—if anything the overall performance is slightly better.

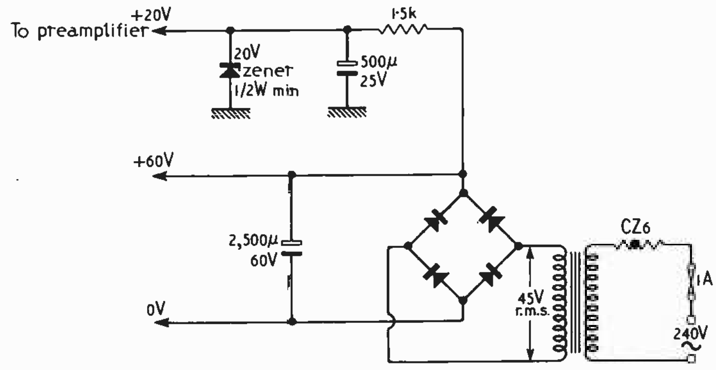
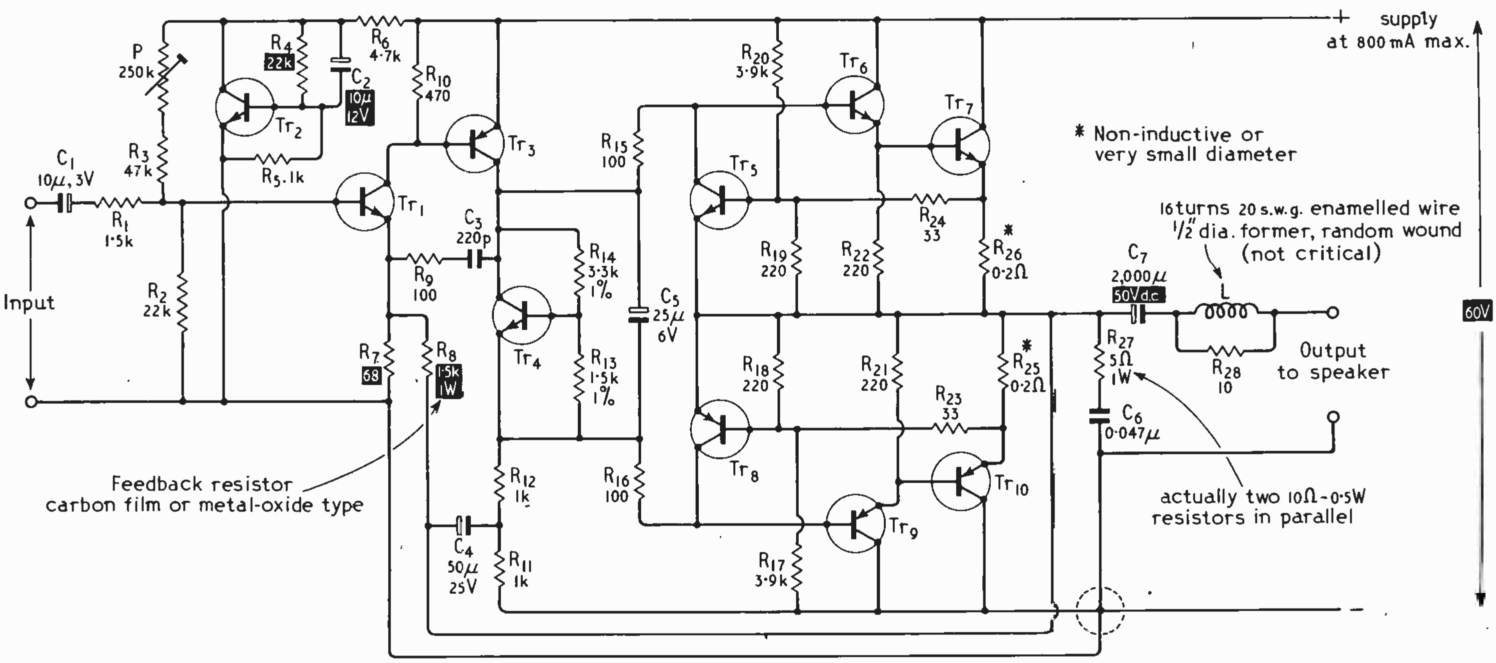


Fig. 2. A suitable power supply for the modified circuit.

The design of a suitable power supply is shown in Fig. 2. The thermistor is included to prevent the charging current in the output capacitor C_7 becoming dangerously large at switch-on and thus endangering loudspeakers. If a stabilized supply is used, then it can be 'slugged' so as to give a slow rise in output voltage at switch-on; this making the thermistor unnecessary.

Fig. 1. Modified circuit of complete power amplifier. The transistors used are: Tr_1—40361 (R.C.A.); Tr_2—BC109 (Mullard); Tr_3—40362 (R.C.A.); Tr_4—BC107 (Mullard); Tr_5—BC125 (Fairchild); Tr_6—40361 (R.C.A.); Tr_7—MJ481 (Motorola); Tr_8—BC126 (Fairchild); Tr_9—40362 (R.C.A.); Tr_{10}—MJ491 (Motorola). Changes of values are indicated by black squares.



Codes and Code Converters

1—Types of codes formed from binary symbols: Using logic networks to detect them

by N. M. Morris, B.Sc., M.I.E.E., M.I.E.R.E.*

Many forms of numbering codes have been developed for particular applications, the most common ones being the decimal and pure binary codes. In general, whatever the code, the final results have to be converted into decimal for human interpretation or into a binary code for use in electronic calculators. This article describes a number of codes and the reason for their use, together with a method of designing networks to convert from one code into another.

Terminology

In conventional numbering systems the initial number is zero, and the second number is unity. In these systems, the addition of unity to any number in the sequence gives the next higher number in the sequence. In logic systems we find ourselves involved with what are known as truth tables. A truth table is a tabular representation of a logical problem. The truth table consists of columns, containing 0s and 1s, corresponding to the condition of the variables in the problem. In the logical sense, a "1" normally represents a state of "existing", or a condition which is "true". A "0" normally represents a state of "not existing", or an untrue statement. It is not possible, as in an arithmetic sense, to get a logical value of 2 from the sum of two logical 1s. Either a statement is true or it is untrue, i.e., it has either the value "0" or the value "1". Any other logical value cannot exist. If a problem calls for the sum of two truthful statements, then the result is truthful, i.e., the logical sum of two logical 1s must be "1". This concept is developed more fully in later sections of the article.

The decimal numbering system uses the ten digits 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. The number of digits used in a system is known as its radix, so in the decimal system the radix is ten. In the binary system the digits 0 and 1 are used and the radix is two.

Each term in a number is associated with the radix raised to a given power which identifies its position uniquely, *viz*:

$$\text{Decimal } 0090 = (0\times 10^3) + (0\times 10^2) + (9\times 10^1) + (0\times 10^0)$$

$$\text{Binary } 0101 = (0\times 2^3) + (1\times 2^2) + (0\times 2^1) + (1\times 2^0)$$

Table 1—The pure binary code

Decimal value	Binary value (8)	(4)	(2)	(1)
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1

Table 2—The 8421 b.c.d. code

Decimal value	8421 b.c.d. code value (80)	(40)	(20)	(10)	(8)	(4)	(2)	(1)
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	1
2	0	0	0	0	0	0	1	0
3	0	0	0	0	0	0	1	1
4	0	0	0	0	0	1	0	0
5	0	0	0	0	0	1	0	1
6	0	0	0	0	0	1	1	0
7	0	0	0	0	0	1	1	1
8	0	0	0	0	1	0	0	0
9	0	0	0	0	1	0	0	1
10	0	0	0	1	0	0	0	0
11	0	0	0	1	0	0	0	1
·								
66	0	1	1	0	0	1	1	0
·								
99	1	0	0	1	1	0	0	1

A shorthand way of writing the words "decimal" or "binary" is to attach a suffix to the number which is equal to the decimal equivalent of the radix. Thus

$$\text{Decimal } 0981 = 0981_{10}$$

$$\text{Binary } 1011 = 1011_2$$

It is convenient in binary numbering systems to be able to discuss the effective values of the 1s in each column. To this end each column is given its decimal equivalent, which is known as the "weight" of the digit in that column. The pure binary code for four digits is shown in table 1, the "weights" of the columns being shown in brackets.

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Binary-decimal codes

Humans work most conveniently in the decimal code while electronic devices operate better in a binary notation. There is consequently a need for codes which convey decimal values in the binary notation. These are known as binary-decimal codes. The 8421 binary-coded-decimal (b.c.d.) code is illustrated in table 2. This code follows table 1 to a count of nine after which its form is modified. The binary groups 1010, 1011, 1100, 1101, 1110 and 1111 never occur in this code and are said to be "can't happen" conditions. On the count of ten the least significant group of four digits all have zero value and a 1 appears in the 5th column (counting from the right leftwards) of the code which therefore has a weight equivalent to decimal ten. The code is divided into blocks of four *binary digits* (bits), each block of digits having weights ten times greater than those in the block below it; thus

$$6039_{10} = 0110{,}0000{,}0011{,}1001 \text{ in 8421 b.c.d.}$$

A group of codes which are sometimes more convenient to operate in are those in which the decimal nine state gives a binary combination of 1111. The advantage of this grouping is that a further 1 causes all four 1s to become 0s and a 1 carry is automatically generated. This provides the first bit in the next group of numbers. Two commonly used codes, the 2421 b.c.d. and the 5211 b.c.d., are given in table 3. There are several variations on these two codes since several of the decimal values are not uniquely defined, i.e. in the 2421 b.c.d. code the value 3_{10} could be either 1001 or 0011 and the value 5_{10} could be either 0101 or 1011 etc. The codes given in table 3 are the forms most commonly used since it is possible to generate them by relatively simple electronic circuits.

Position-sensing codes

In industry coded plates and commutators are used to detect the position of, say, the workpiece or bed of a machine tool. A coded commutator comprises an insulating surface with conducting areas deposited on it which are detected by brushes which

Table 3—Other binary-decimal codes

Decimal value	2421 b.c.d. (2)	(4)	(2)	(1)	5211 b.c.d. (5)	(2)	(1)	(1)
0	0	0	0	0	0	0	0	0
1	0	0	0	1	0	0	0	1
2	0	0	1	0	0	0	1	1
3	0	0	1	1	0	1	0	1
4	0	1	0	0	0	1	1	1
5	0	1	0	1	1	0	0	0
6	0	1	1	0	1	0	0	1
7	0	1	1	1	1	0	1	1
8	1	1	1	0	1	1	0	1
9	1	1	1	1	1	1	1	1

Table 4—The Gray code

Position in code	Gray code A	B	C	D	
0	0	0	0	0	
1	0	0	0	1	
2	0	0	1	1	
3	0	0	1	0	
4	0	1	1	0	
5	0	1	1	1	
6	0	1	0	1	
7	0	1	0	0	
8	1	1	0	0	Repeat
9	1	1	0	1	
10	1	1	1	1	
11	1	1	1	0	
12	1	0	1	0	
13	1	0	1	1	
14	1	0	0	1	
15	1	0	0	0	

touch its surface, in much the same way as in an electric motor commutator. Optical versions are obtainable in which the code is produced on the surface of a translucent material by depositing an opaque material on it. The position of the opaque material is detected by photoelectric means.

The errors which result during a transition from one code group to the next are dependent on what is known as the "distance" of the code. The "distance" between two binary coded characters is the number of bits that change in one character in a code to give the following character. Thus the distance between 0111 and 1000 is four, since all four bits change, three from 1 to 0 and one from 0 to 1. The minimum distance of the code is the minimum number of bits that must change in order to convert any character in the code to any other character in the same code.

Since it is practically impossible to manufacture a coded plate or disc to give zero misalignment between the segments, a typical pure binary change from 0111 to 1000 may occur as follows.

Initial state	0111
Transient states	1111
	1101
	1100
Final state	1000

The transient states give rise to erroneous readings of position. For this reason special codes for position sensing have been devised, the most useful of these being unit-distance codes. A unit-distance code is one in which only one bit is changed to convert any character in the code to the next character (either greater or less than the previous character). The most common of these, the Gray code, is shown in table 4 for a four-bit combination, where A is the most significant digit.

Codes of the type in table 4 are said to be cyclic, since the final character is a unit-distance step away from the first character. The choice of the end and the start of the code are arbitrary; the value 0000 could be regarded as the final or any intermediate point in the code. The Gray code is known as a "reflected" code for the following reason. The code combinations in positions 2 and 3 of table 4 have in the D column the same values as those in the unity and zero positions, respectively. That is, the least significant digit values of the first two code combinations are "reflected" in the second two combinations. The only change in the code, in positions 2 and 3, is the addition of a 1 in the next higher column (column C in this case). The four combinations which follow, i.e., 4 to 7, are formed by reflecting the C and D columns of the 3 to 0 combinations, and adding a 1 in the B column. Code combinations from 8 to 15 are generated by reflecting the first eight combinations of B, C and D about the seventh position in the code, and adding a 1 in the A column. A five-bit code is generated by repeating the first sixteen characters in the code in the reverse order, and then adding a 1 in the next higher digit position. This process can be continued indefinitely. Thus the combinations in the 8 to 15 section of table 4 have the same values in the B, C and D columns as those in the 7 to zero section (reading from 7 to zero), but have a 1 in the A column whereas the 7 to zero section has a 0 in the A column. That is the B, C and D combinations in 8 are the same as in 7, in 9 as in 6 and in 15 as in zero. A five-bit code is generated by repeating the first sixteen characters in the code in the reverse order and then adding a 1 in the next higher digit.

The code in table 4 is as a "complete" code since it uses all 2^N characters, where N is the number of places in each character. Thus a four-bit code is complete if it uses all sixteen characters. An incomplete code is one which does not use all the 2^N possible combinations. Special purpose incomplete unit-distance codes are sometimes used, an example of one being given in table 5.

Logic

Logic in its engineering sense is now becoming widely used but readers approaching the subject for the first time may be unfamiliar with the terminology. An abbreviated treatment is given here for clarity.

The whole population of any village, town, country or continent can be divided into binary groups and combinations of these groups. One division would be between those who have blonde hair (defined as B) and those who do not have blonde hair. Those who do not have blonde hair are defined as $\overline{B}$, the bar over the B representing the logical NOT connective, and is described as "NOT B". Alternatively the same group of people may be divided into electricians (E) and non-electricians ($\overline{E}$), or gardeners (G) and non-gardeners ($\overline{G}$) etc., giving

Table 5—An "incomplete" unit-distance code

Position in code	A	B	C	D	
0	0	0	0	1	
1	0	1	0	1	
2	1	1	0	1	
3	1	0	0	1	
4	1	0	1	1	Repeat
5	1	1	1	1	
6	0	1	1	1	
7	0	0	1	1	

binary groups of people. Readers will, no doubt, think of other binary groups of people, including the obvious one of male and female (non-male).

We may be interested in people who have blonde hair OR who are electricians. This combination is represented by the logical statement

$$B + E$$

The "plus" sign is used here as the logical OR connective. The combination $\overline{E} + \overline{G}$ are that group of people who are NOT electricians OR who are NOT gardeners.

The set of people who are electricians AND who are gardeners are represented by the logical statement

$$E.G$$

The "dot" is the logical AND connective. If Y is the set of people who have blonde hair OR are NOT electricians AND are gardeners, the logical relationship is written

$$Y = B + \overline{E}.G$$

When we say that we are interested in group B, we need to define all those who are B, irrespective of their other qualifications. Since we are constrained to think only of the variables in the problem, whose who are B include gardeners and non-gardeners, electricians and non-electricians, i.e., the groups $G.E.B$, $\overline{G}.E.B$, $G.\overline{E}.B$ and $\overline{G}.\overline{E}.B$. Similarly, those who are $\overline{E}$ are all the people who are non-electricians, which includes gardeners and non-gardeners, and those who are, and are not blonde. Each of the terms in a logical expression has a value 0 or 1, in accordance with the ideas developed in the section on "Terminology". If the value is 0, then we are not interested in that section of the community, and if 1, then we are interested in it. For the purpose of the above equation, Y exists (has the value 1), only if $B = 1$ OR $E = 0$ ($\overline{E} = 1$) AND $G = 1$. In this problem, if $Y = 0$, it merely means that we are not interested in that section of the community, it does not mean that they do not exist! The reader may find it an interesting exercise to show that, in the above problem, we are NOT interested in the group $\overline{B}.E$ OR the group $\overline{G}.\overline{B}$.

In a computer or industrial logic system the logical state, i.e., 0 or 1 of each of the variables is represented by a voltage or current level, usually the former, in the circuit. These levels are detected by logic gates. With inputs U, V and W to the AND gate in Fig. 1(a) the output is $U.V.W$. In (b) the same inputs applied to the OR gate yield an output $U + V + W$. The unity sign in the circle in (b) symbolises the logical OR

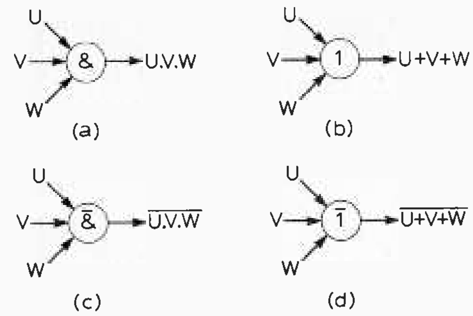


Fig. 1. Symbolic representation of (a) AND, *(b)* OR, *(c)* NAND *and (d)* NOR *gates.*

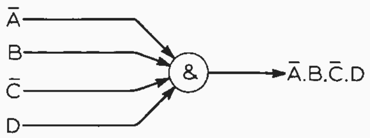


Fig. 2. Detection of the code group ABCD = 0101 by an AND *gate.*

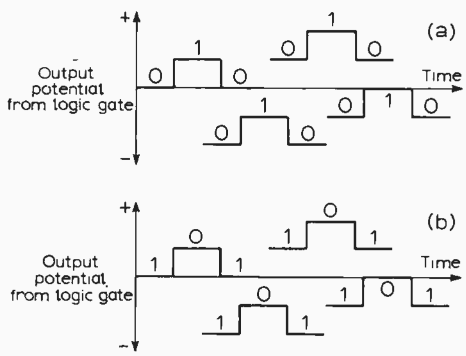


Fig. 3. Examples of (a) positive and (b) negative logic levels.

Output logic level	Input logic level +	Input logic level −
+	OR	NAND
−	NOR	AND

Fig. 4. Device matrix for a positive logic OR *gate.*

relationship since an output exists if any one of the inputs exist. Both the AND and the OR gates are known as discrete function gates since each may be used to perform only one logic function. NAND and NOR gates, known as universal logic gates, may be used to perform any logic function. With input lines U, V and W the NAND gate (NOT-AND) (c) gives an output $\overline{U.V.W}$. and the NOR gate (NOT-OR) (d) gives output $\overline{U+V+W}$. With a single input, say U, the output of both the NAND and the NOR gates is $\overline{U}$, i.e., they complement or invert the input logic level, so that a 1 at the input gives a 0 at the output and vice versa. The logical NOT function is therefore generated by either a NAND or a NOR gate which has only one input line.

Any given code combination can be detected using the above gates. For example, the combination 0101 in table 5 (the second row) can be detected if the combination $\bar{A}$ AND B AND $\bar{C}$ AND D, i.e., $\bar{A}.B.\bar{C}.D$ exists. This is illustrated in Fig. 2 using an AND gate.

For most practical purposes it is convenient to regard the zero level of any quantity, such as voltage or current, as the logical 0 level. In the early days of the development of logic networks p-n-p transistors were used and the potential at the collector was either practically zero in the "on" state or a finite negative potential in the "off" state. For convenience zero potential was taken as the logical 0 signal and the finite negative potential was defined as the logical 1 level. This became known as *negative logic* since the more negative of the two potentials was defined as the 1 level. Even so a number of manufacturers used a reverse form of logic in which the more negative potential was regarded as the logical 0 level and zero potential as logical 1. This became known as *positive logic* since the logical 1 level is the more positive of the two potentials. The advent of n-p-n transistors has resulted in an increase in the popularity of positive logic since logical 0 can again be taken as zero voltage level. Examples of positive logic are shown in Fig. 3(a) and negative logic in Fig. 3(b). Certain forms of monolithic integrated circuit logic modules use logic levels with a "floating zero" as shown in the figure.

Inspection of the waveforms in Fig. 3 yield an interesting property of the logic NOT gate. In any selected waveform among those shown, say the upper left-hand one, the logical level corresponding to zero output potential is 0 in positive logic and 1 in negative logic. The opposite applies at the higher output potential. Since $1 = \bar{0}$ and $0 = \bar{1}$, it is clear that the NOT gate can be used to invert logic levels. Thus if the input to a NOT gate is 0 in positive logic its output may be regarded as either 0 in negative logic or 1 in positive logic. This conversion may be stated as follows:

Positive logic = NOT negative logic
Negative logic = NOT positive logic.

Device matrix

The logical properties of the basic gates (considering two input lines only) are listed in table 6. This table is true for either positive or negative logic. A problem which now presents itself is what logical function is performed by, say, a positive logic OR gate if it is used in a system employing negative logic? In addition some systems employ mixed logic, i.e., positive logic levels may be used at the input to the gate and negative logic at the output, or vice versa. The problem is approached by means of a specific example.

A logic gate is found to have the input and output potentials given in table 7 where L represents a low potential (less positive or more negative) and H represents a high potential (more positive or less negative). In positive logic $L = 0$, $H = 1$ and in negative logic $L = 1$, $H = 0$. Inserting the values for positive logic levels gives table 8, and for negative logic levels gives table 9. Comparing the results of these tables with table 6 shows that the device operates as an OR gate in positive logic and as an AND gate in negative logic. If the device operates with negative logic levels at the input and positive levels at its output (designated logic α for convenience) we get the results shown in

Table 6—Logical properties of the basic gates

Inputs		Outputs			
A	*B*	OR	NOR	AND	NAND
0	0	0	1	0	1
0	1	1	0	0	1
1	1	1	0	1	0
1	0	1	0	0	1

Table 7—Voltage levels at the input and output of the gate in the example

Inputs		Output
A	*B*	
L	*L*	*L*
L	*H*	*H*
H	*H*	*H*
H	*L*	*H*

Table 8—Positive logic version of table 7

Inputs		Output
A	*B*	
0	0	0
0	1	1
1	1	1
1	0	1

Table 9—Negative logic version of table 7

Inputs		Output
A	*B*	
1	1	1
1	0	0
0	0	0
0	1	0

Table 10—Logic α version of table 7

Inputs		Output
A	*B*	
1	1	0
1	0	1
0	0	1
0	1	1

Table 11—Logic β version of table 7

Inputs		Output
A	*B*	
0	0	1
0	1	0
1	1	0
1	0	0

Table 12—Logic functions of the gate in example 1

Input logic level	Output logic level	Logic function performed
+	+	AND
−	−	OR
−	+	NOR
+	−	NAND

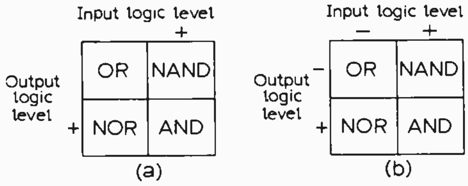


Fig. 5. Figure for example 1.

Fig. 6. Figure for example 2.

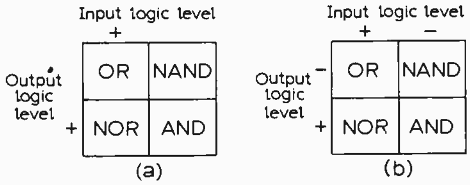


table 10. With positive input and negative output logic levels (designated logic β) we obtain the results in table 11. Comparing these with table 6 shows that when working in logic α the device operates as a NAND gate, and in logic β as a NOR gate.

This state of affairs is represented in matrix form in Fig. 4. It is clearly necessary to define not only the logical function carried out, i.e., AND, OR etc., but also the logic levels employed, in order to define the precise operation of the gate. The general procedure for use of the device matrix is given below.

1. Write down the names of the logic functions in the device matrix in the order given in Fig. 4.

2. Locate the logic function carried out with the known polarities of input and output logic levels.

3. Fill in the remaining values of logic levels. The logical properties of the gate are then defined for all modes of operation.

