IGITAL VOLTMETER TECHNIQUES

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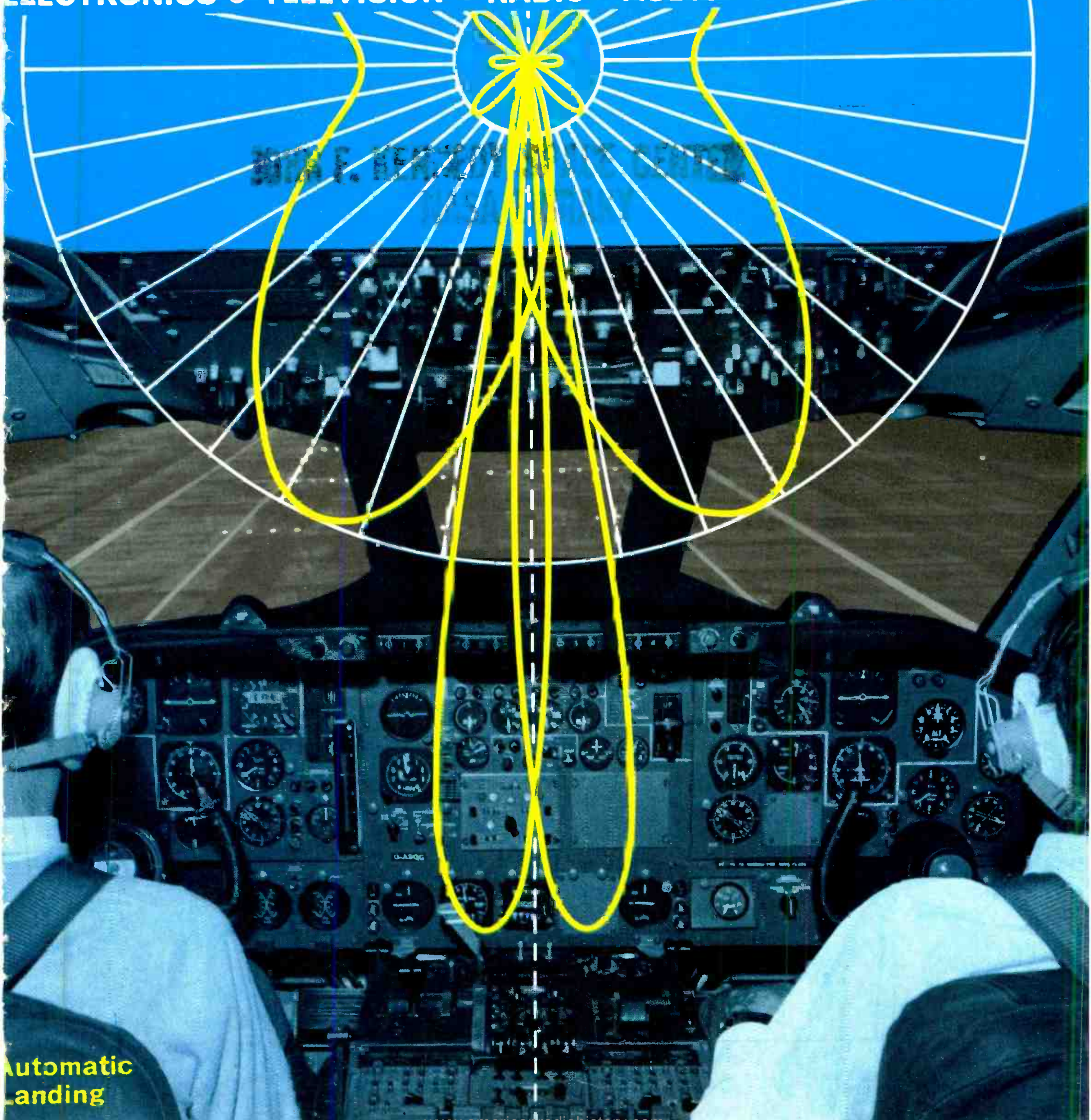

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