The following examples will illustrate the use of the procedure.

Example 1: Deduce the logic functions in all modes of operation performed by the positive logic AND gate.

Solution: Steps 1 and 2 are shown in Fig. 5(a) and step 3 in Fig. 5(b). The logic functions of the gate are then deduced by reference to the input and output logic levels which locate the function. These are listed in table 12.

Example 2: Using the device matrix, show that a number of NOR gates can be used to generate the OR, AND and NAND functions.

Solution: Steps 1 and 2 are shown in Fig. 6(a), it being assumed that positive logic is used. Step 3 is shown in Fig. 6(b). The OR function is seen to be generated if positive input and negative output logic levels are used. It was shown earlier in the article that the NOT gate can be used as a logic level inverter and that a NOR gate with a single input can be used as a NOT gate. By feeding the output of a NOR unit with multiple inputs in Fig. 7(a) to a final NOR gate to provide inversion of the output logic levels, the OR function is generated.

The AND function is generated if negative input and positive output logic levels are used. The input levels in Fig. 7(b) are inverted individually before being applied to the final NOR gate to give the overall AND function. The NAND function is generated if negative input and output levels are used, shown in Fig. 7(c).

The device matrix allows logical networks to be designed to detect any particular code combination. For the combination $ABCD = 0101$ the AND gate in Fig. 2 gives a logical 1 output whenever the input combination $\overline{A}.B.\overline{C}.D$ exists. The device matrix in Fig. 5(b) for the positive logic AND gate shows that a NOR gate performs the same function if the input logic is inverted, i.e., input lines A, $\overline{B}$, C and $\overline{D}$ are used. This is illustrated in Fig. 8(a), the output being 1 when the code combination exists, otherwise it is 0.

A NAND gate can be used to detect the combination 0101 by inverting the output logic, as shown in Fig. 8(b). This gate gives a 0 when the code combination is detected, otherwise it is 1. An OR gate can be used by inverting both input and output logic levels, as shown in Fig. 8(c). This gate gives a 0 when the code combination is detected.

(The concluding part of this article will deal with the Karnaugh map, minimisation using the map method, "can't happen" conditions, representation of codes on the Karnaugh map, and various types of code converters.)

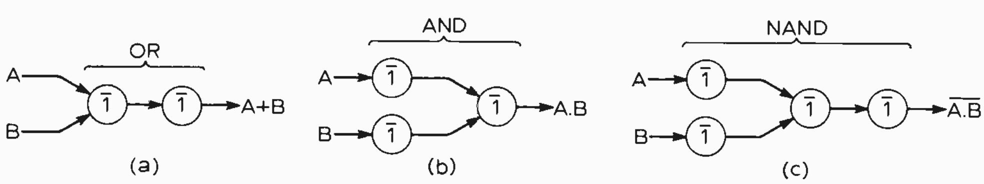


Fig. 7. Generation of (a) OR, *(b)* AND *and (c)* NAND *functions using only* NOR *gates.*

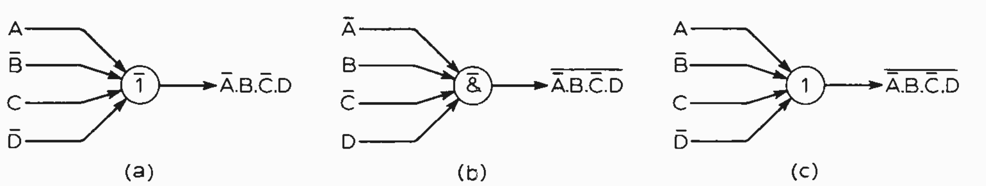


Fig. 8. Methods of detecting the code group $ABCD = 0101$ using (a) NOR, *(b)* NAND *and (c)* OR *gates.*

Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

LONDON

Oct. 31-Nov. 1 — Birdcage Walk
Basic Problems of Artificial Prehension, Movement and Control of Artificial Limbs
(I.Mech.E., 1 Birdcage Walk, London S.W.1)

Nov. 19-20 — Birdcage Walk
Lasers and the Mechanical Engineer
(I.Mech.E., 1 Birdcage Walk, London S.W.1)

MANCHESTER

Nov. 4-6 — Hotel Piccadilly
Electronic Instruments Exhibition
(Industrial Exhibitions Ltd., 9 Argyll St., London W.1)

OVERSEAS

Nov. 5-12 — Oslo
Automatica Exhibition
(Studieselskapet for Norsk Industri, Forskningsveien 1, Oslo 3)

Nov. 6-8 — Grenoble
Reliability of Electronic Components
(Centre d'Etudes Nucleaires de Grenoble, B.P. 269, 38-Grenoble)

Nov. 6-8 — Boston
Northeast Electronics Res. & Eng. Meeting
(I.E.E.E., 31 Channing St., Newton, Mass. 02158)

Nov. 6-8 — Los Angeles
Conference on Broadcasting
(W. B. Whalley, Autonetics—GE 28, 3317 Miraloma Ave., Anaheim, Cal., 92803)

Nov. 7 & 8 — Quebec
Communications Symposium
(A. Breton, POB 802, Station B, Montreal 2)

Nov. 7-13 — Munich
Electronica—Electronic Components and Measuring and Production Equipment
(8000 München 12, Theresienhohe 15, Germany)

Nov. 10-15 — New York
S.M.P.T.E. Technical Conference
(Soc. Motion Picture & TV Eng., 9 E. 41st St., N.Y. 10017, U.S.A.)

Nov. 11-13 — Munich
Microelectronics Symposium
(Internationaler Elektronik-Arbeitskreis, 8000 München 12, Theresienhöhe 15)

Nov. 17-21 — New York
Magnetism and Magnetic Materials
(R. C. Barker, Yale Univ., 10 Hillhouse Ave., New Haven)

Nov. 17-21 — Houston
Engineering in Medicine & Biology
(Dr. L. A. Geddes, Baylor University College of medicine, 1200 Moursund Ave., Houston, Texas 77025)

Nov 19-21 — Pasadena
Photovoltaic Specialists Conference
(I.E.E.E. 345 E. 47th St., New York, N.Y. 10017, U.S.A.)

Nov. 20-26 — Milan
Automation & Instrumentation Conference
(Fed. delle Assoc., Scientifiche E Techniche di Milano, Piazzale Rodolfo Morandi 2, 20121 Milan)

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Television interference filter

I read with considerable interest, in the September issue of your journal, the article entitled "Combating Television Interference" as it describes in almost complete detail a unit which I have been manufacturing and supplying to the trade since May 1966. For a moment I wondered if this was a machination of the present trend towards the Common Market and that your journal was adopting the policy of certain French technical journals of publishing what at first sight seem to be constructional articles and then in the final paragraphs turn out to be manufacturers' products. This I am sure is however not your policy but I should first mention that a full description of the filters which I manufacture has already appeared in "The Practical Aerial Handbook" (Gordon J. King).

The original design was the work of the G.P.O. Engineering Dept and this was circulated to B.R.E.M.A. and R.E.C.M.F. with what I took to be a suggestion that they should be manufactured to combat interference due to Sporadic E conditions. This letter was dated January 1966. I examined the design and came to the conclusion that manufacturing tolerances of viable coils would not permit the satisfaction of the equation with the fixed resistance of about 150 ohms specified. This was because my tests showed that a very considerable attenuation of the unwanted signal was required to eliminate all patterning; a requisite of a true interference eliminator. My production models therefore included a variable resistance in the bridged T filter which could be set for maximum attenuation. In this respect, the Bovill filters differed from the original G.P.O. design. I also modified the length of the output lead after finding in practice that the length specified caused attenuation of Band III signals on certain channels.

In the article in question, the original G.P.O. performance figures are quoted. In the manufactured filter, with the modifications already mentioned, these are improved upon, which I attribute to the coil design, layout and of course the addition of the variable resistance.

I must say frankly that I do not think that the design published and as shown in the photograph, particularly with respect to the inductor construction, layout and method of tuning, would be sufficiently stable to meet the G.P.O. specification. The notch is capable of extreme sharpness and even flexing of the lid of the tobacco tin would appreciably alter its tuning and lead to poor results. I base this assumption on my own experience on the design and manufacture of a very large number of filters of this type.

CHARLES BOVILL
London, S.W.10.

Segmented-fit squaring circuit

Now that analogue computers are common and good operational amplifiers can be obtained cheaply, circuits such as the one Mr. Lamden describes in the October issue are becoming of interest to engineers working in fields other than electronics. Thus I hope we will see more articles similar to Mr. Lamden's clearly presented contribution.

We use very similar circuits in undergraduate laboratory classes to produce non-linear forms of damping when studying vibrating systems on the analogue computer. In such problems and in many other applications it is more relevant to consider accuracy of fit in terms of the actual output voltage and not the full scale output voltage. If this criterion were applied to the circuit shown in Fig. 4 of Mr. Lamden's article with a sine input of one volt peak, the maximum error in fit would be about 30%. Measurements confirm this, showing that the output of spurious harmonics would be only 10 dB down on the second harmonic. This can be overcome by using segment breakpoint voltages spaced in proportion to the output voltage. It is not possible to go into more detail in a letter but it should be pointed out that even with this technique the error in the fit of the first segment will always be very large as can be shown by the following analysis using the same symbols as Mr. Lamden.

To fit $V_o = V_i^2$ we use $V_o = A_1 V_i$ since $V_c = 0$ for the first segment.

Therefore the fractional error

$$= \frac{E}{V_o} = \frac{V_i^2 - A_1 V_i}{V_i^2} = 1 - \frac{A_1}{V_i}$$

Hence as

$$V_i \to 0, \qquad E/V_o \to -\infty$$

This difficulty can be overcome by employing a diode with a "gentle" break point for D_1 and D_3 (Fig. 4) so as to give a curved section to the first segment. Several diod[e]s can be placed in series to produce the desire[d] curve.

T. A. HENRY
Simon Eng. Labs.
University of Manchester.

Electronics and the artist

I refer to your article "Electronics and th[e] artist" in the October issue of *Wirele[ss] World*.

It is usually very sad when art critics get up set by machines but one must forgive them. When scientific journals get muddled then it i[s] harder to do so. I refer specifically to the sentence about computer music. The definitio[n] that the sounds produced by the compute[r] have no pattern is pretty arbitrarily give[n] by "J.G." and must not be allowed to stan[d]. In fact he falls by it himself by praising th[e] Illiac Suite. The whole point of this com[-]position is that it was produced by a compute[r] using random numbers and probability. Th[e] computer at the exhibition which produce[s] variations, sometimes in strict harmon[y] and sometimes very loosely, to a them[e] whistled to it by a passer-by cannot be sai[d] to have "no points of reference and n[o] sequential pattern". Surely the actua[l] digitalizing of a theme and playing it bac[k] in another key makes nonsense of the state[-]ment.

It is a pity that your correspondent shoul[d] be so gloomy and misinformed.

PETER ZINOVIEFF,
London, S.W.15.

"J.G." replies:

The whole point about "Experiment 4" of the Illiac Suite is that it is satisfying music. The reason for this lies in the programme fed to the computer and the limitations imposed on the latter. Art cannot be created by a machine. A man with a computer is no different from a man with a paintbrush. If I "produce variations" by dealing a piano keyboard random swipes with a cricket bat, then from Dr. Zinovieff's standpoint there are indeed points of reference, there is a sequential pattern. This is because the arrangement of the piano's notes is orderly, and the "music" follows the "programme" fed in by the blows of the bat. We know however that for artistry to be evident the computer called a piano needs a programmer called a pianist, and a gifted one at that. The man/machine interface has always been at the basis of art, but only fairly recently in music has the subtle nature of this interface been abused with such wayward innocence.

Sonar transducers

It has just been pointed out to me that there is a discrepancy in the winding detail of the two transformers feeding the transducers of the sonar model. (Figs. 8 (a) and (d) on pp. 326/7 of the September issue.

The primary should be wound with 22 s.w.g. and not 12 s.w.g. wire as is given on the original.

Please accept my apologies for this error.

BRIAN WYNDHAM,
Royal Radar Estab.,
Gt. Malvern.

Tropospheric Propagation

Latest measurement and observation techniques described at London conference

Because of the need to extend the usable radio spectrum to accommodate the spectacular growth of world communications there is a great deal of interest in the propagation characteristics of extremely short wavelengths. In going from centimetric to millimetric wavelengths we encounter progressively increasing absorption and scattering from rainfall, while oxygen and water vapour contribute a series of absorption bands which have been well mapped experimentally, and whose origins are well understood theoretically. Practical communication systems on frequencies above 30 GHz (wavelengths shorter than 1cm) have perforce to use the "windows" in the spectrum which lie between these absorption bands. A further important factor is scintillation fading due to atmospheric turbulence, where the accompanying irregularities and fluctuations can be detected in fine detail by a cavity refractometer.

An opportunity for radio scientists and engineers to discuss the effect of the troposphere on these very short wavelengths was provided by a recent three-day I.E.E./I.E.R.E./I.E.E.E. conference on tropospheric wave propagation held in London at the Institution of Electrical Engineers. As pointed out by Dr. J. A. Saxton in a wide-ranging introductory lecture, this field of enquiry began to be intensively developed only some 25 years ago, and has now extended its frontiers into the millimetre, sub-millimetre and optical wavelengths.

With the advent of the laser we have a powerful tool for examining the fine structure of the atmosphere. Measurements in Colorado of the statistical characteristics of the amplitude fluctuations of a laser beam propagated over various distances have confirmed fundamental features of scintillation theory, and accompanying observations of beam wandering and variations in beam width are directly relevant to the engineering of very wide-band communication links at optical wavelengths.

Although the highest frequency allocated for satellite communications is at present about 8 GHz (3.75 cm), millimetre band allocations may be possible later and several contributors discussed the potentialities of that band for this purpose. Tests using the sun as a source of 35 GHz (8.6 mm) radiation have confirmed that with a clear sky, the total atmospheric attenuation is very low so long as the satellite is raised at least 5° above the horizon—thereby avoiding an excessively long path through the earth's atmosphere. A high and dry site would be desirable for the earth station, and rainfall attenuation might be kept within bounds by means of a space diversity system exploiting the localized nature of heavy rainfall.

Thinking on similar lines, another contributor proposed the use of "route diversity" in connection with ground-to-ground communication in the 10-40 GHz band, of which part has been internationally assigned since May 1961 to fixed and mobile services. Tests at 18 GHz have shown that, thanks to the patchiness of heavy rainfall, the appropriate selection of alternative radio routes round an equilateral triangle with 10-km sides greatly improves circuit reliability by circumventing the worst of a localized rain area. Another contributor showed that without route diversity and assuming rainfall statistics appropriate to Cardington, the range of a link using the 100 GHz (3 mm) band would probably be restricted to about 10 km for 99.9% reliability, using practicable dish sizes and the maximum transmitter power at present available.

Many contributions were devoted to the tropospheric scatter mode of beyond-the-horizon propagation, which involves scattering or partial reflection from refractive index irregularities within an elevated volume of the atmosphere. This so-called "common volume" is "illuminated", search-light fashion, by the intersecting narrow beams of the terminal aerials. Reradiation from multitudes of random scatterers in the extensive common volume generates a disorderly, instead of an ideal, plane wavefront at the receiving aerial, resulting in reduced aerial gain, a limited bandwidth, and diversity effects. These and other interrelated effects were considered in several highly mathematical papers based on idealized statistical models of the troposphere, together with supporting 1800 MHz measurements of diversity distances obtained with small spaced aerials. A kindred investigation involving the sounding of the troposphere with high-power vertically pointing radars on 3 and 10 cm showed a striking tendency in anti-cyclonic weather for the largest atmospheric irregularities to congregate within the first 2000 m of the atmosphere.

A notable advance in this field, both from the atmospheric physics and engineering standpoints, was disclosed in two papers describing troposcatter path measurements with a "Rake" receiver. Briefly, the "Rake" technique measures the relative arrival times (in 0.1 microsecond intervals) of the numerous elements of the received signal—which have taken differing routes due to the extended nature of the active scattering volume. Simultaneously, measurements are made of the spectrum of Doppler beat frequencies (ranging over about 15 Hz) arising mainly from the various cross-path velocities of the scatterers, which are generated by cross-path winds and by atmospheric turbulence. From tests on 900 MHz over long land and sea paths, the authors have mapped by this means the positions, velocities and refractive structure of representative scatterers and reflecting atmospheric layers. Though designed for other purposes, the "Rake" system seems pre-eminently adapted for sounding the troposphere, and its findings promise to be of great value in pointing the way to improvements in the performance of troposcatter links.

Due to the difficulty of finding an adequate mathematical description of the troposphere, methods of predicting the performance of troposcatter circuits are generally empirically based on a multitude of radio and meteorological measurements. Several papers with an engineering orientation surveyed the relative merits of various prediction methods, and one contributor propounded a new method which is claimed to give better predictions in diverse climates than does the conventional procedure based on knowledge of the atmospheric refractive index near the ground. Another contributor ventured into the field of economics by weighing the cost of a confirmatory pilot radio survey against the increased risks of over- or under-engineering arising in its absence.

Several contributors were concerned with long-range propagation in the v.h.f. and u.h.f. bands, with particular reference to the avoidance of co-channel interference with television reception. An important factor is the tendency to diurnal and seasonal variations in this interference, with differences between over-land and over-sea behaviour. Another contribution relevant to television coverage discussed measurements of "shadow" losses behind scale-model obstructions using a laser beam, where the effect of various obstructing shapes unamenable to calculation could be investigated. An interesting feature is the progressive reduction in shadow loss behind a rounded hill as its surface is made increasingly rough.

The Conference performed a valuable service to both physicists and engineers by high-lighting the powerful techniques now available for probing the troposphere, which cannot fail to advance the communications art by eventually resolving many of the uncertainties with which radio scientists and systems planners are at present beset. A pointer to future trends was the sizable number of contributions on millimetre wave and optical propagation. While the physics and engineering aspects of these bands are probably outside the present purview of many of the 150 Conference participants, some of them may well be confronted with problems of this nature in the not-too-distant future.

M. W. Gough

Recording Pilot Tones on Magnetic Tape

A brief history of the recording technique used in synchronizing audio and visual information

*by E. A. Hadenfeld**

The synchronization of sound and action on films began in about 1940. At first short scenes were recorded in the studio using non-synchronized tape recorders and a clapboard. From 1950 perforated tape was employed in a synchronous system. The resultant equipment was heavy, and was soon replaced by the pilot recording system in which the film camera drive generated a pilot frequency for synchronizing purposes.

The oldest known patent for the pilot system was taken out in Germany by E. Schuller of A.E.G. in 1941. In 1949 J. Schuerer of Munich took out another patent which became the basis of the pilot system in Germany. The first pilot synchronized television recording was made during a Congo expedition in 1953 by German television.

* Bosch Ltd.

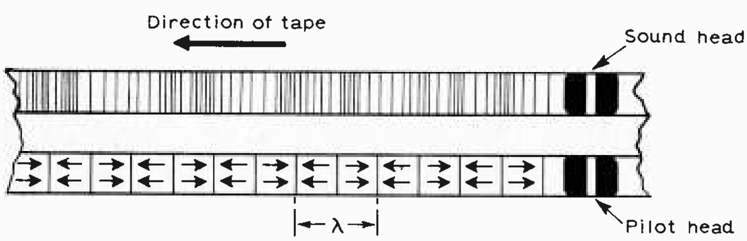


Fig.1. Simplest sound and pilot recording technique. λ is one wavelength of the pilot signal.

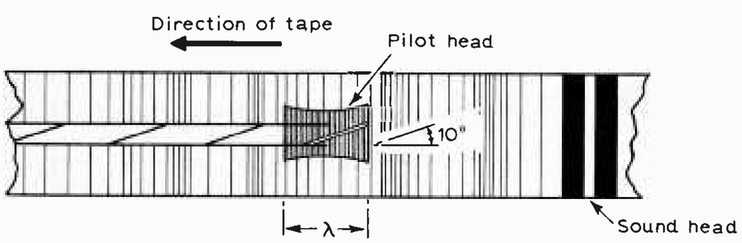
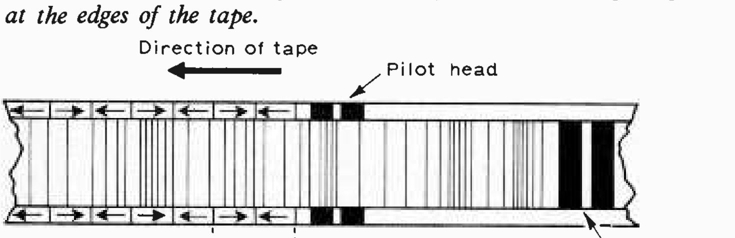


Fig.2. The American "Ranger" system. Pilot signal recorded in the centre of the tape at an angle of 10° to the sound track.

Fig.3. The "Perfectone" system. Pilot signal recorded in push-pull at the edges of the tape.



In the design of a pilot system the following must be considered from the outset:
1. Compatibility of the pilot-recorded tapes between studio equipment and portable field equipment avoiding crosstalk between sync and sound.
2. No decrease in the signal-to-noise ratio due to tape transport errors.
3. Optimum use of the tape for actual audio material.
4. The avoidance of crosstalk between the pilot tone and the lower frequency audio signals.

Several pilot recording systems are used for synchronizing film and sound. Fig.1 shows the simplest method, with the sound on an upper track and the pilot tone on a lower track. Both tracks are recorded in the conventional way. This simple solution does not however fulfil professional requirements, because these half track tapes cannot be replayed on full-track equipment. Also the signal-to-noise ratio is slightly lower using half track recording. Fig.2 shows the American "Ranger" system. Here the pilot frequency is recorded in the centre of a full-track tape at an angle of 10° to the sound track. The width of the sync head is related to the wavelength of the pilot frequency and its harmonics. During replay the transverse pilot head picks off the pilot tone, but at the audio head the pilot tone has no effect—the gap width in the sound head ensuring that the flux from the pilot track averages to zero at any instant. Crosstalk into the sound channel depends upon control of tape speed in relation to pilot frequency for a given sound head. Fig.3 illustrates the "Perfectone" system. The pilot frequency of 100Hz is recorded in push-pull on to the outer edges of the tape. Symmetry during record and playback is ensured by
1. Setting the two pilot heads in parallel,
2. Maintaining the correct height of the two heads, and
3. Providing equal magnetic flux for the two pilot tracks.

German pilot systems

One form is shown in Fig.4. The pilot frequency is recorded transversely in the centre of the tape. The pilot head width is approximately 0.5mm, the gap width 0.4 to 0.5mm. Sync pulses are recorded at an angle of 90° to the track. The pilot track lies in the centre of the tape, its width being determined by the width of the head. The pilot tone averages to zero within the gap of the sound head. Very precise conditions have been laid down for this system in the DIN 15575 specification. Crosstalk from the pilot channel to the sound channel must be not less than 58dB down. The pilot tone must not cause the audio sound level from the tape to drop by more than 2dB. Signal-to-noise ratio in the pilot channel itself must be larger than 14dB.

In the beginning, transverse pilot recordings suffered from crosstalk. The problem was to design a pilot head of 0.5mm gap

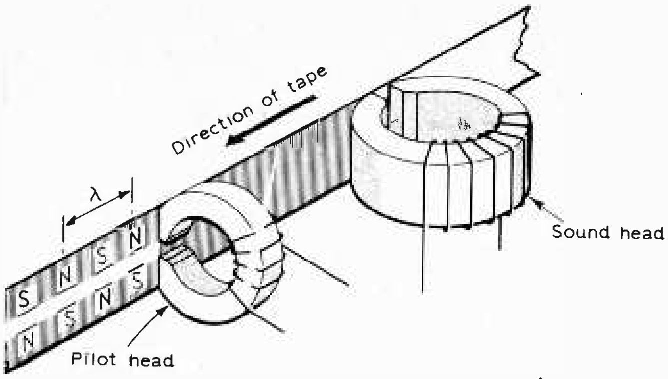
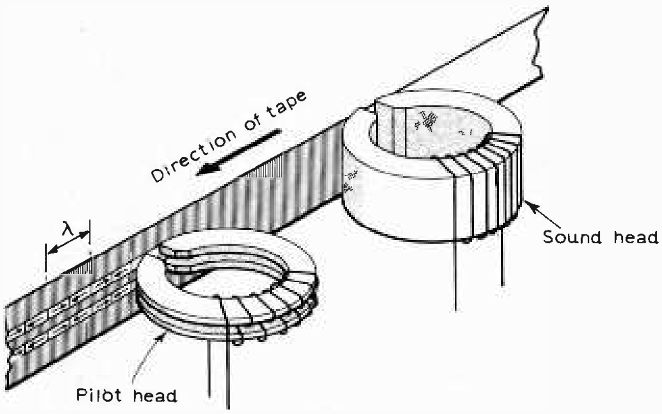


Fig.4. The transverse-recording system.

Fig.5. The push-pull neo-pilot system.



width which could be biased. The required bias-field density easily saturated the iron of the head, thus overloading the bias oscillator. Telefunken subsequently brought a pilot head on the market which only dissipated 150mW with bias at 80kHz.

Also included within the DIN 15575 standard is the push-pull pilot recording which "Nagra" and "Uher" incorporate in their pilot tape recorders. The system operates with two conventionally recorded pilot tracks in the centre of the tape as shown in Fig.5, track width is 0.45-0.1mm. This system has proved to be the most satisfactory one and incorporates the following features:

1. The recording can be played back from a standard transverse head because the magnetic intensity of the tracks cancels out in the sound head gap.
2. Balance between the two pilot tracks, for minimum crosstalk, can be achieved by resistors.
3. Smaller head gaps result in less bias power dissipation.

Books Received

The Semiconductor Data Book produced by Motorola contains some 1,700 information-packed pages and represents very good value for money. The book contains a comprehensive index listing most of the Jedec type numbers (1N, 2N, 3N), including non-Motorola types, with reduced performance data. The index also lists Motorola "inhouse" M numbers. In the body of the book each type of device is listed under one of thirteen separate section headings. Headings include the various categories of transistors, zener, varicap, thryistors and conventional diodes, multiple devices, integrated circuits and special devices—incorporating photo-cells, current regulators and surge suppressors. In each section a quick selection guide is incorporated and full device performance details are given. A section is devoted to hardware and the last section consists of some 130 pages of application notes. The book costs 50s and is available from the Modern Book Company, 19-21 Praed Street, London, W.2.

The Radio Communication Handbook, 1968, is the fourth edition of what used to be called the "Amateur Radio Handbook". The period since the third edition of 1961 has witnessed the trend towards miniaturization, with the wider use of semiconductors and printed circuits. This new edition reflects this change. It is fifty per cent bigger. Besides the general rewriting of chapters and their extension, there is a new chapter on RTTY. Single sideband techniques are fully discussed. The increasing use of the h.f. band is matched by much new material on aerials, transmitters and receivers. Not surprisingly the treatment of wave propagation has been considerably developed. The pages are numbered separately for each chapter. A very good index is provided. Pp. 800. Price £3 3s. Radio Society of Great Britain, 35 Doughty Street, London W.C.1.

Fundamentals of Reliable Circuit Design, Volume 3, by Mel Xlander, describes the procedure for the design and analysis of small-signal transistor amplifiers. Transistor equivalent circuits and essential a.c. theory are dealt with in the early chapters, followed by a valuable central chapter of 33 pages devoted to the derivation of general equations for negative feedback amplifiers. Difference amplifiers, operational amplifiers and video amplifiers are discussed separately, and the final chapter is titled "Worst-case Design and Analysis". Worked examples, employing simple algebraic formulations, are used when appropriate. Major points are reviewed at the end of each chapter, and a series of exercises enables the reader to test his acquired knowledge. Pp. 176. Price 30s. Iliffe Books Ltd., 42 Russell Square, London W.C.1.

Digital Systems Logic and Circuits, by B. Zacharov, is a text in the Unwin Studies in Physics series. The book is the result of a course for undergraduates in their last year reading for the B.Sc. Special Physics Degree of London University. It deals with elementary aspects of binary digital systems viz. digital number systems, Boolean algebra, and the electronic and electrical hardware appropriate to digital systems. Chapter 5, called "The Physical Implementation of Logic Operations", takes up a third of the book, and deals comprehensively with the variety of transistor configurations employed in digital circuits. Each chapter has a very full bibliography, and there is a good index. Pp. 160. Price 30s. George Allen and Unwin Ltd., 40 Museum Street, London, W.C.1.

Precision Electronics, first English edition, by G. Klein and J. J. Zaalberg van Zelst, is a quite singular and down-to-earth treatment of electronics. Dr. Klein works on instrumental electronics in the Philips Research Laboratories at Eindhoven and is also Extraordinary Professor in electronic instrumentation at the Delft Technical University. Dr. Zaalberg van Zelst is a professor at the Eindhoven Technical University. The authors aim to present the fundamentals of electronics, which underlie both valve and transistor circuits, in a way which avoids "verbose over-simplified discussions, excessive calculations and a loss of general clarity . . . We first discuss the most common components, methods of calculation and basic circuits in electronics, and then turn to principles and methods with special attention to the limits in the design of electronic measurement equipment." There are 43 chapters, or sections, having headings such as 'current and voltage sources', 'output impedance', 'cascode', and 'balanced amplifiers'. There is a bibliography and a good index. Pp. 462. Price £6 18s. Philips Technical Library distributed in U.K. and Eire by Macmillan & Co., Little Essex Street, London, W.C.2.

Electronic Design Handbook, second edition 1968, is a reference source of over 500 different tried and tested circuits. The circuit diagrams are complete with component values, transistor and valve types, and any relevant waveforms. Although an extremely varied selection of circuits is included, reference to a specific configuration is made very easy by a full and well laid out table of contents. Headings for sections of the book cover circuits for control, regulation, protection, pulse generation, comparison, counting and timing, and many others extending across the whole field of electronics. Most of the circuits use transistors, but valves make numerous appearances, and nearly every other known electronic device is made use of in one context or another. Pp. 318. Price £7 approx. Tab Books, U.S.A. Available in the U.K. from Transatlantic Book Services, 28 Norfolk Street, London, W.C.2.

Fun with Short Wave Radio by Gilbert Davey is a revised edition of the author's **Fun With Short Waves** first published in 1960. The first chapter is an introduction to short waves and is preceded by a page of electronic symbols for the beginner or the uncertain. Chapter two calls the reader to amateur radio as a hobby, and the rest of the book deals with practical shortwave radio receiver circuits beginning with a battery one-valve and ending with a nine-valve superhet communications receiver. Two transistor circuits are included; one a two-transistor t.r.f. experimental type, and the other a six transistor superhet. Full constructional details are given for each receiver. The last two chapters deal with aerials and earths and buying components. Pp. 64. Price 16s. Kaye and Ward Ltd., 194-200 Bishopsgate, London, E.C.2.

'A Guide to Amateur Radio'. It is regretted that in mentioning this book in the October issue we referred to the twelfth edition which cost 5s. The thirteenth, and latest, edition costs 6s.

Wireless World Colour Television Receiver

6. Luminance video amplifier

The luminance amplifier as a whole includes two transistor phase-splitters in cascade and a pentode output stage, which actually provides the whole of the amplification. The first phase-splitter is included in the i.f. strip; it is directly-coupled to the diode video detector and is fed with a signal at its base which is positive-going on sync pulses. One output is taken from the emitter to feed the chrominance circuits and another in opposite phase (that is, with negative-going sync pulses) from the collector. This feeds the second phase-splitter through a delay line which delays the whole video signal by 0.6μsec.

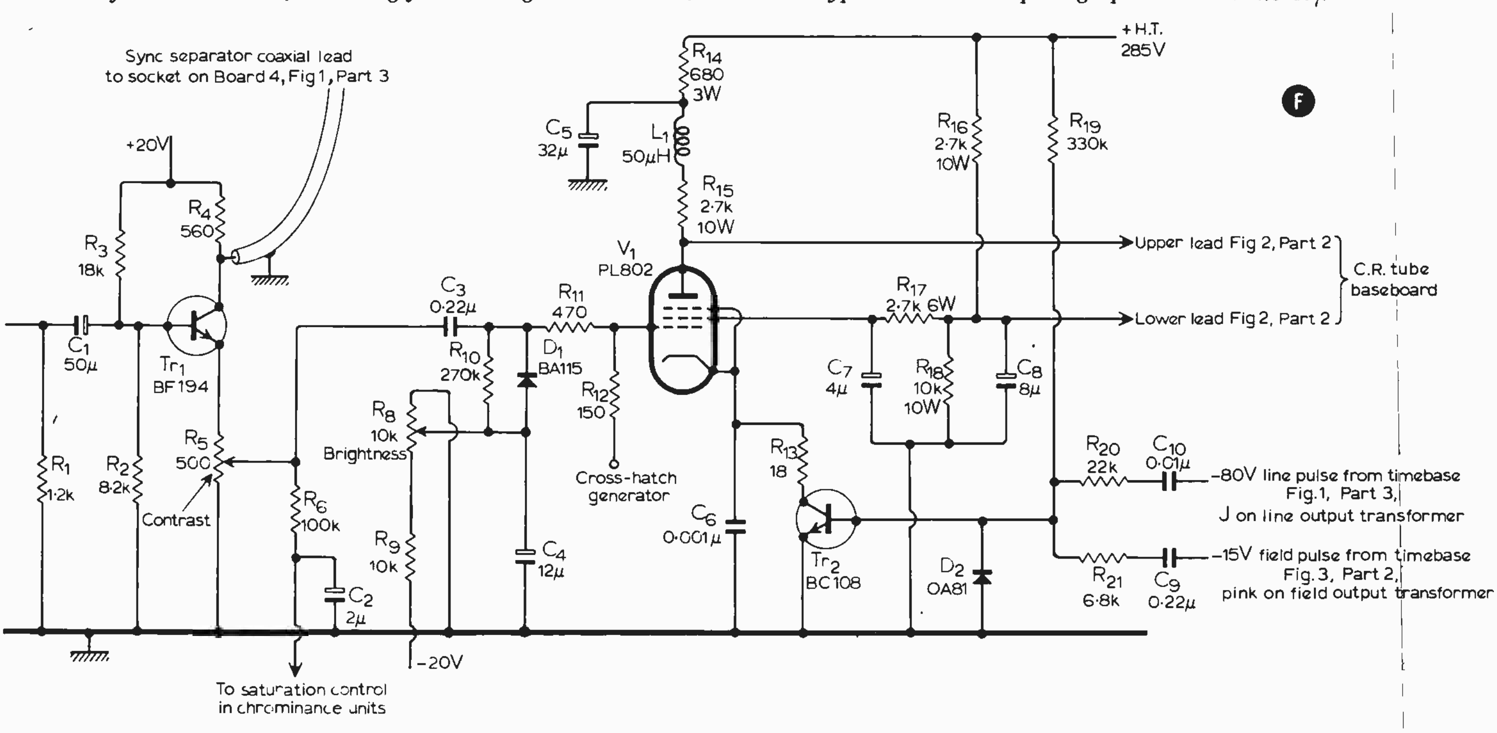
It is not always realised that it takes time for a signal to pass through electronic circuits nor that this time is related to bandwidth; the narrower the bandwidth, the longer it takes for the signal to pass. This does not matter when all signals pass through the same circuits for they are all delayed by the same amount. After the first video stage, however, the luminance and chrominance signals are separated and pass through different circuits. The luminance channel has a bandwidth approaching 5MHz, whereas the chrominance channel has one of rather less than 1.5MHz. Unless the transit times of the signals in the two channels are equalized, therefore, the colours in the picture will appear displaced sideways from the picture detail. The 0.6-μsec delay line is thus included in the luminance channel to equalize the transit times of the two channels. It is mounted in the i.f. strip and will be dealt with in detail in a further article; its terminating resistance, however, is R_1 of 1.2kΩ in Fig. 1.

This diagram shows the circuit of the luminance amplifier unit, the physical details of which are given in other illustrations. It is fed at its input with the delayed luminance signal having negative-going sync pulses. The first transistor, Tr_1, is a phase splitter. The collector output is of opposite phase with positive-going sync pulses and is fed to the sync separator in the timebase unit through a coaxial cable. This is possible since a considerable amount of capacitance loading is permissible on this circuit.

The emitter output is in the same phase as the input and feeds the grid of the output stage V_1. The cathode load is a 500-Ω potentiometer R_5 which acts as the contrast control. It is a wire-wound component. In this unit it is mounted close to the transistor and in such a position that an extension shaft from the front panel can be coupled to it. This is not essential, however; because of the low output impedance of the transistor at its emitter an appreciable amount of shunt capacitance on R_5 is allowable. It is permissible, therefore, to connect R_5 with screened leads of a low-capacitance type if they are kept reasonably short.

When the contrast control is adjusted it not only varies the

Fig. 1 Circuit diagram of the luminance amplifier. The transistor Tr_1 can be type BF194 or BF184 without affecting the performance. The latter has four connections, one being for earthing its metal case, and is the type shown in the photographs. There is no R_7.



magnitude of the video signal at the slider but also the d.c. potential. The video is removed by a simple filter R_6C_2 and the d.c. is applied to the saturation control of the chrominance channel so that adjustments of contrast have little effect upon the colour saturation.

The luminance signal is passed to V_1 through C_3 and is d.c. restored by D_1. This diode and the grid leak R_{10} are returned to the slider of the brightness control R_8 which is connected with a series resistance between chassis and -20V. In some designs R_8 is taken through a pair of resistances to $+285$V and their junction is taken through a diode to the e.h.t. stabilizer circuit. This is done to limit the beam current of the cathode-ray tube if the brightness control is turned up too much. It is not done in this case, because it adds yet more interconnecting wires between the units and it has not been found to be necessary. The normal lack of contrast appears if brightness is turned up too much well before the beam current is excessive.

R_{11} is the usual grid stopper. R_{12} is included to enable a cross-hatch pattern generator to be connected. When this is used for convergence adjustments (Part 5) it is connected to this resistor and the contrast control is turned to minimum. This cuts off the picture signal and R_{12} and R_{11} form a potential divider across the generator output so that the input to V_1 is 470/620 of the generator output. It is essential to turn down the contrast control fully. If this is not done some of the output of the cross-hatch generator is applied to the emitter of Tr_1, is amplified by it, and is fed to the sync separator and so upsets the synchronizing of the timebases.

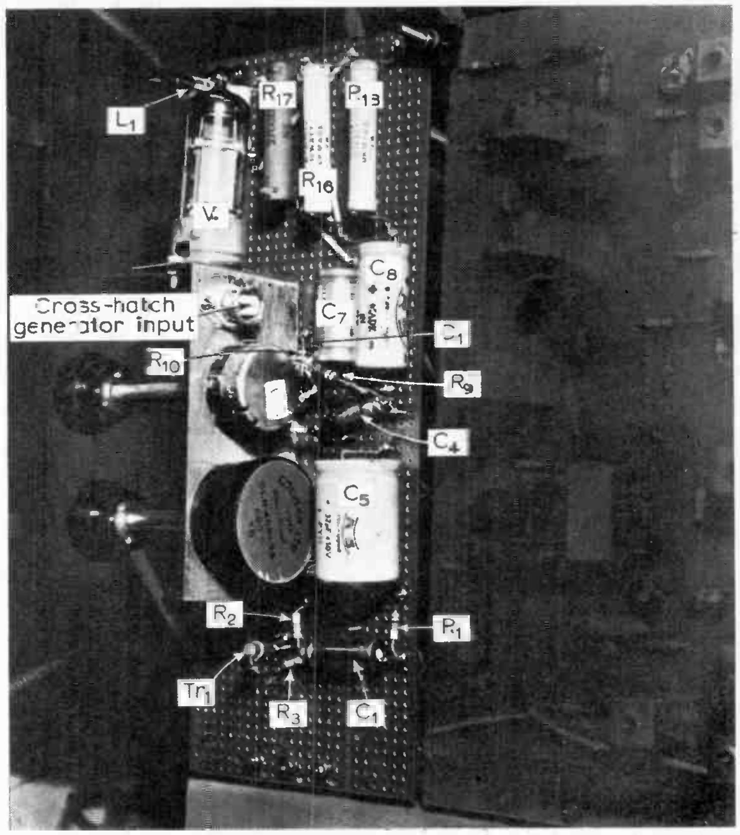
Reverting to Fig. 1, the d.c. restored video signal with negative-going sync pulses appears at the grid. The valve is of a high-g_m type and of a high-current rating, for it has to provide an output of 140V p-p (including sync pulse) with an anode load R_{15} of only 2.7kΩ. The 50-μH inductor L_1 is included in series with it to increase the bandwidth in the usual way and some cathode compensation is also provided by C_6. The screen-feed network R_{16}, R_{17}, R_{18} with C_7 and C_8 not only provides the proper d.c. screen voltage, but, in conjunction with R_{14} and C_5, gives the proper low-frequency response.

A transistor Tr_2 is included in the cathode circuit, and its base, with the safety diode D_2, is fed with negative-going pulses at line and field frequencies. The base is normally biased positively through R_{19}, so Tr_2 is normally conductive and, with R_{13}, its low collector-emitter impedance forms a cathode-bias resistor for V_1. The negative-going line and field pulses cut off Tr_2, however, and so V_1 is also cut off. This line and field blanking prevents any traces of the timebase flybacks from being visible on the picture.

Construction

The parts shown in Fig. 1 are all mounted on a piece of plain Veroboard measuring $9\frac{1}{2}$in.$\times 3\frac{3}{4}$in. Double-ended pins are inserted at the appropriate points to serve as anchorage points for the connections. A metal bracket holds the controls and the valveholder. The board is mounted on a hinge to a block of wood which is screwed to the base of the equipment. In normal operation the board is vertical and the shafts of the two controls are in line to connect with extension shafts which can come through the front at the side of the cathode-ray tube. By disconnecting couplers to these shafts the board can be hinged down to a horizontal position. This enables easy access to its back for fault-finding. More important, it enables one readily to reach the static convergence magnets from the front of the set on this side of the tube. Since the timebase unit is also hinged to open out, all these magnets can be reached from the front.

The three coaxial cables, one to the sync separator, one from the line timebase and one from the field timebase, are all soldered directly to the appropriate points in this video amplifier.

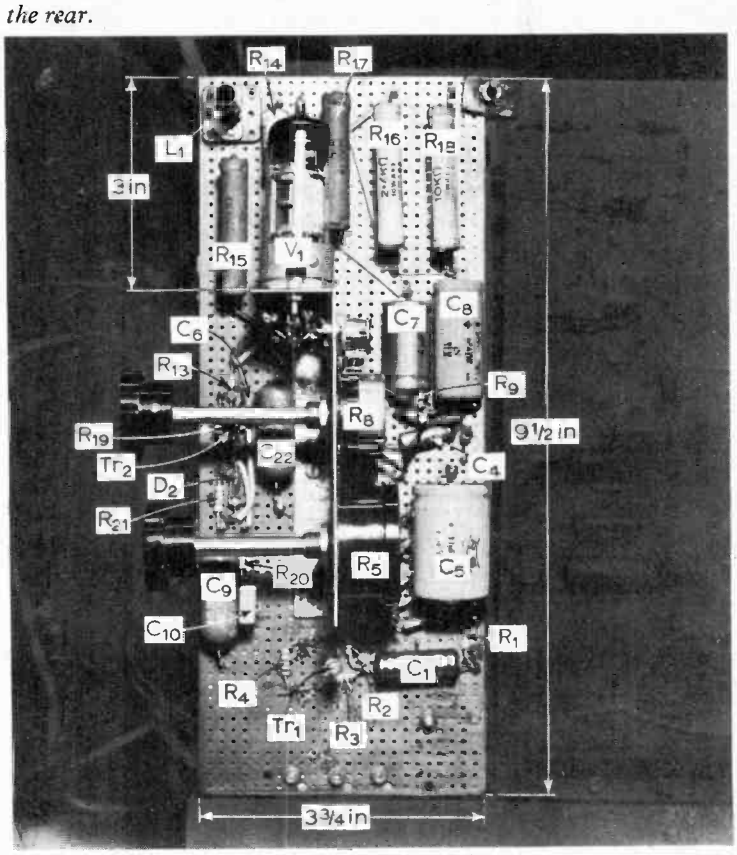


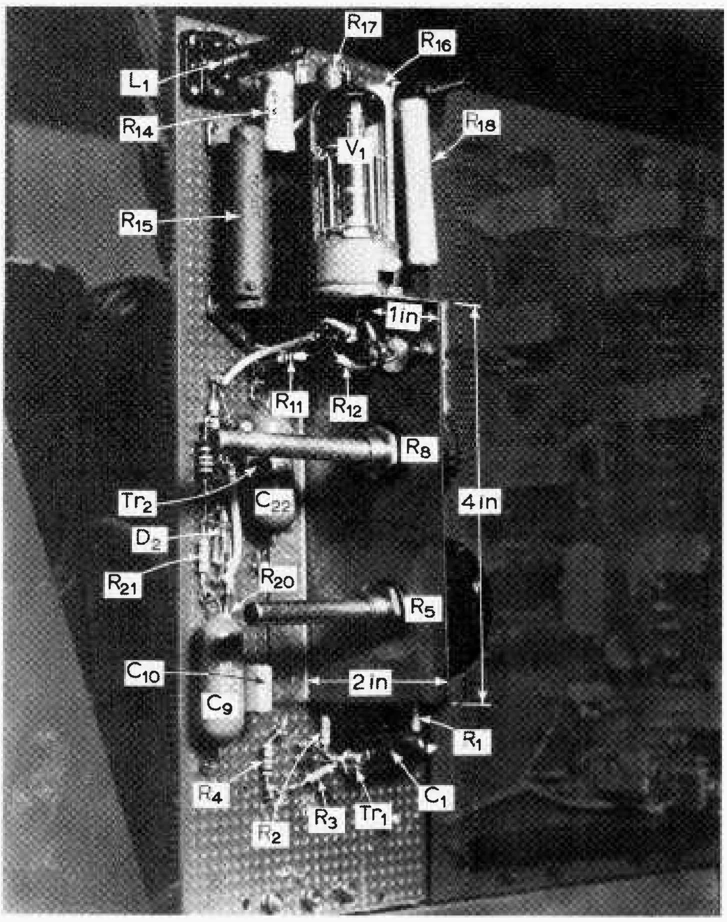
Front of luminance amplifier alongside i.f. strip.

The one to the sync separator is terminated at its other end with a plug to fit the socket which is mounted on Board 4 in the timebase unit and it is made long enough to pass loosely between the units in front of the power unit when both units are fully opened out horizontally.

The other two cables are also soldered directly to their

Front of luminance amplifier. There are no components mounted on the rear.





This view shows the bracket which carries the variable resistors and valve.

appropriate points in the amplifier. There are no sockets for these in the timebase and here also cables are soldered directly to the appropriate points. In order to allow for ready disconnection, however, connectors are fitted in the cable run between the units. There are two possibilities. The obvious one is to terminate the cables from one unit with the usual free plugs and those from the other with free sockets. Although they are listed, free sockets do not seem to be so readily available as free plugs; it is practicable, therefore, to terminate all cables with free plugs, and use double-ended connectors for joining them; these are readily available.

The exact layout of the parts is by no means critical, but the positions of the high-wattage resistors, which are wire-wound types, and of the electrolytic capacitors should be followed reasonably closely. These positions have been carefully chosen so that the resistors have a free flow of air around them and the capacitors are as far from them as is practicable and out of the hot air stream from them.

As a temporary measure for the initial trials an additional potential divider should be connected across the 285-V line and chassis. This should comprise two resistors each of 10k Ω, 3W rating, joined in series between the +285-V line and the negative line. Their junction is taken out through a lead to all three grids of the cathode-ray tube. There is plenty of room for these resistors to stand out at the back of all other components on the tube side of the board and they can be held by their leads. They can be removed when the chrominance circuits are brought into action, but until then they are needed so that the equipment can be operated to give a monochrome picture.

All the luminance power-supply connections are brought into this luminance-amplifier board and, as can be seen in Fig. 1, Part 4, they comprise +285V, +20V, 0V, −20V, −24V, and two heater leads. The −24-V supply is not needed in the video unit, but it is convenient to bring it into this unit with the others and to use this unit as a distribution point for the i.f. unit. This latter needs supplies at 0V, −20V and −24V only; it is mounted immediately alongside the video board and a video interconnection between the two is needed in any case. The power supply for the tuner is then taken from the i.f. board.

The choice of components is straightforward. Capacitors associated with transistor circuits need a voltage rating of no more than 25 volts, whereas those associated with the valve should be of 350 volts working. Even C_4 should not need to be of more than 25V rating, but perhaps 30V is a little safer to cover an adverse tolerance on resistor values.

The inductor L_1 is 50μH. Almost any coil wound to this inductance can be used, but the one employed comprises 120 turns of No. 40 enamelled wire close wound as a single layer on a former of $\frac{5}{16}$in. diameter. The winding length is $\frac{19}{32}$in. It is convenient to use a standard Aladdin former of the type which takes a 6-mm core, but no core is used.

Do's and Don'ts

A minor constructional point should be mentioned here. It is really one of universal application, but it arises particularly here because of the use of pins in Veroboard for anchorage points for components. It applies to all components, but especially to low-wattage composition resistors. Do not connect a resistor directly between two pins with very short leads. When the leads contract after the heat of soldering they can pull out of the resistor body, or, rather, one may be pulled sufficiently to be disconnected internally. It looks right when in position, but pulls out if the lead is unsoldered. It provides a fault which can be hard to trace.

It is more likely to arise with pins in Veroboard than with ordinary tagboards because of the unusual rigidity of the pins. No trouble at all arises, even with quite short leads, if the leads and resistor are not kept quite straight between the pins, but are given a slight bend. The contraction of the leads after soldering can then be taken up merely in reducing the bend.

Suppliers of Parts

We are informed that Forbes Electronic Services, 5 Hamilton Road, Berkhamsted, Herts (Berkhamsted 6454), can supply retail components manufactured by Plessey Ltd.

We are also informed that Forgestone, Ketteringham, Wymondham, Norfolk (Hethersett 453), can supply colour television parts to mail order.

Addendum to Part 2

Due to the omission of a word in Part 2, in paragraph 3, p. 192, a potentially dangerous situation could arise. It is said there that the tube screen "can be held in place by four lengths of similar spring external to the screen and attached to holes in the screen on the one hand and to lugs under the tube-mounting bolts on the other". The word "insulated" should be inserted before "lugs".

The tube-mounting brackets are in contact with the rimband of the tube and if metal lugs are used for the springs the rimband becomes connected to the screen and thence to one side of the mains. It is, therefore, imperative to use insulation of one form or another between the springs and the tube mounting.

We are informed by RCA Colour Tubes Ltd. that their 19-in tube type A49-15X and the 25in tube type A63-17X are interchangeable with the Mazda CTA 1950 and CTA 2550 types.

Letter from America

This year the New York Audio Fair—sponsored by the Institute of High Fidelity Manufacturers—moved to a new venue at the Statler-Hilton Hotel. For the last few years the show has been held at the old Trade Show Building a few blocks away but this was far from satisfactory. Not only is the location poor, parking and restaurant facilities somewhat limited—but to make matters worse organization was complicated by Union difficulties!

Hotels are not ideal for hi-fi demonstrations either, but this particular move met with general approval from the majority of exhibitors. The Statler-Hilton is an older hotel with some of the staid, quiet atmosphere of an Edwardian type 'potted-palm' Grand Hotel still perceptible under the chromium plated efficiency of the newer Hilton 'face-lift'.

Some 100 exhibitors were dispersed over two floors and there were the usual seminars and lectures which are a feature of these shows. Among the subjects discussed were amplifier power measurements, characteristics of tape recorders, the how and why of stereo disc recording and room acoustics, and there was a Symposium for Novices. A popular item consisted of live demonstrations of some problems encountered by hi-fi enthusiasts—speaker placement, phasing, balance, the effects of reverberation and so on.

At the Show itself, Japanese imports were well represented and again I was impressed with the excellent engineering and superb styling. There is no doubt that this competition is causing some concern here and a trade magazine reported a prominent executive as saying ". . . the Japanese offer good products at highly competitive prices. Why should my company spend a lot of money on a show that's going to introduce the public to all this new competition?" This is an understandable if illogical point of view but it does underline the fact that American firms are getting worried. The hi-fi market is a highly competitive one and many firms have been trying to 'broaden the base' by making cheap record players, radiograms, tape units, etc. As a marketing executive put it "What is happening is that hi-fi manufacturers want a bigger piece of the non-audiophile pie and they recognize that retractable, disappearing control panels and wrist watch radios can be far more appealing to the mass market than a system that delivers 19,000 Hz instead of 18,000 Hz."

Undoubtedly, Japanese competition will provide further impetus to this policy. As a matter of interest, both Fisher and Scott were showing $1\frac{7}{8}$-in tape cassette units which up to now have not been considered very seriously by hi-fi *aficionados*. However, they *are* convenient to use and with the constant improvements in servo type motor controls and the tape itself the quality will soon approach the standard obtained from $3\frac{3}{4}$-in reel-to-reel machines. Going to the other extreme, KLH were demonstrating their new Model 40 tape recorder which is the first non-professional machine to use the Dolby process. Although $7\frac{1}{2}$-in tape speed is available, the recommended speed is $3\frac{3}{4}$ in and KLH claim that at this speed the recorder sets a new standard which compares more than favourably with studio machines operating at 15 i.p.s. In fact they were demonstrating this at the Show by making recordings on the Model 40 and a professional machine. When the tapes were played back, the differences were inaudible and it was claimed that some listeners said "the only difference they heard was $2,900!"

An interesting feature of the KLH 40 was the provision of only one VU meter that reads both stereo channels and indicates the louder of the two at any given moment. The meter can also be switched to either channel but I personally would prefer to have the convenience of two meters. However, Model 40 represents good value at $600 (say £250).

EMI (through their agent, Benjamin) were showing a new speaker system using a 15-in bass unit, two 5-in mid-range plus two pressure units. Fisher were demonstrating two new systems, one using a 12-in and the other a 15-in bass speaker. Small speaker systems are still fairly popular but there appears to be a definite trend towards the larger, more elaborate systems. The new Bose system which uses eight rear mounted speakers with one front mounted unit attracted a lot of attention. The speakers are quite small (4in) and built-in electronic equalization is provided to compensate for bass loss, etc. This is not a new approach and it is not cheap (each unit costs $476 (£200)) but they provided some of the best sound heard at the show—at least in my opinion. Bogen were demonstrating a receiver with remote control tuning (much easier to design with varicap front-ends) and Kenwood had a super-receiver with electronic crossovers. Similar receivers were shown by Sony, JVC and Pioneer although the last-named was in fact a complete integrated system with loudspeakers.

KLH Model 40 tape recorder which incorporates the Dolby process.

So much for the Audio Show. Turning now to television, here are the sales figures up to August this year: Colour receivers 3,266,172 and monochrome 3,446,256, representing a small increase over last year's figures. Radio sales were 13,625,464 of which about half were car radios, C.C.T.V. equipment accounted for no less than $12.4 million for the first 6 months compared with $12 million for the same period last year.

Westinghouse have been spending a lot of time investigating the effect of heating and pressure on certain materials. Methods have been discovered of pressing out 'holes' left by misplaced atoms in some types of alloys called 'defect lane' compounds. The 'ironing' is done at very high temperatures between 1500 and 3000 deg F and is followed by rapid cooling. This changes the molecular structure of the material so that the atoms take on a crystal form. The change is permanent and can be reversed only by heat application. One of the materials amenable to treatment is titanium monoxide which is normally full of sub-microscopic 'holes' that can all be eliminated. The treatment can be controlled so that a proportion of holes is left untouched depending on the exact characteristics required. It is reported that removing the holes from titanium monoxide more than tripled its super-conducting temperature and Dr. Taylor of Westinghouse, said "it is well known that these holes can exert a tremendous influence on other physical properties such as electrical resistance, elasticity, ageing and magnetic properties." He went on to say that research is continuing and that the discovery might result in a new class of materials. Westinghouse are also experimenting with a new thin film technique with piezoelectric materials. Multi-layer structures have been made that can be used for delay lines and electric-to-sound transducers with four times the power and twice the frequency range of uniform layer thin films. An acoustic delay line can produce in one inch the same effect produced by cable delay lines almost 2 miles long. The new process involves alternate reversal of the various layers so that as one layer contracts under electric stimulation the next layer expands. In other words, each pair of layers functions as a sort of 'full-wave' device. Such transducers are most efficient at a single frequency but bandwidth can be increased by making the layers of slightly different thickness.

G. W. Tillett

A Convention of Vision

I.B.C. 1968

When 700 delegates meet for a period of four or five days to hear a possible total of more than 100 technical papers and to inspect the wares of 45 exhibitors, hopes and ambitions are raised high on all sides. From the delegates' point of view the success of the convention is measured by its breadth and depth—the scope and pertinence of its concerns. On the other hand from the exhibitors' point of view it has all been worth while if a satisfactory response is gained—measured in terms of genuine enquiries leading to sales. Organizers of such a convention have got to balance these demands. They have in fact to aim for a matched complementry output. This was the achievement of the organizers of the International Broadcasting Convention at Grosvenor House. Running from September 9th to 13th, it was the second of such ventures in London, the third being scheduled for September 1970.

The convention was opened by the Postmaster General, the Rt. Hon. John Stonehouse, M.P., who declared "it is most fitting that from time to time all those concerned on what I might describe as the technological and professional side should pause to take stock of the position. This convention provides an opportunity to do so." Apart from the guiding light of this pronouncement we are of course in the dark as to what pressed the mass of individuals into attending. Over 150 foreign delegates had registered by the opening day.

With very few exceptions the technical papers delivered dealt with aspects of television technology. These included the design of cameras, aerials, and colour-television studios; techniques for wideband-signal coding, amplification and transmission; and various developments in colour-video recording on tape and on magnetic disc. L. S. Golding, of the Communications Satellite Corporation Labs., in America, gave a lecture on "Digital television transmission systems for satellite communication links". This paper, perhaps the most important delivered to the convention, argued for digital transmission, over against f.m. transmission, of the analogue television signal. The main reasons given were that (1) many signal processing techniques for increasing transmission efficiency are only possible using digital techniques; (2) interference, and its effect on satellite communications and terrestrial communications, can be reduced easily; and (3) digital television systems are compatible with future time-division-multiplexed pulse-code modulation systems for telephone and data transmission. The actual system described, employing comb filters for separation of the luminance and chrominance video components, cannot be described in detail here, but provided considerable material for discussion and dissension. D. J. Bryan of Thames Television, ended his lecture entitled "A system for distributing television pulses in coded form" with a tentative request for an international standard for a coded pulse signal.

Moving now from the lecture theatre to the Great Room we encounter the exhibition. The distribution of shows afforded justifiable prominence to the large companies, huge structures being necessarily grouped centrally. In some cases however the sheer bulk seemed inessential, not being counterbalanced with significant exhibits. Mere flag waving is rather disappointing at an exhibition like this. It is also questionable whether Thames Television's live colour TV programme, with the enigmatic title "Camera Two Double O One", really drew attention to the E.M.I. equipment being used.

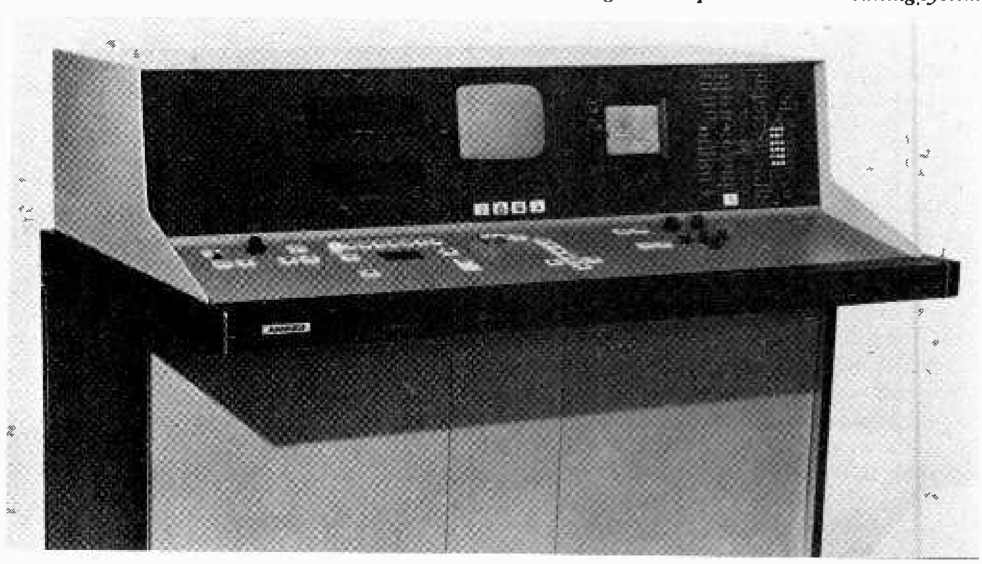
Ampex had equipment worth about £400,000 on display and a good body of technicians willing to explain things in detail. Highlighted was the HS-200 colour disc recording and computer-controlled editing system, being shown in England for the first time. The signal is recorded on the concentric tracks of a magnetic disc, each track being a "still" or single frame. The record/replay head jerks from track to track to simulate a continuous recording. If during replay the head stays still against a track the recorded material appears as a still. Slow-motion effects are achieved, without loss of definition, by programming the head movement to include a recap action so that the scanning speed is maintained but the ground covered in the time is less.

From Switzerland, Sandor's sprocketed magnetic-tape recorder type OMA2 has several notable features. These include a start-up time of less than 5ms with wow and flutter stable after 200ms, and a pulse driven polarized coincidence motor with a 100-pole permanent-magnet rotor. The pulse generator operates photoelectrically and is coupled directly to the drive of say a cine projector.

From Germany the TAFCO-system, EMT 400, time and frame coder system for magnetic video and sound recording, and seen for the first time in England, was the subject of a paper at last year's convention. It is capable of two functions. Used one way it can put time pulses in minutes and seconds onto video tapes or sound recordings. This not only provides a digital indication of the running time but can be used to trigger other equipment into action. Alternatively four-digit numbers can be tagged along the tape enabling the position of video and audio events to be established accurately. This permits cuts, cross fades, and sound-effect additions to be carried out speedily and accurately. The system consists of five separate units including direct read out digital indicators.

Also the subject of a paper at last year's convention was the Richmond Hill Laboratories' Uni-Pulse equipment. This Canadian equipment is designed for single-cable pulse and subcarrier distribution systems. A full range of coders, decoders and phase-shift and delay modules makes the system applicable to both the N.T.S.C. 525-line and the PAL 625-line television standards. The system can be used with any make of sync generator.

The control console of the Ampex HS-200 colour disc recording and computer controlled editing system.



[est Your Knowledge

:ries devised by L. Ibbotson*, B.Sc., A.Inst.P., M.I.E.E., M.I.E.R.E.

. Semiconductors

The form of crystal bonding in silicon and :rmanium is:
(a) covalent
(b) ionic
(c) metallic
(d) Van der Waals forces.

. The term "energy gap" as applied to a :miconductor means:
(a) a mechanical discontinuity in the crystal structure which only very energetic carriers can cross
(b) the energy required by a bound electron to move from one atom to the next
(c) the least energy required to break a valence bond and release an electron and hole as carriers
(d) the least energy required to remove an electron from the crystal.

;. At 2°K the resistivity of a single crystal of ›ure silicon is:
(a) very high
(b) very low
(c) about 50 ohm-cm
(d) zero.

4. In a pure single crystal of germanium at room temperature conduction is due to the presence of:
(a) positive holes only
(b) conduction electrons only
(c) equal numbers of positive hole and conduction electrons
(d) germanium ions.

5. P-type silicon is made by adding impurity atoms having:
(a) 3 valence electrons
(b) 4 valence electrons
(c) 5 valence electrons
(d) no valence electrons.

6. The presence of the extra conduction electrons in n-type silicon results in there being:
(a) more positive holes than in intrinsic silicon at the same temperature
(b) the same number of positive holes as in intrinsic silicon at the same temperature
(c) fewer positive holes than in intrinsic silicon at the same temperature
(d) no positive holes.

7. If electromagnetic radiation strikes a piece of semiconductor material its conductivity increases only if:
(a) the radiation intensity is greater than a certain value
(b) the energy of a quantum of the radiation is greater than the energy gap in the semiconductor
(c) the semiconductor is extrinsic (doped)
(d) the semiconductor is at room temperature or above.

8. A semiconductor rectifying p-n junction is formed if:
(a) a piece of n-type semiconductor is brought in contact with a piece of p-type semiconductor
(b) a single crystal of semiconductor material is so doped that one half has a predominance of donor impurities, the other half a predominance of acceptor impurities
(c) the number of doping atoms per c.c. in a piece of n- or p-type semiconductor varies with distance through the crystal
(d) electrons are injected into p-type material or positive holes into n-type material.

9. The "potential barrier" exists in a p-n junction because:
(a) p-type material is positively charged, n-type material is negatively charged
(b) initial diffusion of majority carriers from each side makes the p side of the junction negative and the n side positive, thus creating an electric field which prevents further diffusion
(c) the constant generation of electron hole pairs by heat represents a source of e.m.f. ready to drive a current when an external circuit is completed
(d) the junction represents a discontinuity which carriers can only cross if they have high energy.

10. The electric charges associated with the barrier potential in an unbiased p-n junction reside:
(a) uniformly throughout the material on either side
(b) on one side of the junction only
(c) in narrow layers on either side of the junction
(d) on the surface of the crystal.

11. A reverse biased p-n junction exhibits a capacitance with a value which:
(a) is independent of voltage
(b) increases with increasing reverse bias
(c) decreases with increasing reverse bias
(d) decreases for small reverse voltages, but increases again at larger reverse voltages.

12. In a p-n junction with uniform doping on either side the primary mechanism of charge transport through the crystal when a forward bias voltage is applied is:
(a) drift of carriers
(b) diffusion of carriers
(c) a combination of drift and diffusion of carriers
(d) migration of impurity ions.

13. The saturated reverse current of a p-n junction:
(a) increases rapidly with increasing temperature
(b) decreases rapidly with increasing temperature
(c) does not vary with temperature
(d) at low temperatures increases with increasing temperature, at high temperatures decreases with increasing temperature.

14. The saturated reverse current at room temperature of a reverse biased silicon p-n junction is much smaller than that of a similar germanium junction because:
(a) carrier mobilities are less in silicon than in germanium
(b) the energy gap in silicon is larger than that in germanium
(c) silicon crystals are more perfect than germanium crystals at room temperature
(d) silicon junctions are made by diffusion of impurities, germanium junctions by alloying of impurities.

15. Generally the largest reverse voltage which can be applied to a p-n junction is determined:
(a) by the onset of thermal run-away
(b) by zener breakdown in all cases
(c) by avalanche breakdown in all cases
(d) by zener breakdown for some junctions, avalanche breakdown for others.

16. If a junction is made between a metal and a semiconductor:
(a) no current can flow between the two
(b) the junction will always act as a normal ohmic contact
(c) the junction will always rectify
(d) in some cases the junction is ohmic, in others rectifying.

Answers and comments, page 429

* West Ham College of Technology, London, E.15.

Literature Received

"This year of hi-fi" (1968/1969) is a 48-page booklet listing the range of audio products handled by Imhofs (retail) Ltd, 112-116 New Oxford Street, London W.C.2. The booklet is well illustrated and contains the technical specifications of the equipment listed. Price 2s 6d in the U.K. from above address—free to readers overseas because of possible currency difficulties.

"R.R.E. Activities Guide". The Royal Radar Establishment at Malvern, is the country's largest electronics research and development centre. The establishment has produced the above booklet which gives an overall picture of the programme of work being carried out. Industrial Applications Unit, Royal Radar Establishment, Ministry of Technology, St. Andrews Road, Great Malvern, Worcs.
WW401 for further details.

We have received a collection of literature concerned with a large variety of **rotary switches** handled by Lorlin Electric Co. Ltd, Billingshurst, Sussex. Lorlin offer a 24-hour switch design service and design sheets for this purpose are enclosed in the literature.
WW402 for further details.

A **logic demonstration unit** is described in a leaflet from L. F. Services, South Street North, New Whittington, Chesterfield. The unit consists of a box containing four digit-input toggle switches, four input-state indicator lamps, four logic function selector switches—NOR, OR, AND, NAND—and an output-state indicator lamp. The unit costs just under £9.
WW403 for further details

The **1968 Labhire Catalogue** is now available. Recent additions to the range of instruments that can be hired from the company include: Tektronix 453 oscilloscopes, Dana digital voltmeters, Racal digital frequency counters and the Marconi TF2006 f.m. signal generator. Applicants for this issue will automatically receive all further editions as they are produced. Labhire Ltd., Station Approach, Bourne End, Bucks.
WW404 for further details

The **I.E.E.T.E. Bulletin** is a paper that will be published every other month, from September 1st last, and will carry news items, announcements to members of the Institution of Electrical and Electronic Technician Engineers, and include a diary of forthcoming events. The paper will concentrate on technical, educational and managerial matters of interest to the technician engineer. I.E.E.T.E, 2 Savoy Hill, London W.C.2.
WW 414 for further details.

Additions to a range of **silicon diodes** are described in four new engineering publications recently issued by Westinghouse. Engineering publications 25-9 **(1)** and 25-10 **(2)** provide full information on 10A (SxAN12) and 6A(SxAN6) silicon diodes with voltage ratings from 100 to 500V. Engineering publication 25-51 **(3)** describes a new range of high-power diodes with current ratings up to 70A and voltage ratings up to 1.4kV. Finally, for higher power diodes, engineering publication 25-50 **(4)** describes diodes that will handle currents from 510 to 830A at voltages up to 3kV. Semiconductor Division, Westinghouse Brake and Signal Co. Ltd, 82 York Way, Kings Cross, London N.1.
(1) WW 406 for further details.
(2) WW 407 for further details.
(3) WW 408 for further details.
(4) WW 409 for further details.

"Relay Summary" (1968/1969) contains 76 pages and describes relays of all shapes and sizes made by ITT (U.S.A.) most of which are available from Electronic Services, Standard Telephones and Cables Ltd, Edinburgh Way, Harlow, Essex. As well as conventional relays, reed and high performance mercury wetted types are described.
WW 410 for further details.

RFI Shields is the catalogue of Knitmesh Ltd., Greenfield, Holywell Flintshire, which describes a range of knitted metal materials suitabl for a number of electronic applications—screening, air filters, gasket etc. Standard knitted products are made in copper, monel, silvered coppe stainless steel and aluminium in a variety of grades and shapes—fla tubular, etc. Other materials and non-standard shapes can be specified b the customer.
WW405 for further details

A range of **t.t.l. integrated circuits** is described in a 47-page engineerin bulletin which we have received from the Technical Literature Dept Sprague Electric Co., Marshall Street, North Adams, Mass. 01247, U.S.A Seventeen types make up the range which have a typical gate propagatio delay of 13ns and a power dissipation of around 10mW per gate.
WW 411 for further details.

Educational films on electronic subjects are listed in a booklet produce by Mullard. Some of the films are available on free loan while others ca be hired. In the booklet a synopsis of each film is given and details of th conditions under which films are lent are included. The Mullar Educational Service, Mullard House, Torrington Place, London W.C.1.
WW 412 for further details.

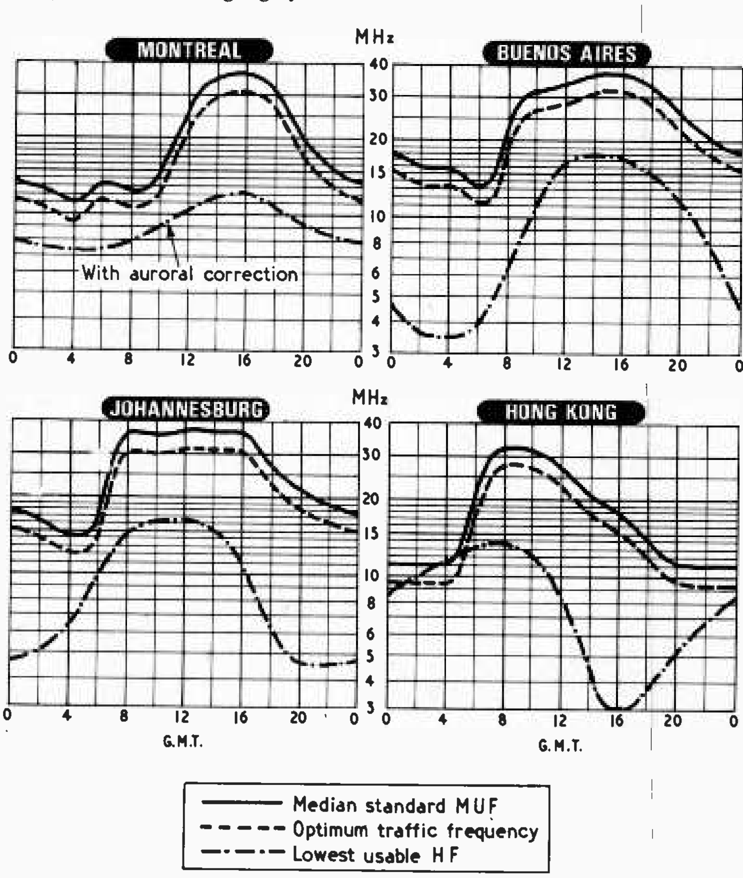
The **Microspot Analyser,** which was pictured in last month's "News o the Month" is described in a leaflet MA100 available from the Electroni Display Department, Ferranti, Gem Mill, Chadderton, Oldham, Lancs. The microspot analyser is an instrument for carrying out accurate c.r.t. resolution measurements.
WW 413 for further details.

H.F. Predictions—November

It will be seen that the MUF for Johannesburg is just over 35MHz for an eight hour period with very small variations. This should provide excellent conditions on the 26-MHz broadcast and 28-MHz amateur bands. The Buenos Aires curve tends to a similar shape and favourable conditions can also be expected.

The routes to the east and west show a high rate of change of MUF for most of the day which will require full use of frequency complements for continuous coverage.

LUFs depend partly on geographic variation of noise level and therefore unlike MUFs, do not apply to both directions of the route. Those shown were prepared by Cable & Wireless Ltd., for reception in the U.K. of point-to-point telegraph services using highly directive aerials.



New Products

Electronic Desk Calculator

Details of a British designed and built desk calculator, the first in the world to use large scale integration (l.s.i.) have just been released by Addo Ltd. This portable instrument, measuring 240 × 320 × 135mm and weighing only 6kg, performs the basic functions of "add", "subtract", "multiply" and "divide", showing the result on a ten-digit visual register. Its operating speed can be gauged from its ability to multiply or divide 10 × 10 digits in 200ms. The instrument is simple to operate; factors and instructions are entered by depressing keys in the same sequence used when putting pen to paper and the digits remain visible until the first digit of the second or subsequent factor is entered. Decimal point location is automatic. The keys actuate magnetically operated reed switches. Digits over the ten digits displayed are stored by an overspill facility for subsequent examination and lost information is always the least significant. Thus the ten most significant digits in all calculations are displayed, with the decimal point correctly positioned. Figures in the visual register can be transferred to a memory register and if these digits carry a plus or minus sign they will add to, or subtract from, figures already in store and display the stored total to this point. The stored figure can be recalled for use in further calculations, and retained in the memory. A constant in both multiplication and division can be provided by depressing the appropriate key. The calculator is completely silent in operation with no clicks from the keys when they are depressed. The solid state circuitry is divided into a number of plug-in modules making for easy servicing in the field and the small size of the unit is due mainly to the incorporation of the l.s.i. circuits. These devices which comprise some hundreds of interconnected transistors were developed by General Instrument Ltd., and are to be produced in their U.K. plant. Three l.s.i. packages containing a metal thick oxide silicon chip are employed in each machine as a shift register storage and calculating unit. The indicator tubes are a recent addition to the S.T.C. range, type GNP-7AH, side-view tubes with two decimal points included in each tube. They are operated by time-shared drive circuits and have a peak current capability of 25mA. Designated type Ten/3 the Addo electronic calculator is stated to cost about £400 and at this price it is expected to make a large impact on this Japanese-dominated market. Addo Ltd., 85 Great North Road, Hatfield, Herts.

WW320 for further details.

Mobile Communications

Storno Ltd., of Camberley, manufacturers of v.h.f. and u.h.f. mobile communications equipment, have recently developed a shared base station (SBS) system which permits the sharing of one base station by up to 20 independent users if they are located within reasonable geographical proximity. The system accommodates standard equipments from the Storno range with the one exception that selective calling of control points from mobiles requires additional tone calling facilities to be fitted to the mobile units. Normal v.h.f. and u.h.f. frequency ranges are available with channel separation of 50, 25, 20 or 12.5kHz. Either simplex or duplex operation can be provided and facilities include group calling, selective calling of individual mobiles, car-to-car operation, connection to telephone network and connection to landline for remote control. Call-time can be monitored for costing purposes. Since one radio channel is common to all subscribers there is a cut-out facility which prevents simultaneous use of the system by more than one subscriber, the other subscribers having visual indication when the channel is engaged, and an engaged tone if the handset is lifted. A variable timing device can be set to ensure equal sharing and prevent monopolization of the system for long periods. Fixed stations can be supplied with r.f. output power of 10, 25 and 50W (v.h.f.) and 2, 6, 15 and 20W (u.h.f.). Selective calls are made by transmitting a two-tone code, audible at the control position, which provides over 60 possible combinations and which could be used to control a fleet of vehicles of that number in one group. Visual indication of the type of call is shown and a horn alarm can be set if the operator has left his vehicle. The tone code removes a 53dB attenuation in the a.f. amplifier circuit of the receiver of the vehicle being called, all other receivers remaining locked-out by the action of the transmitted carrier. Circuit modules with the exception of the transmitter/power output stages are common to base station equipment and mobile units, and are interchangeable for servicing purposes. Latest in the range of Storno mobile installations is the CQL600 shown in the photograph which has the transmitter/receiver and controls all housed in a single dashboard-mounting unit. Transistors are used throughout and it provides a maximum of six crystal-controlled channels. Storno Ltd., Frimley Road, Camberley, Surrey.

WW325 for further details

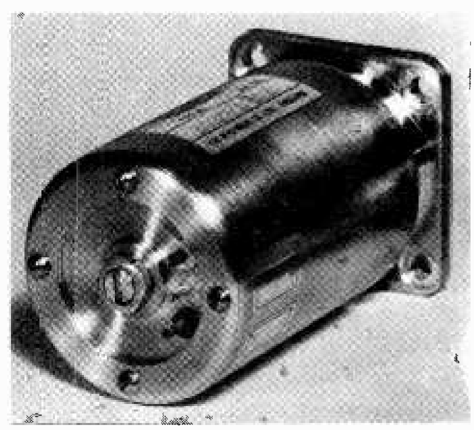
Specialized Computers

Two compact computers with specialized application are manufactured in Russia and marketed in the U.K. by Aveley Electronics. The first of these, type EMPT2, is for the clothing industry where it can determine the optimum cutting of cloth from a given length with minimum scrap and remnant. In addition to the optimum solution, the computer will give all subsequent combinations for a given piece of cloth as the optimum solution decreases. Operation is simple and the results are presented in digital form in an illuminated counter. The computer is capable of 100,000 adding operations per second. Operation is from 220V 50Hz a.c. and power consumption is 170W. The second computer is a small transistor unit designed to assist engineering calculations. Its main feature is that it can be used directly by a wide variety of specialists who are not required to take instruction on programming. The computing algorithm is introduced through an electric typewriter in the form of words and formulae, and conventional symbols of elementary functions may be used. Russian words are used to describe the computing algorithm; "calculate", "modify", "if", "then" etc. and to determine the type of data output; printing in line, in column, multi-position table, chart etc. Output data is copied on to a single or double sheet of paper by a typewriter. Aveley Electric Ltd., South Ockendon, Essex.

WW327 for further details

X-band Generator

Electronically tuned solid-state power generator, type E3288, by the M-O Valve Co., is suitable for use as a local oscillator or test source at X-band frequencies. It comprises an L-band (1-2 GHz) varactor-tuned oscillator coupled to a diode harmonic generator. The required output frequency is selected by an adjustable band-pass filter. Operating frequency is 8-11GHz with a tuning range of 400Hz and power output is 10mW. The device can be operated from a −17.5V stabilized supply and consumes 1.5W. Overall

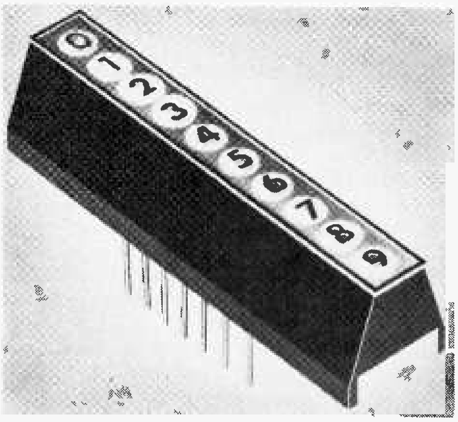


size is 42×42×75mm; weight 110 gm. A complementary varactor modulator with an internal pulse generator can be supplied, and power units are also available. The M-O Valve Co., Ltd., Brook Green Works, London W.6.

WW 308 for further details

Dual-in-line Readout

The Component Marketing Co. has announced a "Decalite" readout unit which is fitted with dual-in-line pin configuration and which can be driven directly from most i.c. elements. Designed



by the Swiss Rotocraft Company, the unit employs long-life replaceable lamps, operating typically at 5 V, 35 mA, thus dispensing with the need for lamp driver elements, and allowing direct drive from decoding gates. The Decalite measures 12×12×43 mm: minimum pin length is 8 mm. Component Marketing Co., 128 Woodlands Avenue, Eastcote, Ruislip, Middx.

WW 312 for further details

Special-purpose Tape Recorders

Truvox have modified their recently introduced Series 50 and Series 200 mono tape recorders making them suitable for such applications as teaching, public address systems and various commercial and industrial duties. Designated R5 and R25 respectively, the R5 is basically a two-track three-speed machine with 18cm reel capacity and two 18 × 10cm loudspeakers. Sockets are provided for the connection of external loudspeakers. Silicon transistor circuitry and rugged mechanical construction are featured. Vertical operation is possible where space is limited. Although normally housed in a wooden cabinet, uncased versions are available if required. Model R25 (left in the photograph) is available in two and four-track versions with greater flexibility and performance than the R5. Additional features of this machine include tape/source monitoring, track-to-track recording, cardioid-type microphone, hub locks and splicing flap for editing. Output is 10W driving a 20 × 13cm loudspeaker. Inputs are provided for microphone (1mV at 50kΩ) and radio/p.u. (50mV at 200kΩ). Outputs provide for the connection of an external loudspeaker and an external amplifier (0-1V variable). Equalization for both machines is to the new C.C.I.R. standard. Prices: R5, 59gn plus tax; R25, 97gn plus tax. Truvox Ltd., Hythe, Southampton, Hants.

WW324 for further details

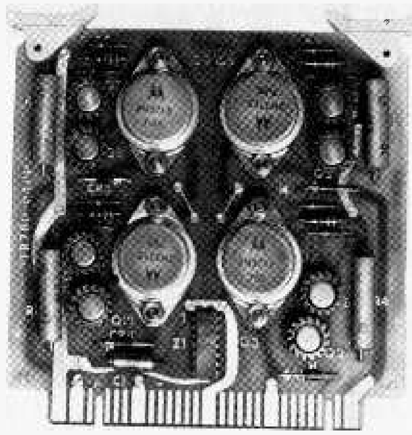
Hybrid Op Amps

Bell & Howell have entered the microcircuit field with two high performance operational amplifiers in hybrid thick-film form. Designed to provide optimum balance between cost, performance and size, the new amplifiers are now available. Type 20-007 is a versatile, general purpose unit featuring internal phase compensation, trimmed offsets, 5-mA output and complete input and output protection. Low offsets (less than 1mV and 150nA at 25°C) combined with high common-mode rejection (typically 100dB at d.c.) make the 007 particularly useful for wideband non-inverting differential applications. Type 20-008 f.e.t. input amplifier features 10^{11}ohm input impedance, 25pA maximum leakage current (a 10pA maximum version is also available), large gain bandwidth, and a 5-mA output. Voltage offset is guaranteed to be less than 1mV. Other features include internal frequency compensation and internal short-circuit protection. The 008 is especially suitable for high accuracy, long time constant circuits such as process controllers, memories and analogue integrators. It is also useful in circuits with large source impedance. Bell & Howell's new operational amplifiers are epoxy encapsulated units measuring less than 2×2×1cm with planar positioned gold-plated leads to match standard pin patterns. Bell & Howell Ltd., Lennox Road, Basingstoke, Hampshire.

WW328 for further details

High Current Driver

Latest addition to the family of Cambion i.c. logic assemblies is a new high-current driver module, part number 780-6404. This assembly has four high-current drivers on one card and



each driver circuit can withstand up to 5A and 40V. This new logic card is suitable for driving components such as stepping motors, solenoids, or comparable applications requiring high current and fairly high voltages. Its size is 11.5×11.5cm and input/output connections are via a standard Cambion 70-pin connector. Cambion Electronic Products Ltd., Cambion Works, Castleton, near Sheffield.

WW329 for further details

Miniature Connector

A recent addition to the Lemo range of miniature coaxial connectors by Nutec Electronics is the C series, with a self-locking latch that provides vibration-free and pull-proof coupling. Coaxial or multi-pin types are available. The connectors are 15mm in diameter, with lengths according to type, and the coaxial models are designed for impedances of 50 or 75Ω. The ten-pin type illustrated takes an 0.84cm (0.33in) cable con-

taining ten wires and is the connector specified by Rank Communications for their two-way pocket phone designed for police and fire services. In this version a moulded neoprene cable entry is used but a screwed cable clamp is available as an alternative if required. Lemo connectors are subjected to pin-to-pin insulation tests of 1.2kV and pin-to-earth of 1.4kV. Each pin and socket will carry a working current of 2A. Nutec Electronics Ltd., Ellen Street, Portslade, Brighton, Sussex.

WW326 for further details

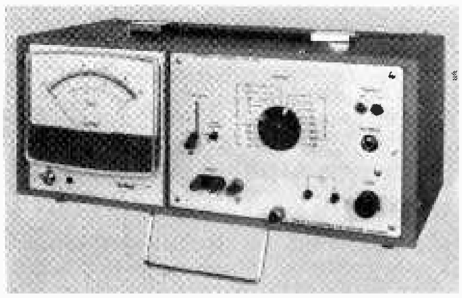
Miniature Motors

Impectron Limited, the sole U.K. agents for Papst Motors of West Germany are marketing a new range of d.c. miniature motors, suitable for a number of applications. The motors are equipped with a 7-part armature which keeps high-frequency interference to a minimum, thus making it unnecessary in many applications to provide special filtering facilities. They are suitable for use in portable tape recorders, miniature dictating machines, record players, chart recorders, and office machines etc. Six motors fall into the miniature category with rated torques ranging from 5 gm/cm to 75 gm/cm. Model GA 25.06 has a voltage range of 6-10V and a rated

orque of 20 gm/cm. Electronic commutation is ɔy means of Hall generators and transistor :ircuitry. The speed is electronically regulated by ı zener diode. The design of this particular motor :nables overall height of tape recorder machine ıssembly to be kept to a minimum with capstan lrive parallel to motor axis. Rated speed is 3000 ·.p.m. with extremely accurate regulation. mpectron Limited, 23-31, King St., London, W.3.
WW322 for further details

Highly Sensitive Microvoltmeter

Designed and made in the U.K., Model 723 nicrovoltmeter, from Dymar Electronics Ltd, will measure 1μV on a scale having an f.s.d. of 10μV, and to 1pA on a scale of 10pA f.s.d. Seventeen ranges are available for each electrical unit being measured. As a voltmeter the full-scale readings range from 10μV to 1kV, and the input ımpedance ranges from 1 to 100MΩ. As a d.c.



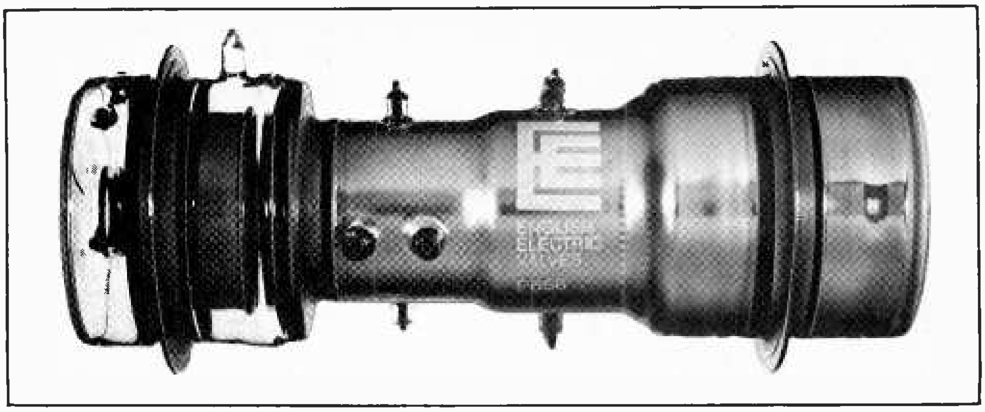
ammeter the full-scale readings measure from 10pA to 1mA. The input impedance decreases from 1MΩ to 1Ω in travelling the whole range, giving a voltage drop between 10μV and 3mV. Full-scale range as an ohmeter is from 10Ω to 300kΩ. After calibration, accuracy is better than $\pm$3% for all parameters. The input is fully floating up to 250V, and there is automatic polarity indication by red and blue lamps. Output to a recorder is 100μA into 3.16kΩ at f.s.d. The new instrument is actually a plug-in plus the standard Dymar Meter Unit, which has a built-in meter and power supply. Dimensions of the complete instrument are 42 × 16.5 × 21.5cm, and the weight approximately 9kg. The microvoltmeter plug-in costs £115, and the cabinet, with meter and power supply, £55. Dymar Electronics Ltd., Colonial Way, Radlett Road, Watford, Herts.
WW315 for further details

Compact Diode

For applications where extreme miniaturization of equipment is required, SGS-Fairchild has introduced a new ultra compact diode which is less than one sixth the size of the standard DO-7 package. Known as the BAW20 nano-glass diode, it is generally intended for applications where special requirements prevent the use of the DO-7 or FDH package. The BAW20 has a minimum power dissipation of 350mW at 25°C. Breakdown voltage is more than 75V; reverse current at V_R=50V is less than 100nA. Forward voltage drop is less than 1V at 200mA. Turn-on time is less than 4ns over the range 100 to 200mA. Main applications for the BAW20 are in core drivers, avalanche circuitry and logarithmic amplifiers. SGS-Fairchild Ltd., Planar House, Walton Street, Aylesbury, Bucks.
WW330 for further details

Multiple Frame Image Converter Tube

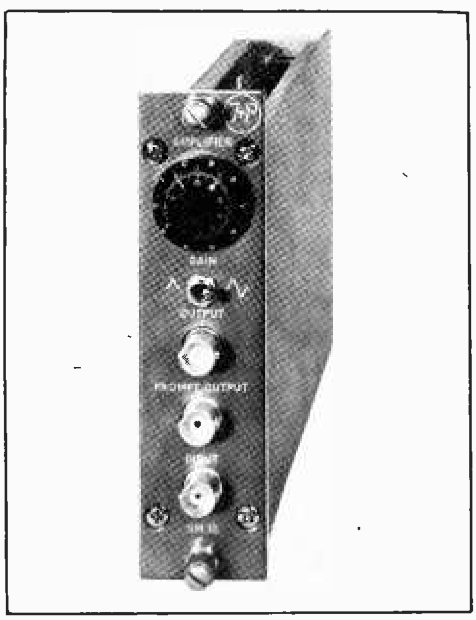
An electrostatically focused triode image converter tube, with electrostatic deflectors for both



pulse and sweep operation, has been added to their range of light conversion devices by English Electric Valve Co., Ltd. This tube, type P856, when installed in a suitable camera, can present on its fluorescent screen a sequence of frames showing the development of a high speed event. The shutter action is achieved by deflection of the electron beam over a slit in an aperture plate in the tube, and shuttering speeds of 20,000,000 per second can be obtained. The flat circular faceplate of the fluorescent screen provides a useful screen area of 7.5 × 4cm. English Electric Valve Co. Ltd., Chelmsford, Essex.
WW307 for further details

Pulse Amplifier

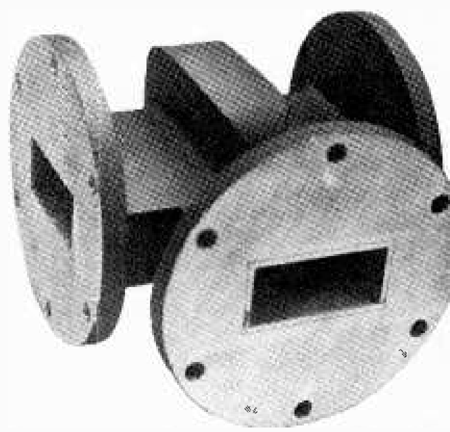
J. & P. Engineering have announced a pulse amplifier to add to their range of instruments in the nuclear instrument modular (N.I.M.) system. The NM111 amplifier is designed for use with scintillation counters, and does not require a head amplifier even with long lengths of cable. This is achieved with a charge-sensitive input amplifier which concentrates all the current from the photo-multiplier into the amplifier and so prevents charge from building up in the cable capacitance. The input amplifier has a rise time of 10 nanoseconds and this is available as a "prompt output" for timing measurements. The main amplifier contains active filter differentiation followed by double integration to provide the optimum pulse shaping for pulse height analysis. Double differentiation, obviating base line shift up to 100kHz mean pulse rate, giving a bi-polar output pulse, can be selected by a front panel switch. The overall gain is controlled by a ten-turn potentiometer. A typical gain stability of 0.05% per °C is expected in production. The



price is expected to be less than £150. J. & P. Engineering (Reading) Ltd., Portman House, Cardiff Road, Reading, Berkshire.
WW301 for further details

Waveguide Isolators

Waveguide ferrite isolators optimized for maximum performance over the commonly used frequency bands especially those used for communication are offered by M.E.S.L. Typical performance is 20dB isolation, 0.2dB insertion loss. Frequencies covered are: 3700-4200MHz, 5952-6425MHz, 6430-6940MHz, 6600-7110MHz, 7125-7425MHz, 7420-7725MHz, 7300-7800MHz and 10700-



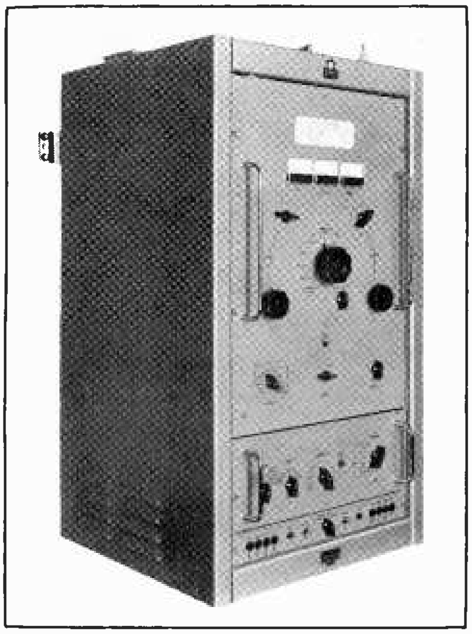
11700MHz. Microwave and Electronic Systems Ltd., Lochend Industrial Estate, Newbridge, Midlothian, Scotland.
WW321 for further details

Metric Drill Sizes

Production Tool Alloy Company Ltd., a member of the Derbyshire Stone Group, announce that all the Ferpro series of circuit board drills are now available in millimetre sizes. Stocks of the popular sizes and types can be obtained "off the shelf". The Derbyshire Stone Group, 18 Marlborough Street, P.O. Box No 2DG, London W.1.
WW 302 for further details.

400W Marine Transmitter

For shipowners whose requirements are for a medium-power, single-sideband transmitter, Marconi International Marine Co. has introduced a new transmitter into its range of ships' equipment, called "Commander". It is designed for use as the main transmitter for both single-sideband and general purpose operation in deep sea vessels and it has a peak output power of 400W on h.f. telegraphy and single-sideband telephony. Complete coverage is given of all bands allotted to the marine mobile service between 400kHz and 26 MHz on telegraphy and telephony (double-sideband, single-sideband or compatible single-side-



band) as appropriate. Transistors are used in all stages up to the power amplifier and all units, including the power unit, are contained, in a single bench-mounted cabinet 63cm wide by 115cm high by 61cm deep. Frequency control is by a system of frequency synthesis based on a single temperature-controlled master oscillator operating at 5MHz. Individual "channel" crystals are used to provide the remaining small fractions of the radiated frequency on the various spot frequencies. These may be plugged-in without the need for frequency trimming. All essential drive frequencies, channelling information and power supplies are provided for the associated "Pennant" single-sideband receiver, enabling the receiver to select automatically the correct receive frequency. Provision is also made for connecting to local and remote speaking units and to telephone terminal equipment. Marconi International Marine Co. Ltd., Ellettra House, Westway, Chelmsford, Essex.

WW 316 for further details

Null Detector

A null detector designed for use with all types of bridges and potentiometers, and to replace the more conventional type of moving-coil galvanometer, has been developed by the Croydon Precision Instrument Co. (Cropico). Outstanding features of the instrument claimed by the manufacturers are ease of operation, high sensitivity and robustness. Common-mode rejection is 126dB at line frequency or d.c.; series-mode rejection is 55dB. Stabilized internal power supplies are employed and tappings are provided for supply voltages of 100-240V a.c. 50Hz. Sensitivity is 50mm meter deflection per μV with zero source resistance on the linear range (3mm on the log range), to 17mm per μV with 10kΩ source resistance

(2mm on the log range). On the log range, f.s.d. of the output meter represents 1mV input at zero source resistance. Overload capacity is 100V d.c. The Cropico null detector measures 33 × 23 × 13 cm and incorporates a 10 cm centre zero meter. Its price is £172. Croydon Precision Instrument Co., Hampton Road, Croydon, Surrey, CR9 2RU.

WW 306 for further details

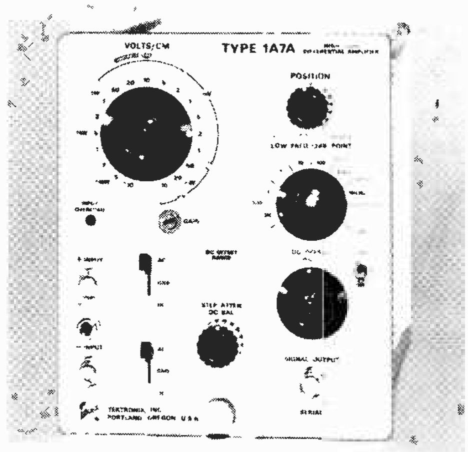
New Loudspeaker Range

Mordaunt-Short Ltd., a new company with Norman Mordaunt as technical director, is making available a range of seven loudspeaker systems all built on the infinite-baffle principle. The smallest model, the MS100, retailing at 33gn, has a 25W power-handling capacity and a frequency range of 45Hz-15kHz. The MS500, MS600, and MS700 are floor-standing speakers each having 30W power-handling capacity, the latter two also having an acoustic lens to disperse the upper frequencies over a wider angle and improve the stereophonic image. The MS300 is described as a bookshelf/floor standing system, and may be used in conjunction with the MS400, a floor-standing speaker, to make a matched stereo pair when space is limited. Each speaker has an impedance between 8Ω and 16Ω, and the cabinets are finished in teak or walnut veneers. Mordaunt-Short Ltd., 12 Hollywood Road, London S.W.10.

WW 303 for further details

Tektronix High Gain Unit

Performance capabilities of Tektronix 530, 540, 550 and (with adaptor) 580 series oscilloscopes are extended by the introduction of type 1A7A differential plug-in amplifier. This is a d.c.-coupled

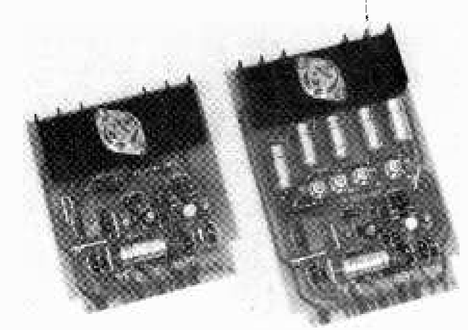


10μV/cm unit designed for stability and ease of control in low-level measurement applications. Solid state circuitry is employed with f.e.t. input stages and bandwidth is d.c. to 1MHz. Trace drift is specified at 10μV/hr d.c.-coupled, with constant line voltage and temperature. Displayed noise is 16μV or less, tangentially measured at full bandwidth; lower noise levels at reduced bandwidth can be obtained by selecting the upper and lower 3dB points via a control provided. Common mode rejection ratio is 100,000:1 from 10μV/cm to 10mV/cm with a dynamic range of 400mV. An internal d.c. offset feature is usable over the full dynamic range. Tektronix U.K. Ltd., Beaverton House, Station Approach, Harpenden, Herts.

WW 305 for further details

Regulator Cards

Additional regulator cards type DNR/DPR (d.c. input) and ANR/APR (a.c. input, and the longer unit shown in the photograph) have been introduced by Coutant Electronics in their Celstab range. They come in three voltage ranges; 4.5–6.5,



9.5–15.5 and 17.5–24.5 with current ratings of 1A at the lowest voltage of each range to 1.5A at the highest voltage. The current ranges can be extended by the addition of new DNA/DPA power amplifier cards up to a maximum of 20A. All the units fit standard 22-way 4mm pitch connectors, and pin connections are arranged for convenient parallel wiring. Stabilization ratio is 3000:1, output resistance 4mΩ and ripple less than 1mV peak to peak for 3V p-p input ripple. Protection against overload and short-circuit conditions is provided. Coutant Electronics Ltd., 3 Trafford Road, Reading, Berkshire.

WW 331 for further details

Miniature Operational Amplifiers

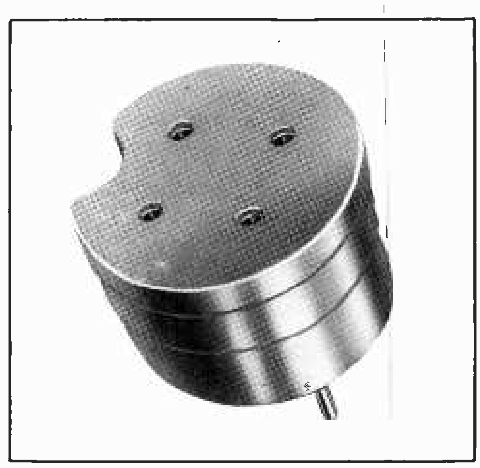
Basing their design on the basic requirements of a large number of op amp users where certain specifications could be relaxed for the sake of cost reduction, Burr-Brown of Arizona, U.S.A. have produced a small chopper-stabilized operational amplifier, model 3113/15. This unit, which is priced at $95 is claimed to be suitable for use in about 70% of all chopper-stabilized applications. It features maximum drifts of $\pm 1\mu$V per deg C and ± 2 pA per deg C, input noise of 4μV r.m.s. (d.c. to 1kHz), a minimum open-loop d.c. gain of 130 dB and a minimum rated output of ± 10 mA. Unity gain-bandwidth is 1 MHz minimum, and minimum full-power response is 20 kHz. An f.e.t. chopper with internal drive is employed. The unit itself has a volume of 21.4 cm^3 and a weight of 60 gm. U.K. Agents: General Test Instruments Ltd., Gloucester Trading Estate, Hucclecote, Gloucester.

WW 309 for further details

I.C. Socket

Jermyn Industries introduce a 4-lead integrated circuit socket, type A1189, for TO-5 cans. The body of the socket is made of p.t.f.e., and is a simple push fit into a countersunk hole, diameter 0.915cm. The four solder leads are made of gold plated beryllium copper. Jermyn Industries, Vestry Estate, Sevenoaks, Kent.

WW 304 for further details



World of Amateur Radio

OSCAR News

The Australian OSCAR (Orbiting Satellite Carrying Amateur Radio) is now ready, having passed all its tests but is not expected to be launched until December 1968 at the earliest. The European OSCAR has been returned to the German constructor for alterations.

Space Conference Coming

The administrative council of the International Telecommunication Union has announced the intention of holding a World Administrative Conference in the latter part of 1970, to deal specifically with space radio communication problems and allocations. The exact dates, location and duration will be decided at the 1969 council session as will be a detailed agenda. Frequencies between 200 and 20,000 MHz are expected to receive the greatest scrutiny. The last space conference was held in Geneva during the autumn of 1963. It is anticipated that the International Amateur Radio Union will be represented at the conference in view of the fact that there are at present a number of allocations to the amateur service between 200 and 20,000 MHz.

Solar Eclipse

The University of Virginia is conducting a survey of radio propagation conditions during and after the partial eclipse of the sun on September 22. Reports on signals received during the eclipse are urgently required by the University who request they be sent direct or via R.S.G.B. Headquarters, 28 Little Russell Street, London, W.C.1.

Amateur Licences

The total number of amateur transmitting licences in force at the end of June 1968 was 16,592, made up of: Sound A 12,837; Sound B 985; Sound Mobile A 2,503; Sound Mobile B 83; Television 184.

At the same date 14,126 model control licences were current. These figures compare with 12,283, 575, 2,284, 14,182 and 11,398 respectively, at the end of June 1967.

Radio Amateurs' Examination

The Radio Society of Great Britain will once again provide a centre (at the College of Preceptors, Bloomsbury Square, London, W.C.1) for the Radio Amateurs' Examination to be held on December 3, 1968. Applications to sit the examination must be sent to the society accompanied by an entry fee of 45/- (35/- in the case of members) but as accommodation is restricted to 90 places they will be dealt with on a "first come, first served" basis with October 31, 1968, as the closing date.

St. Pierre and Miquelon Restrictions Lifted

Some time ago the authorities responsible for the administration of amateur radio licence matters in this French colony intimated that licences would not be issued to foreigners, but this decision has recently been altered because call signs in the series FP0 are being issued to visitors—the first such call reported being FP0EB.

R.A.E.N. Activity

The Radio Amateur Emergency Network which sprang to life following the disastrous east coast floods of 1953 continues to attract members from all parts of the country, many of whom have constructed special equipment for use in an emergency. At the recent amateur radio exhibition in London the Manchester Group of the R.A.E.N. were well represented in a display of sophisticated equipment. The hon. secretary of the network is E. R. L. Bassett, 57 Upper St. Helen's Road, Hedge End, Southampton, SO34LG, who will be pleased to hear from anyone interested be he or she a licensed amateur or a short-wave listener.

DX Challenge

A new challenge for DX-minded radio amateurs comes into being, officially, on January 1, 1969, with the inauguration of the A.R.R.L. Five-Band DX Century Club award. Only contacts made after that date will count towards this new DX achievement. Contacts with at least 100 countries must be confirmed on each of five separate bands to qualify for this, the world's most difficult award.

It Can Still Be Done

Writing in his "Four Metre and Down" column in a recent issue of *Radio Communication*, the author Jack Hum (G5UM), reports that during the sixth open v.h.f. contest the G8APZ/G8APO/G8AZU team manning G8APZ/P (held by Brian Coleman) at Alton, Hampshire, used an 800 milliwatts transmitter throughout the contest to work 82 stations in 24 countries on 2 metres and to reach-out as far as Barrow-in-Furness, 230 miles distant. The transmitter when used by Mr. Coleman at his home address in Sunbury-on-Thames has brought him contacts with 100 different stations since G8 three-letter licence holders were first allowed to operate on 2 metres; a fine achievement for an input power of one watt. A similar rig for 70 cm enabled him to work 56 stations using no more than half-a-watt input power.

First U.K. Fox Hunt

Fox hunting, the name by which amateur radio direction finding contests are known on the Continent, made its debut in England recently when G3VJF/M, G3PKT/M, G8AJC/M and G3TDP/M, from Ashford, Kent, equipped themselves with 2-metre receivers and an assortment of aerials, ranging from dipoles to 4-element beams, and set forth from the Motorway Café on the M2 to track down the "fox" (G3EMU/M) located at Harty Ferry, 3 miles north of Faversham, 13 miles distant. The competition was won by G8AJC/M who located the "fox" in a time of about 95 minutes. Further "fox hunts", possibly on foot, are planned for later.

Cheshire Homes

There are between 40 and 50 Cheshire Homes in the United Kingdom. At three of the Homes an amateur radio transmitting station is installed, mainly as the result of help and interest shown by clubs and amateurs in the locality. Group Captain Cheshire has often expressed the hope that an amateur radio station will operate from each Home. Club secretaries and others interested in helping this good cause can obtain local addresses and telephone numbers by writing to The Cheshire Homes for the Sick, 7 Market Mews, London W.1.

New 13 cm U.K. Distance Record

On July 21, the British distance record on 13 cm was raised to 52 miles when L. W. Sharrock (G3BNL), operating from Cleeve Hill, near Cheltenham, contacted A. Wakeman (G3EEZ), operating from a site seven miles north-west of Wolverhampton. Signal reports were R5 S9 in both directions.

Generous Donation

The Amateur Radio Mobile Society anticipates donating about £250 to the League of Friends of Normansfield as the result of the international mobile meeting held at R.A.F. Mildenhall, on June 30, where there was an estimated attendance of 8,000. The charity was suggested by A.R.M.S. member, Brian Rix (G2DQU), the well-known actor-manager.

Iceland on 4 Metres

Station TF3EA of Reykjavik, Iceland, has recently received permission to operate in the 70 MHz amateur band. Transmissions are restricted to the spot frequency of 70.250 MHz using a maximum d.c. input power of 25 watts, but with sporadic-E conditions expected to occur at this time of the year contacts between the United Kingdom and Iceland are likely on frequent occasions.

JOHN CLARRICOATS G6CL

November Meetings

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

LONDON

4th. I.E.E.—Colloquium on "Direct broadcasting from satellites" at 09.30 at Savoy Pl., W.C.2.

5th. I.E.E.—"Corona and precipitation interference in v.h.f. television reception" by H. Page and D. J. Whythe at 17.30 at Savoy Pl., W.C.2.

5th. I.Mech.E.—Discussion on "Computer aids in design" at 18.00 at 1 Birdcage Walk, S.W.1.

7th. Inst. Electronics.—"M.O.S.Ts in integrated circuits" by K. V. Clark at 18.45 at the London School of Hygiene & Tropical Medicine, Keppel St., W.C.1.

7th. R.T.S.—"The technology of education versus educational technology" by C. Gane at 19.00 at the I.T.A., 70 Brompton Rd, S.W.3.

8th. I.E.E.—Colloquium "Constructional techniques used in microelectronics" at 10.30 at Savoy Pl., W.C.2.

11th. I.E.E.—"Parametric amplifiers" by J. Gittins and J. C. Voakes at 17.30 at Savoy Pl., W.C.2.

11th. I.E.E. & I.E.R.E. Grads.—"Integrated circuit design" by R. C. Foss at 18.30 at Savoy Pl., W.C.2.

12th. Radar & Electronics Assoc.—"The practical possibilities of optical communication systems" by F. F. Roberts at 19.00 at 21 Bloomsbury St., W.C.1.

13th. I.E.R.E.—"Electronics in the Nation's economy" by Ieuan Maddock at 18.00 at the London School of Hygiene and Tropical Medicine, Keppel St., W.C.1.

14th. I.E.E.—Discussion "Experience and problems with high-resolution radar" at 17.30 at Savoy Pl., W.C.2.

14th. R.T.S.—Discussion "The first year of colour television" at 19.00 at the I.T.A., 70 Brompton Rd, S.W.3.

15th. I.E.E.—Colloquium on "Advances in broadband amplifiers" at 09.30 at Savoy Pl., W.C.2.

18th. I.E.E. & I.E.R.E.—Discussion on "Integrated circuit value analysis" at 17.30 at Savoy Pl., W.C.2.

19th. I.E.E. & I.E.R.E. Grads.—"Pulse code modulation" by G. H. Bennett at 18.30 at Willesden College of Technology, Denzil Rd, N.W.10.

21st. I.E.E. & I.E.R.E. Grads.—"New developments in microelectronics" by C. P. Sandbank at 18.30 at Kingston College of Technology, Penrhyn Rd, Kingston.

22nd. I.E.E. & I.E.R.E.—"Method of measuring noise in transistor circuits" by P. J. Baxandall at 17.30 at Savoy Pl., W.C.2.

26th. I.E.R.E.—"Frequency modulation transducers" by J. Agar at 18.00 at 9 Bedford Sq., W.C.1.

27th. I.E.R.E.—"World telephone communication" by S. Welch at 18.00 at 9 Bedford Sq., W.C.1.

27th. B.K.S.T.S.—"The usable sensitivity of a radio receiver" by J. Moir at 19.30 at the Royal Overseas League, Park Pl., St. James's St., S.W.1.

29th. I.E.E.—Colloquium "Computer methods in network design and synthesis" at 09.30 at Savoy Pl., W.C.2.

29th. R.T.S.—Symposium "Television news techniques" at 17.00 at the I.T.A., 70 Brompton Rd, S.W.3.

ABERDEEN

13th. I.E.E.—"Training the electrical engineer" by Prof. E. Williams at 19.30 at Robert Gordon's Inst.

BANGOR

28th. I.E.E. Grads.—"Computer-aided circuit design by E. Wolfendale at 19.00 at the University.

BARROW-IN-FURNESS

20th. I.E.E. Grads.—"Automation and electronics in ships" by D. S. Townend at 19.30 at the Hotel Imperial.

BATH

14th. S.E.R.T.—"Microelectronics" by J. D. Martin at 19.45 at the Technical College.

BELFAST

12th. I.E.R.E. & I.E.E.—"Stereophonic transmission" by Dr. G. J. Phillips at 18.30 at the Ashby Inst., Queen's University, Stranmillis Rd.

BIRMINGHAM

4th. I.E.E.—"The management of men and money in an electronics company" by Dr. F. E. Jones at 18.30 at M.E.B. Offices, Summer Lane.

12th. R.T.S.—"E.M.I. 2001 colour television camera" by I. J. P. James at 19.00 at the B.B.C's Gosta Green Studio.

13th. Brit.Acoust.Soc.—"Sonar and underwater communication systems" symposium at 12.00 at the University.

14th. I.E.R.E.—"The strange journey from retina to brain" by Dr. R. W. G. Hunt at 19.15 at the Department of Electronic & Electrical Engineering at the University.

25th. I.E.E.—Discussion on "The optimum size of an electronics research and development organisation" at 18.00 at the M.E.B. Offices, Summer Lane.

BRIGHTON

19th. I.E.R.E.—"Random signal studies using a hybrid computer" by Dr. N. Meadows at 19.00 at the College of Technology.

BRISTOL

4th. I.E.R.E. & I.E.E.—"Use of pseudo-random sequences in control" by Prof. J. L. Douce at 18.00 at the University.

28th. I.E.E.—Faraday Lecture "Microelectronics" by P. E. Trier at 18.30 at Colston Hall.

CAMBRIDGE

14th. I.E.R.E. & I.E.E.—"Thick film technology" by R. F. Russell at 20.00 at the University Eng'g Laboratories, Trumpington St.

19th. I.E.E.—"Concorde electronics" by H. Hill at 19.30 at the College of Art and Technology.

28th. I.E.E.—"Vacuum deposition, techniques for electronics" by L. Holland at 20.00 at the University Eng'g Laboratories, Trumpington St.

CARDIFF

13th. I.E.R.E.—"Industrial applications of direct digital control" by L. I. Lowe at 18.30 at the University of Wales Inst. of Science & Technology.

COVENTRY

7th. I.E.E.—"Stereophonic broadcasting" by Dr. G. J. Phillips at 18.30 at Lanchester College of Technology.

18th. I.E.R.E.—"Aspects of the research activities of the control group at the University of Warwick" at 19.15 at the Lanchester College of Technology.

CRAWLEY

20th. I.E.E.—"The postal service and the electronics engineer" by J. Piggott and P. Pilling at 18.30 at the College of Technology.

DUBLIN

7th. I.E.E.—"Field effect transistors" by Prof. W. D. Ryan at 18.00 Trinity College.

DUNDEE

14th. I.E.E.—"Training the electrical engineer" by Prof. E. Williams at 19.00 at the University.

EDINBURGH

12th. I.E.R.E. & I.E.E.—"Electronic research on British Rail" by Dr. L. L. Alston at 18.00 at Napier College of Science and Technology, Colinton Rd.

FARNBOROUGH

14th. I.E.R.E.—"Circuit integration in colour television receivers" by B. J. Rogers at 19.00 at the Technical College.

26th. I.E.E.—"Digital filters" by A. R. Owens at 18.30 at the Technical College.

GLASGOW

11th. I.E.R.E. & I.E.E.—"Electronic research on British Rail" by Dr. L. L. Alston at 18.00 at the University of Strathclyde.

HORNCHURCH

27th. I.E.E. & I.E.R.E.—"Applications of microelectronics" by Dr. S. S. Forte at 18.30 at Havering Technical College, 42 Ardleigh Green Rd.

HUDDERSFIELD

21st. I.E.R.E.—"Colour television receiver circuit techniques" by B. A. Horlock at 19.00 at the Dept. of Electrical & Electronic Eng'g at the College of Technology.

LIVERPOOL

13th. I.E.R.E.—"Quantified reliability engineering" by A. E. Green at 19.00 at the Dept. of Electrical Eng'g and Electronics, the University.

18th. I.E.E.—"Aspects of semiconductor physics" by D. W. F. James at 18.30 at the University.

MALVERN

19th. I.E.R.E.—"Microwave communications" by E. M. Hickin at 19.30 at the Abbey Hotel.

MANCHESTER

5th. I.E.E.—"Why should engineers be good managers?" by B. Walls at 18.15 at the University's Inst. of Science & Technology.

6th. I.E.R.E. & I.E.E.—"Modern memory systems" by J. James at 18.15 at the University's Inst. of Science & Technology.

12th. I.E.E.—"Holography and its applications in engineering" by A. E. Ennos at 18.15 at the University's Inst. of Science & Technology.

20th. I.E.E. Grads.—"Hi-fidelity" by M. Humble at 18.45 at the Inst. of Science & Technology.

NEWCASTLE-UPON-TYNE

13th. I.E.R.E.—"Global communications" by R. W. Cannon at 18.00 at the Inst. of Mining and Mechanical Engrs., Neville Hall, Westgate Rd.

22nd. I.E.E. Grads.—"Radio controlled models" by C. Pule at 18.30 at the University.

PLYMOUTH

14th. I.E.R.E. & I.E.E.—"Digital data transmission" by M. B. Williams at 19.00 at the College of Technology.

PORTSMOUTH

20th. I.E.E.—Colloquium on "Microwave aerials" at 15.30 at the College of Technology.

27th. I.E.R.E.—"Incremental computer techniques" by D. W. Hampshire at 19.00 at Highbury Technical College, Cosham.

READING

11th. I.E.E.—"Colour television" by L. G. Dive at 19.30 at the Gt. Western Hotel.

19th. I.E.R.E.—"Electronic control of aircraft and missiles" by G. C. Howell at 19.30 at the J. J. Thomson Physical Laboratory at the University.

RUGELEY

7th. I.E.R.E.—"Future trends in power semiconductors" by G. A. K. Wilkinson at 19.00 at Thorn Automation Ltd, Armitage Rd.

SALISBURY

14th. I.E.E. & R.Ae.S.—"The automatic landing of aircraft" by S. A. W. Jolliffe at 19.00 at the Salisbury & S. Wilts College of Further Education.

SHEFFIELD

6th. I.E.E.—"Pulse-code modulation and the telecommunication network" by R. R. Teesdale at 18.30 at the University.

STONE

11th. I.E.R.E., I.E.E. & I.P.O.E.E.—"Contacts in telephony"—by L. J. Allen, T. A. Davies and J. Williams at 19.00 at the G.P.O. Training School, Yarnfield.

SWANSEA

26th. I.E.E.—Faraday Lecture "Microelectronics" by P. E. Trier at 18.30 at Brangwyn Hall.

Answers to "Test Your Knowledge"–6

Questions on page 421

1. *(a)*. Silicon and germanium form the diamond lattice structure which is covalent bonded.

2. *(c)*.

3. *(a)*. Pure semiconductors are basically insulators in which the energy gap is small enough to allow heat to liberate a significant number of carriers at room temperature, but not at as low a temperature as 2°K.

4. *(c)*. The breaking of a valence bond releases one electron and one positive hole.

5. *(a)*.

6. *(c)*. The presence of many more electrons than in the intrinsic material increases the probability of a hole encountering an electron and recombining with it. For a given material in equilibrium, whatever the degree of doping (unless it is very excessive), the product of the number of holes and the number of conduction electrons is a constant.

7. *(b)*. A valence bond can be broken by absorption of a quantum of radiation if the quantum energy is above a "threshold value" which is the energy gap.

8. *(b)*.

9. *(b)*. The statement in (a) is a common error. P-type material is not positively charged. Although it contains a preponderance of positive holes it also contains fixed negatively charged ionized acceptor atoms so that an isolated piece of the material is electrically neutral. Similarly n-type material contains fixed positively charged ionized donor atoms and is electrically neutral. Solution (c) also contains a common fallacy; the barrier potential in a p-n junction is not a source of e.m.f. and cannot drive a current.

10. *(c)*. The carriers move back from the junction and uncover the fixed ionized impurity atoms. This region is called the "depletion layer".

11. *(c)*. The capacitance of a reverse biased junction is associated with charge stored in the depletion layer. As this stored charge increases the depletion layer widens, resulting in a decrease of incremental capacitance with applied voltage.

12. *(b)*.

13. *(a)*. The reverse current is due to minority carriers. These are thermally generated and increase in number exponentially with temperature.

14. *(b)*. At any given temperature there are far less minority carriers in a specimen of extrinsic silicon than in a similarly doped specimen of germanium due to the larger energy gap of the silicon. Carrier mobilities are generally less in silicon than in germanium, but this would only cause a small difference in current.

15. *(d)*. Zener breakdown occurs in abrupt junctions where the material on either side is heavily doped. If zener breakdown does not occur then avalanche breakdown will. One or other of these effects (or in a few cases a combination of the two) always occurs in practice at a much lower voltage than that required to produce thermal run-away with the basic leakage current.

16. *(d)*. Most junctions between a metal and a semiconductor will in practice be ohmic. It is possible however, by careful techniques and using particular combinations of metal and semiconductor, to produce a rectifying junction.

Real and Imaginary

by "Vector"

On pulling down barns

Say what you like about the electronics industry (and most of us do, at frequent intervals) there's never a dull moment, really. This take-over epidemic, for instance. You are going about your lawful occasions feeling that the bird's on the wing, the snail's on the thorn when—whoops!—somebody you've never heard of gets a touch of the Charles Clores and you're not only working for a brand-new boss but you also find yourself in the same stable as Phialpha Ltd.

This last bit is more than a shade disconcerting because for years you and everybody else at Blackbox Electronics have known that the Phialpha crowd are an unscrupulous shower, who by assorted skulduggery (to which your company would never stoop, thank Heaven) have on divers occasions filched contracts which rightfully should have gone to Blackbox. (Inexplicably the Phialpha boys seem to feel the same way about your outfit, which only goes to show what a warped outlook they have.) But now, at the scratch of a pen you are to become closer than brothers, "sharing each other's troubles, sharing each other's joys." Said joys to include—and this is the unkindest cut of all—your new fast rise-time device (patent applied for) which was designed specifically to wipe their Mark V digital display unit right across its eye.

But, personal feelings apart, it seems that there is much to be said in favour of a take-over. It pleases the Industrial Reorganization Corporation and the Ministry of Technology because it demonstrates to Mr. Harold Wilson that they are doing their homework. It pleases Mr. Wilson because in the fullness of time two or three big electronics groups are going to be more easily nationalized than a multitude of tiddlers. The insurance companies which have put up the money are pleased because of all the lovely interest which is going to roll in. The shareholders are pleased because the value of their investments has leapt. The new chairman is pleased because up until now he has always felt, by comparison with American electronics combines, like a bicycle parked alongside a Cadillac; the deal has raised his status to that of a Mini. The Americans are pleased because with a little more manipulation of world markets and a British general election that little Mini will be swept into the boot of the Cadillac. The economists are pleased because they can now write reams of wild conjecture for the financial journals.

Everybody, in short, is pleased. Except for old Joe Tymebase. Joe has been with Blackbox Electronics since the days when it was Bildaset Ltd., the wireless constructor's best friend. He cut his teeth on 0-V-2's and swinging-coil reaction (and if you don't know what they are, ask your father). A brisk lad with ideas, Joe gravitated into R and D and his patents over the years have added up to a tidy figure in terms of company profit.

But Joe was brought up on valves and didn't take kindly to transistors when they came in. Microcircuits plague him even more. So Joe still sorts out his schemes on a valve basis, leaving it to the young bloods around the lab. to re-fiddle them transistor-fashion. And now, with retirement only six years away, the ideas don't come so fast and the valve-to-solid-state transition slows matters even more. It isn't an efficient set-up and Joe in his quieter moments knows it. The old management knew it too, but remembering what he has done they gave him a not-too-onerous chairborne job, with a soldering-iron not too far out of reach whenever he feels like using one.

But to the new boss Joe is a unit of personnel; a number on a card index. The new Fuehrer drafts in his team of efficiency experts; purposeful characters with eyes which exhibit the same warmth of expression as those of a defunct cod. Their business is to clear away dead wood and to "rationalize" according to their lights, and they are very good at both. Before Joe knows what has hit him he is on the receiving end of a gold watch, a copper handshake and the company's best wishes for a future which does not include electronics.

Business-wise, the removal of the Joes of this life is no doubt a good thing. The philosophy that it pays to shoot an admiral from time to time to encourage the others can be extended to include less exalted ranks. Having first administered a salutary warning to *les autres* it gives the young blood in the firm the opportunity to move a rung or so up the ladder.

It has been argued by some that there should be no rules in the conduct of warfare. If you are going to be beastly to someone, why draw lines of demarcation? If you are going to hit them with high explosive, why prohibit nuclear or bacteriological weapons? Big business, too, is a fiercely fought war, in which rules tend to go by the board. We are coming under the command of a Stock Exchange dictatorship and ma[tters] are rapidly approaching the point whe[re] everything and everyone is expendable exce[pt] the profits.

In research, particularly, it has become [an] article of faith that electronics is a you[ng] man's game. I'm told that statistics show th[at] the research man has shot his inventive b[olt] by the time he reaches 35. So the wa[y] things are going, a career in research ma[y] soon be equated with that in profession[al] football. You may say that Joe should ha[ve] had the common sense to keep up with th[e] times and to some extent you would [be] right. But, in viewing his passing wi[th] equanimity, never send to know for who[m] the bell tolls; it tolls for thee, brother.

There is at present a general unease b[e]cause the top-grade output from the un[i]versities seems to have a marked aversion [to] going into the electronics industry. Can it [be] that the new generation is wiser than we ha[ve] supposed? That they saw the red light befo[re] we did?

In his leader in the October issue th[e] Editor trailed a pretty cloak in front of tha[t] emasculated bull, the British domestic rad[io] industry. He remarked that whereas in [its] heyday this area attracted the cream of th[e] country's radio engineers, it seems to be fa[r] from true now. "Is this cause or effect [of] the domestic industry's unsatisfactor[y] situation?" he asked.

The heyday to which he refers was awa[y] back when a considerable number of in[de]pendent receiver manufacturers existe[d]. In those days the brand name really mean[t] something, for the competitive element kep[t] the individual design teams on their toe[s]. Then the financial wizards moved in. Un[-]economic operation, they said. Amalgamat[e] for higher profitability and to increase ex[]ports they said. And so it came to pass; a[t] least, the amalgamation did.

Today, if there is higher profitabilit[y] (which is extremely doubtful) it is bein[g] made at the expense of the retailer an[d] the customer. Names mean little or nothing; the same mediocre chassis can skulk behin[d] several brand names. It is mediocre becaus[e] there is no compulsive reason for it to b[e] otherwise. The former development team[s] moved out to engineering areas where (i[t] seemed at the time) they would not b[e] bought and sold *en bloc* like cattle at [a] market. Export performance? Pathetic.

"I will pull down my barns and buil[d] greater" said the rich man in the parabl[e] —and we all know what happened to him[.] That parable lives again in the domesti[c] receiver industry; a solemn warning to th[e] capital goods side of electronics, to which th[e] blight is already spreading. Intelligent ration[]alization can do nothing but good; em[]pire-building will, in the not-so-long run[,] bring catalepsy and eventual death. B[y] which time, of course, the financiers wil[l] have hopped like fleas from the corpse.

I had hoped to chew over the fallacy tha[t] size equates with efficiency but space ha[s] run out. Another time, perhaps. But anyway[,] talk will get us nowhere. We need action[.] Isn't it time that the professional engineering societies threw their weight in to stop the Stock Exchange tail from wagging the electronics dog?

CLOSED-CIRCUIT TV SURVEY

C.C.T.V.—from Novelty to Necessity

A review of some of the equipment currently available

Not many years ago, use of closed-circuit television for observation and monitoring purposes was a technical novelty. Early valve equipment was bulky and heavy—factors which prevented its use in numerous applications. Today, however, equipment which has evolved from the use of silicon transistor techniques, particularly in the planar technology, is smaller, lighter, consumes less power and develops less heat. New techniques and new ideas have produced a wide range of complete systems, some simple, some complex. All types of applications such as education, industry, banking, mining, medicine, public safety, research and transportation are catered for, and in many C.C.T.V. is now considered a vital necessity.

This review is a two-stage interpretation of information supplied by those manufacturers, agents and distributors who responded to our invitation. In the first stage, information regarding features and characteristics is presented in overall terms of general equipment and techniques and in the second, specific details are given of individual units.

Features of a C.C.T.V. system

In its simplest form, a C.C.T.V. system comprises a television camera and viewing unit interconnected by a cable. This basic arrangement can be expanded progressively in finite steps to a complex system with many different types of facilities. There is no technical reason why equipment used for broadcast television should not be used for C.C.T.V. Such equipment, however, is designed to meet stringent G.P.O. specifications and its use is usually not justified mainly on the basis of expense alone. Most manufacturers produce a range of units specifically designed for C.C.T.V. Various combinations of these units are then employed to provide the user with a 'tailor made' system suitable for his particular requirements. An overriding advantage of this popular type of unit-by-unit system is that progressive stages of expansion can be controlled to suit a financial budget.

Cameras and tubes

Where cameras are intended primarily for continuous viewing of one scene, the external controls are usually limited to on-off and focus. Automatic light compensation is used to compensate for changes in light level, and ranges of several thousands to one are common. When this feature is combined with changes of aperture of the iris, overall ranges of hundreds of thousands to one are possible. In some cameras, visual indication of the lighting level can be incorporated in the form of an exposure meter. Automatic light compensation is of particular importance when the camera is used as a fixed, unattended monitor.

Different applications involve systems using different techniques. E.M.I. have devoted a considerable amount of effort to the design and development of miniature C.C.T.V. equipment. Apparently, this type of equipment operates in some of the most difficult environmental conditions, and is designed basically for use in areas not readily accessible to the eye. Typical operating conditions involve very high ambient temperatures, low light levels and vacua. Low light levels at the 'scene' necessitate the use of a light source combined with the camera head and usually takes the form of bulbs mounted in a ring round the lens. Furthermore, where the system is used for internal inspection of pipework—a popular application—it is necessary for illumination to be directed in one direction to avoid multiplicity of shadows when searching for surface flaws or irregularities. This shadow problem is overcome by using prefocused lamps. Cooling in the E.M.I. equipment is effected by feeding air into the camera via the specially constructed connecting cable.

When considering a C.C.T.V. camera, the camera tube is obviously a most important factor. Three types of tube are generally available. (1) In the image orthicon, the phenomena of photo emission and secondary emission is utilized to convert the optical image into a pattern of electrostatic charges. A characteristic of this type of tube is the absence of lag which makes it suitable for applications where transmission of images of rapidly moving objects is involved. (2) In the vidicon, the charge pattern is formed by photoconduction. Compared to the image orthicon the vidicon is smaller, simple to adjust, costs less and has better stability. Disadvantages of the vidicon are high dark current and slow speed of response under low lighting conditions which can cause blurring of moving objects. (3) In Philips Plumbicon tube, the principle of operation is the same as that of the vidicon, but the photoconductive layer is different. Advantages of both the vidicon and image orthicon can, to a certain extent, be considered to be combined in the Plumbicon, which is also more suitable for use in colour cameras than the image orthicon or vidicon.

Electrostatically or magnetically focused vidicon tubes are available. The electrostatic type is suitable for small lightweight cameras where only low power consumption can be afforded. Because of the electrostatic principle of focusing, the focus coil is unnecessary and the power required by the focus electrode is negligible. An additional advantage accruing from the absence of the focus coil and its associated strong magnetic field is that the deflection field strength required need be as little as one-sixth of that required for a magnetically focused tube. This type of vidicon is claimed to be particularly suitable for multi-tube colour cameras because it is free from 'S' distortion and focus induced image rotation normally associated with magnetically focused tubes.

Magnetically focused vidicons are available as either separate mesh or integral mesh types. Improved resolution—in excess of 1,000 TV lines—is obtained with the separate mesh type.

Integral mesh tubes are supplied as replacements in cameras designed specifically for this type of tube.

Optics

The resolving power of a lens (its ability to record fine detail) is not so important in television as it is in photography. This is because the structure of the scanning process by which the image is converted to an electrical signal is relatively coarse. What is important is the ability to record wide variations of light intensity (light modulation).

When choosing lenses for C.C.T.V. applications, it may happen that a lens already available is suitable in all respects except for the image size. It should be noted that it is possible to compensate electronically an unwanted image size by adjustment of the scanning circuits. Any television camera can be adjusted to scan an image slightly larger or smaller than the one for which it was designed. Such an adjustment is not acceptable for broadcast television, but for C.C.T.V. it is not usually very important whether the picture on the monitor is slightly larger or smaller than the size of the screen. Anyway, the scanning circuits of the receiver can always be adjusted to compensate for over or under scan in the camera. Admittedly, the picture quality is not so good if the camera under scans, but if the final picture quality is acceptable the degradation is obviously not important.

Combining C.C.T.V. techniques with different optical methods such as found in microscopes, intrascopes, endoscopes and fibre optics has made possible C.C.T.V. systems which can take a "big look" at scenes impossible or impractical to view by the human eye. The medical art of endoscopy (examining the inside of the human body) has been established for some time, but not until of late, after the establishment of fibre optic techniques, has C.C.T.V. really become practical in this respect. A fibre optic light guide used in an endoscope is approximately one metre in length and can contain nearly 200,000 glass fibres which "guide" the light from one end of the guide to the other A television camera at the end of the guide enables the scene at the "other end" to be viewed simultaneously by several doctors or even a lecture hall full of students.

Another use of fibre optics is as a direct coupling between certain types of light sources and the camera tube. Vidicon tubes are available with a fibre-glass faceplate, and the metho is particularly suitable for applications where the vidicon view a device having a phosphor screen output. A considerable im provement is obtained by fitting fibre optic faceplates on eac device so that both devices are coupled in direct optic contact. The fibre optic coupling is more compact than a len system and unaffected by atmospheric pollution.

This portable television unit from the Marconi Co. enables television training programmes to be recorded on the spot anywhere in a factory or educational establishment by using equipment mounted in two-wheeled units each no bigger than a tea trolley. In its basic form the system would typically include two portable consoles one containing the sound and vision control equipment (right) the other carrying the preview monitors and video tape recorder two cameras and 23" display monitor (left).

Viewing units

A standard domestic television receiver can be used as a vide monitor, and in fact some manufacturers appear to conve standard television receivers and market them as video monito at a nominally increased price. Where finance is the fir consideration this conversion method is a definite advantag but where better resolution and high reliability are of fir importance, a unit designed specifically for video monitoring the first consideration. Domestic receivers are not designed fo round-the-clock use and overheating can be a problem.

Two forms of signal are popularly used—video an modulated r.f. A domestic-receiver monitor would be used with modulated r.f. signal. How far the signal can be routed withou amplification and still remain usable depends on such factors a the distribution system, the line and the form of signal. As rough guide, a modulated r.f. signal can be used over almo twice the distance as that of a video signal.

Colour

In the majority of applications, monochrome pictures suffic but in many instances colour provides not only more accurat but also essential information. Colour is particularly importan where C.C.T.V. is used for medical purposes. Disease of certai tissues can be recognized only by colour. The extent to whic colour techniques have advanced was illustrated approximatel a year ago when a Siemens camera was used in Wester Germany to transmit colour pictures direct from the huma stomach and esophagus. Colour C.C.T.V. is also finding man important applications in metallography, mineralogy and pet rography. The techniques involve micrographic studies by mean of a television microscope.

One practical aspect of a colour television camera tha should not be overlooked is the light intensity requiremen which is several times higher than that for a monochrom camera. This is because the light entering the lens of the colou camera is decomposed into the three primary colours an passed to three pick-up tubes via three dichroic mirrors an intermediate lenses. Greater light loss occurs because of th more complicated lens system.

Remote control

For control functions over short distances, control units an multicore cables are normally used. The video signal, o course, requires coaxial cables but if used in conjunctior with line equalizer units a balanced telephone pair can be used

In the Pye Telephone Dial remote camera control system al control functions are effected over a telephone pair with signa earth return; consequently, a big saving as regards cables is effected. Basically, the system utilizes a sequential contro method. All that is necessary is the dialling of the chosen function—pan, tilt, focus, on-off, etc.—on an appropriately marked dial and the operation of a "joystick" control.

When remote control is used, a monitor screen for camera view finding and control is essential; but some applications allow the use of optical view finding. In the Rank Taylor Hobson Telemetric View Finder, the path of light to the viewing

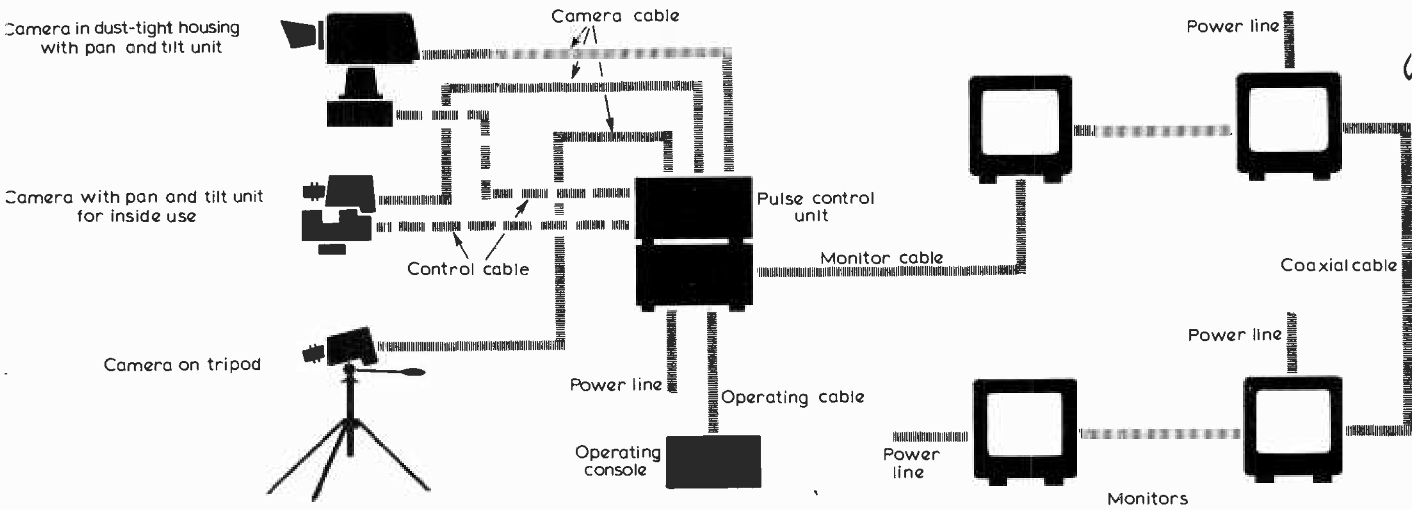


Fig. 1. Example of a Siemens' large closed-circuit television system with three cameras.

eyepiece does not pass through the iris. As a result, viewing is not affected when the iris is stopped down or closed. Two tiny reflecting mirrors (not much bigger than pin heads) are used, and because of their size they do not obstruct the light to the camera as much as full area semi-reflecting mirrors. Because of their position in the optical system, the mirrors are static and hence the flicker associated with a moving mirror is absent. The principle by which focus is indicated is very simple. Under conditions of correct focus the light rays are parallel in the part of the lens system where the mirrors are positioned. Consequently, the two mirrors produce coincident images at the eyepiece. Conversely, an out-of-focus condition produces a double image at the eyepiece.

Complete systems

In its simplest form, the basic E.M.I. Type 9 system includes one of three types of cameras: BC900 (used for general industrial purposes); BC910 (used for small studio types of applications such as education and sales promotion); BC930 (measures only 4.3 cm in diameter and is specially designed for inspection of pipes and other locations which would otherwise be inaccessible). The camera is fed from a camera control unit (Type CC900) which contains video circuits and provides synchronizing pulses for the system. Control of the system is effected from a camera control panel (Type RA908) on which are mounted a mains supply on-off switch and controls for adjustment of target, beam focus and beam current. The basic system operated with random interlace, but addition of a synchronizing pulse generator (Type SG900) provides drive pulses for 2:1 interlace scanning on 625-, 525- or 405-line systems. For this mode of operation an internal adaption needs to be effected in the camera control unit.

More than 20 additional ancillary units and accessories are available so that the basic concept of this system can be expanded to suit a more extensive range of applications.

An example of a larger system using Siemens equipment is shown in Fig. 1. Three cameras are used, one is hand operated, and two are remotely controlled. One of the remotely controlled cameras is mounted in a protective weatherproof and dust-tight housing suitable for open air environments and can be fitted with automatic iris control and lens drive. The housing can be installed on a tilt bracket or on a pan and tilt unit, and fitted with sun visor or screen wiper. Pan and tilt angles are 325° horizontal and $\pm 35°$ vertical. The other remotely controlled camera is mounted on a pan and tilt unit of low noise design (not more than 30 phons at a distance of 1 metre) and is intended for indoor use. Controlled angles are 340° horizontal and $\pm 45°$ vertical. From a system point of view the important units are the pulse control unit and the operating console.

The essential functions which the pulse control unit has to perform within the system are: generating, shaping and mixing of the control pulses; amplification of the video signal fed from the camera; mixing of the amplified video signal with the pulses required for brightness modulation and synchronization of the monitors; stabilization of the electric focus and operating voltage supplies for the cameras. In addition, the sensitivity of the pick-up tubes has to be adapted to the actual ambient illumination and this is effected by a built-in automatic light-figure selector which has a control range of approximately 3000:1. When used in conjunction with automatic iris control, compensation of variable light intensities in a ratio of up to 500,000:1 is possible depending on the range of the iris.

Services

It is interesting to note the appearance of another apparent trend in C.C.T.V. More firms are offering equipment for hire. This obviously indicates that there is a growing demand for a service of this nature. Is it cheaper to rent than buy? Is it because many potential users have only short-term requirements? Is it because many firms who use C.C.T.V. do not employ staff qualified to maintain such equipment? Whatever the answers the following firms provide a hiring service.

Beulah Electronics Ltd., 126 Hamilton Road, West Norwood, London S.E.27. (Tel: 01-670 6166)
A Video Industrial Training (V.I.T.) plan is operated and enables companies to obtain C.C.T.V. equipment, including a video-tape recorder, for a few pounds weekly leasing charge.
WW 501 for further details

General Descaling Co. Ltd., Worksop, Notts. (Tel: Worksop 3211-6)
The company's inspection service using C.C.T.V. is intended as an aid for engineers, surveyors, consultants and public authorities.
WW 502 for further details

F. B. Phillips & Co., 283 Poulton Road, Wallasey, Ches. (Tel: Wallasey 6529)
Primarily installation and maintenance engineers the company

has now introduced its own range of group viewing receiver/monitors.
WW 503 for further details

Radio Rentals Wired Systems Ltd., Shrivenham Road, Swindon, Wilts. (Tel: Swindon 21111)
Contracts for 3, 5, 7 or 10 years can be arranged and include full maintenance and servicing. A wide range of equipment —from U.K. and overseas manufacturers—is available for hire or sale.
WW 504 for further details

Zoom Television Ltd., East House, Chiltern Avenue, Amersham, Bucks. (Tel: Amersham 5001/3)
The company manufacture C.C.T.V. systems, vision mixers, video amplifiers and distribution systems and supply equipment made by well-known manufacturers. One of the company's specialities is outside broadcast location recording and it provides professionally staffed mobile C.C.T.V. and video-tape recording units from £60 per day.
WW 505 for further details

Some of the manufacturers

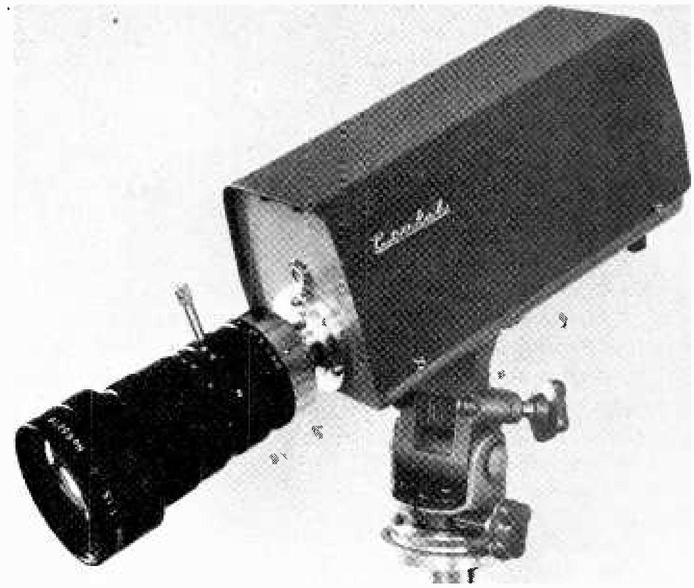
Most of the companies represented in this review manufacture comprehensive ranges of units suitable for all types of C.C.T.V. applications. Space allows the description of only one or two items produced by each manufacturer. Collectively, however, the items described are indicative of most aspects of C.C.T.V. equipment.

Ampex International, 72 Berkeley Avenue, Reading, Berks. (Tel: Reading 55341)
The latest addition to the Ampex range of video-tape recorders for closed-circuit operation is the VR-5003. It is the smallest and lowest priced (£795) instrument the company has produced. This machine, like all other Ampex v.t.rs, are switchable for both 525- and 625-line standards.
WW 524 for further details

Barr and Stroud Ltd., Kinnaird House, 1 Pall Mall East, London S.W.1. (Tel: 01-930 1541)
An **image orthicon camera** manufactured by the company is fully transistorized and employs a 7.6cm tube. Designed for special industrial applications where the level of illumination is too low to permit the use of a vidicon, the camera can be incorporated in a variety of optical systems including periscopes. Output is 1.3V p-p positive; bandwidth is 7 MHz and a 625-line, 50-field, 2:1 interlaced scanning system is employed.
WW 506 for further details

Belling & Lee Ltd., Great Cambridge Road, Enfield, Middx. (Tel: 01-363 5393)
Distribution equipment, employing coaxial cables to feed standard commercial monochrome or colour TV receivers, covers the basic requirements for a flexible closed-circuit television system. To provide for distribution at both u.h.f. and v.h.f. Belling-Lee have introduced a new ultra-broad band series of amplifiers etc. with a frequency coverage of from 40 to 850 MHz.
WW 507 for further details

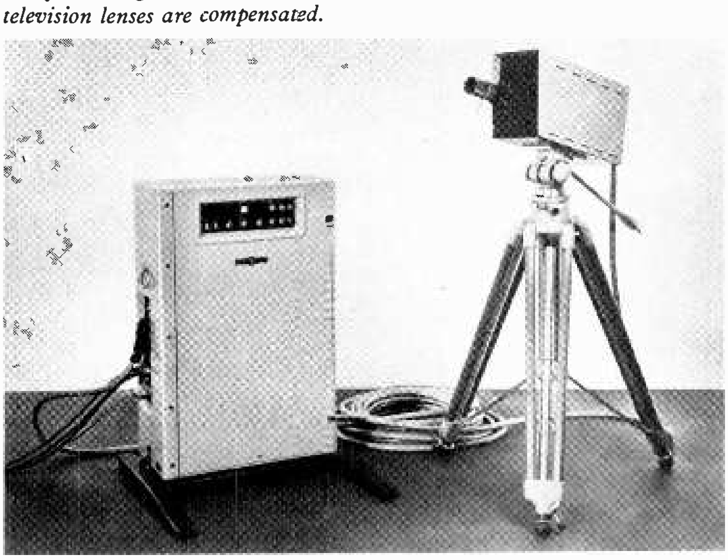
Beulah Electronics Ltd., 126 Hamilton Road, West Norwood, London S.E.27. (Tel: 01-670 6166)
The range includes cameras, video monitors and r.f. monitors. The Type 1400 **video monitor,** priced at £108, has a frequency response of 5 MHz ± 3 dB and operates with a 625-line system. Non-linearity on both vertical and horizontal scans is less than 4%. Input impedance is 75 Ω and input level required is 1V p-p. This company is the sole U.K. distributor of the National range (Matsushita Electric) which includes the WV600N **special effects generator.** This unit incorporates a variety of special effects such as superimpose, fade-in and fade-out, and several wipes. Any two of three video (1.4V p-p composite) input signals from cameras operated by an external synchronizing generator can be selected. Video output and sync. output from 75 Ω is 1.4V p-p composite for video and 4V p-p sine wave (horizontal) and 4V p-p negative pulse (vertical) for the two sync. outputs.
WW 508 for further details



Nuvistors are used in the early amplifier stages of the Beulah SD80 camera to ensure that the noise factor is as low as possible.

Bosch Ltd., Rhodes Way, Radlett Road, Watford, Herts. (Tel: Watford 44233)
The company claims it is the only manufacturer of an industrial camera using the E.E.V. Isocon image tube developed for use in conditions of complete darkness. Except for price, £2,500, and the fact that the camera is based on the existing Type TV120, no further details are as yet available. In the TV120, the high sensitivity of the image orthicon necessitates reduction or control of the amount of light reaching the tube. A motor-driven variable density optical filter is employed for this purpose. Control may be effected manually or by remote control which senses on the amplitude of the picture signal. Image brightness is controlled by a factor of 1:1000.

The Bosch TV140 vidicon colour camera costs approximately £10,000. The influence of dark current is prevented by inserting a true black level at the beginning of each line and by clamping this level to a defined potential. At the same time, illumination of dark picture parts and therefore changes in the chroma due to scattered light behind the television lenses are compensated.

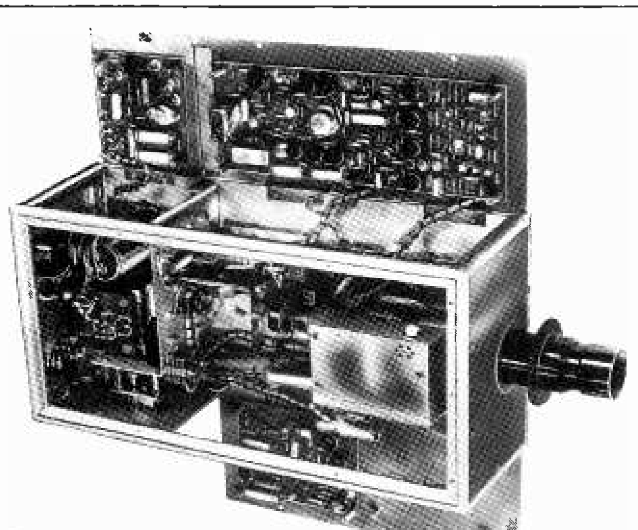


Where extreme fluctuations of illumination level are to be compensated, the variable density filter can be coupled to the lens diaphragm to increase the control factor to 1:100,000.
WW 510 for further details

British Insulated Callender's Cables Ltd., 21 Bloomsbury Street, London W.C.1. (Tel: 01-636 1600)
POD, a recently introduced **television relay cable** is claimed to have an improved cross-talk at least 5 dB better than conventional multipair cables and can be used for circuits operating at frequencies of up to 20 MHz. Basic construction of a POD cable (combined pair and quad construction) comprises two video cores accurately twisted together with special lays with a smaller pair of cores in the interstices. The smaller pair may be used for audio frequency operation. For a larger number of distribution channels, several PODs are laid together to form a multi-POD cable.
WW 509 for further details

English Electric Valve Co. Ltd., Chelmsford, Essex. (Tel: 0245 61777)
A wide range of tubes suitable for C.C.T.V. applications is available including the Isocon mentioned above. The majority of the range of **vidicons** can be manufactured with a fibre optic faceplate to special order. The P844 is a 2.5cm diameter vidicon of separate mesh construction and employs magnetic deflection and focusing. The photosurface may be exposed to bright stationary scenes for long periods without risk of burn-in or long term after-image. At high light levels the image retention time is very short, thus the tube is particularly suitable for use in telecine equipment. When used with tungsten illumination, the spectral response is substantially panchromatic. Peak illumination of the faceplate is over 10000 lux.
WW 511 for further details

G.E.C.-A.E.I.(Electronics) Ltd., Spon Street, Coventry, CV1 3 AZ. (Tel: Coventry 24155)
The PM7 **viewfinder monitor** is an all-transistor a.c.-operated 18-cm picture monitor for use on 625/50 or 525/60 line standards. Required level of video signal input is 0.25 to 2V p-p composite or non-composite, and sync. level is also 0.25 to 2V p-p composite video or mixed sync. Input impedances of both signals is 75 Ω terminated or 3k Ω bridged. The h.f. amplifier response is −3 dB at 8 MHz and highlight brightness is at least 350 cd/m^2 from a peak white.



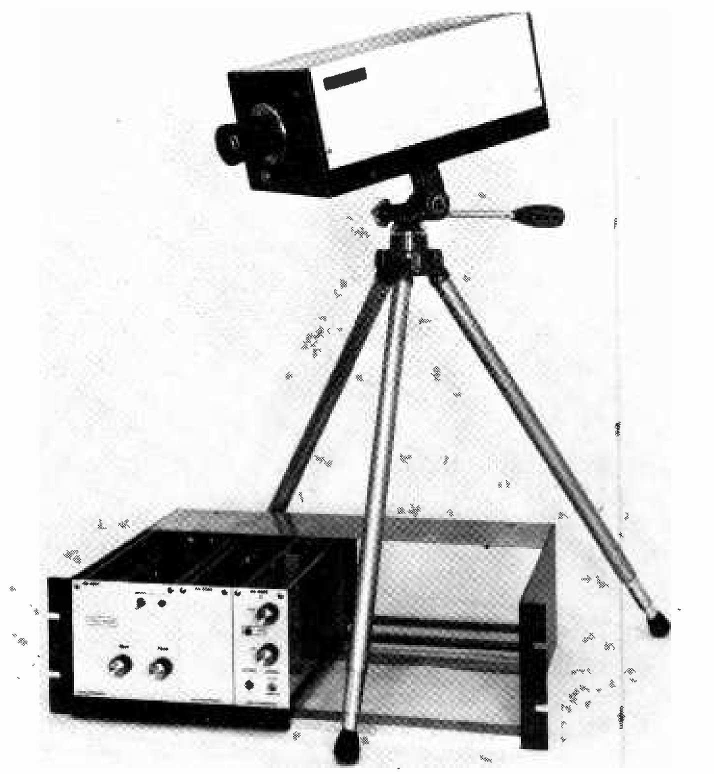
All circuits in the G.E.C. Type VCT2 camera are transistorized. Servicing in the field has been facilitated by using replaceable printed circuit boards or modules.

The **video distribution amplifier** manufactured by th company accepts 5 inputs and has a high impedance (2.7 k nominal) so that several units may be fed from one 75 source. The 5 outputs are closely matched (maximur difference between any two outputs is 2%) and features hig isolation (separation between outputs is 40 dB and 60 dB at MHz and 10 kHz, respectively), low noise (better than −50 dI relative to 1V) and are at nominal ground potential. A pane mounted gain control is provided for each input signal and ha a range of ±3 dB relative to unity gain. Silicon transistors ar used and an internal power supply stabilizer is fitted.
WW 512 for further details

Highgate Acoustics, 184-8 Great Portland Street, London W.1 (Tel: 01-636 2901)
Loewe Opta **video tape recorders** are handled in the U.K. b this company. Both the Optacord 602 and 603S employ 25.4mr tape. Running time using a 228.6mm reel at 15.22cm/s is 10(minutes. The overall size is 52 × 41 × 21cm and it weighs 22kg
WW 525 for further details

Link Electronics Ltd., Kildare Close, Eastcote, Middlesex. (Tel 01-866 5515/6)
The Type 320 **sawtooth generator** produces a composite vide output when driven with 1V min. mixed sync. and blanking pulses; with blanking pulse output only the output is nor composite. Controls are provided inside the generator for amplitude adjustment of sawtooth and sync. levels. The output signal is a 1V p-p composite line sawtooth from a source impedance of 75 Ω Silicon tramsistors are used throughout the circuitry, and the unit is built as a self powered module 5cm wide, 13cm high and fits in a standard 19-in (48-cm) rack mounting frame.
WW 513 for further details

Designed for high-quality industrial and educational caption applications, the Type 102 camera from Link Electronics uses a separate mesh vidicon operated in the high field mode for optimum resolution. Output from the head amplifier in the camera is fed to three rack-mounted modules—control, processing amplifier and power supply.



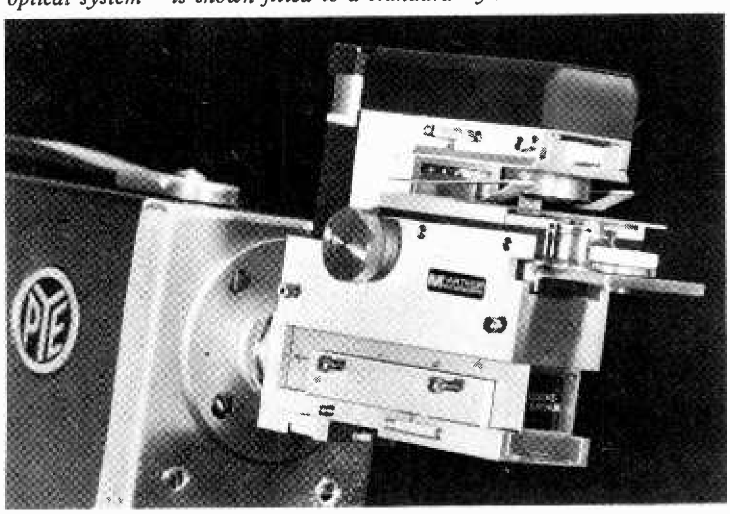
Iullard Ltd., Industrial Electronics Division, Mullard House, 'orrington Place, London W.C.1. (Tel: 01-580 6633)
ligh sensitivity, low dark current, fast response independent of ght level, and small size are features of the 55875 and 5875-1G series of Philips **Plumbicon tubes.** These tubes are .2 in (3 cm) diameter and are intended for use as sensitive, igh-definition pick-up devices in monochrome or colour, roadcast and C.C.T.V. cameras. The dark current is less than ; nA and resolution is more than 600 TV lines. The maximum llumination is 500 lux. Faceplate illumination level for mono-hrome and luminance tubes to produce 0.3 μA target urrent is approximately 5 lux. Beam current should always be djusted to a value at which all high lights are stabilized.
WW 514 for further details

Peto Scott Ltd., Addlestone Road, Weybridge, Surrey. (Tel: Weybridge 45511)
A Philips multi-purpose **camera chain** is available in different versions for operation in accordance with European 625-line and American 525-line scanning systems or 875 lines (50 fields) and 735 lines (60 fields).

Various versions of the camera are available and have a basic designation of LDHO150 or LDHO160. Either a Plumbicon or a vidicon equipped camera can be used according to the application. The polarity of the output signal of the process amplifier can be reversed by means of a POS/NEG switch. This facility can be used to improve the contrast of microscopic and X-ray pictures. Changeover from 625- to 525-line standard or from 875- to 735-line scanning is automatic and requires no switching whatsoever. The timebase circuits are auto-sensing; accordingly, triggering by the respective sync signal is sufficient. Direction of scan can be reversed horizontally as well as vertically by means of scan reversal switches in the camera. The deflection coil assembly can be rotated through 90° to compensate for different orientations of the camera.
WW 515 for further details

Pye TVT Ltd., P.O. Box 41, Coldhams Lane, Cambridge. (Tel: Cambridge 45115)
The Sentinel 8047 **solid-state camera head** built into a spherical housing employs a separate mesh vidicon tube. Built-in facilities include positive/negative picture switching, aperture and gamma correction controls, dark current compensation, and ability of sync generator to lock to crystal, mains, or an external reference. It is available with 405-, 525- or 625-line scanning. Satisfactory pictures can be obtained with illumination of as low as 50 lux at f1.9.
WW 516 for further details

Television microscopy is one application of C.C.T.V. In the illustration, the Pye Lynx television microscope—a three objective device with a folded optical system—is shown fitted to a standard Lynx camera.



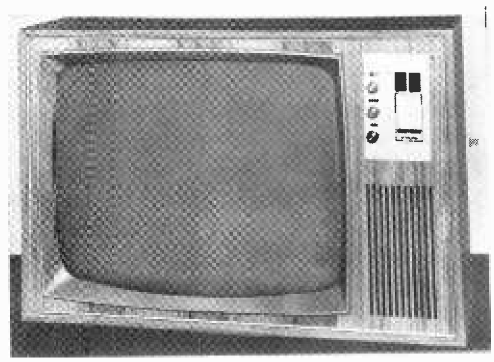
The Rank NIVICO TKE1 video mixer and effects generator costs £150.

Rank Taylor Hobson, Leicester, LEI 9JB. (Tel: Leicester 23801)
The company manufacture and market what is probably the widest range of C.C.T.V. **lenses** in the world. In the Monital zoom lenses for C.C.T.V. there are three series, M, L and R. To deal with one; the M series covers a 5:1 zoom ratio and has been developed to include a wide choice of control systems and basic focal lengths. Except for one lens, the basic focal length can be varied by fitting different rear lens elements. These rear elements are interchangeable—an important feature for users who require zooms of different basic focal length. The exception is the 17 to 85 mm lens in which the zoom optics require special correction for use with a short focal length rear element.
WW 519 for further details

RCA Great Britain Ltd., Lincoln Way, Windmill Road, Sunbury-on-Thames, Middlesex. (Tel: Sunbury-on-Thames 85511)
The PTS-1 **video switching system** 8A accepts signals from eight picture sources and is especially suited to C.C.T.V. systems. Ideal for use with all types of picture sources, the system provides bounce-free pictures and a choice of programme transitions such as direct switching, fades and dissolves. Selection of any input on either of two mix bus bars and choice of programme control techniques are available, such as instantaneous selection of any picture source; fading a picture to and from black; dissolving between pictures at any desired speed. Switched video signals overlap for several milliseconds to ensure smooth transfer of pictures and avoiding loss of sync when switching composite signals.
WW 518 for further details

Rediffusion Industrial Services Ltd., Astronaut House, Hounslow Road, Feltham, Middlesex. (Tel: 01-890 6325)
The RT100 **camera** operates from normal mains supplies or, to special order, from a 24V battery. The only external electrical control is an on-off switch. The camera uses fully stabilized electronic control and incorporates automatic compensation for varying levels of illumination over a range of

The Rediffusion Type VM1002 58 cm video monitor incorporates random or full interlaced 405- or 625-line standards, line flywheel synchronizing and d.c. restoration of the picture.



2000:1. The 625-line standard with random interlace is used although another version of the camera is available with double interlacing. With lens aperture set at $f1.5$ a well contrasted picture can be obtained with scene illumination of 40 lux. A usable picture can be obtained under similar conditions with a scene illumination of only 10 lux. Using a standard vidicon separate mesh tube, type 9677, response is panchromatic. Ultra violet and infra-red sensitive tubes are available. Price is £200.
WW 517 for further details

Sony (U.K.) Ltd., 36/40 Wigmore Street, London W.1. (Tel. 01-935 3546)
The DVK2400B/VCK2400B **portable video recording unit** is typical of equipment which opens up innumerable possibilities for the professional who wishes to experiment with new techniques

Sony portable video recording unit. The camera has a built-in electronic viewfinder.

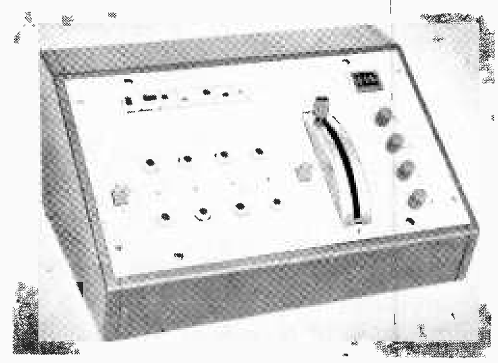
or the amateur who just wishes to experiment. The units are battery operated and together weigh less than 18lb. The VCK2400B (£287) camera uses a separate mesh Vidicon operating with a 405-line (50 fields) system with 2:1 interlace supplied from the DVK2400B (£287) recorder. Signal-to-noise ratio is greater than 40 dB.
WW 526 for further details

Teleng Ltd., Church Road, Harold Wood, Essex. (Tel: Ingrebourne 42976)
The claim for the company's **distribution system,** intended for educational, hospital and municipal use, is that it is the only one available where each individual receiver outlet can be used also as an input point for a television camera. The specific function to be performed at a given point is determined by the type of plug-in unit used. Each line in the system is based on a 'loop wired' principle. At each 'loop' a unit is fitted and the incoming and outgoing ends of the cable are terminated with two coaxial sockets. When the point is not in use (i.e., external equipment is not connected) the two sockets are linked by a continuity unit.
WW 520 for further details

Vectron Electronics Ltd. (sole U.K. agents for Shibaden), Hythe, Southampton. (Tel: Hythe 3265)
Shibaden HV-50 is a **hand held camera** with a built-in optical view finder. The camera is primarily intended for use with a video tape recorder and is connected via a 20-ft cable to a separate camera control unit which in turn is supplied with a 10-ft mains cable, 5-ft video cable and 4-ft r.f. cable. A random interlace scanning system (525 or 625 lines) is used. Resolution is 400 lines (horizontal). Fitted with a 25 mm $f1.9$ lens and vidicon tube the camera requires an illumination of 100 lux Complete with camera control unit and lens the HV-50 costs £175.
WW 521 for further details

Video Electronics Ltd., 70, Hanover Street, Leigh, Lancs. (Tel: 05235 74870)
The VEL System 70 is a comprehensive range of **modular processing units** which includes pulse and video distribution amplifiers, solid-state video switching units and matrixes; micrologic industrial and professional synchronizing pulse generators; negative picture amplifiers; graticule and dot generators. The Type SPG1 and SPG1A synchronizing pulse generators utilize silicon integrated circuits and market at £255 and £220, respectively. Output pulses are negative and adjustable

The model SS3 special effects unit from Video Electronics sells for £435. The outputs of up to four standard cameras can be selected in any sequence or combination of two cameras.



in level at 2V or 4V p-p. Control of a master oscillator can be effected by choice of several operating modes: locked to internal mains supply; locked to external 50 Hz sine wave; external twice line frequency drive; internal LC control; or internal crystal drive (SPG1 only).
WW 522 for further details

Visual Engineers Ltd., Stocklake, Aylesbury, Bucks. (Tel: Aylesbury 5931)
The VR-621 **camera** has video and r.f. outputs which can be switched to either a video monitor or a domestic television receiver. A 2.5cm vidicon tube is used with a random interlace scanning system. Frequency response is 6 MHz and output signal levels are 1.4V p-p (video) and 30 mV r.m.s. (r.f.) at an output impedance of 75Ω. Horizontal video resolution is more than 500 lines at centre and vertical r.f. resolution is more than 300 lines at centre. Price of the VR621 is £134.
WW 523 for further details

Round-the-lens light sources and a 4 rev/min rotating mirror are shown in this illustration of the rotating view camera head from Visual Engineers.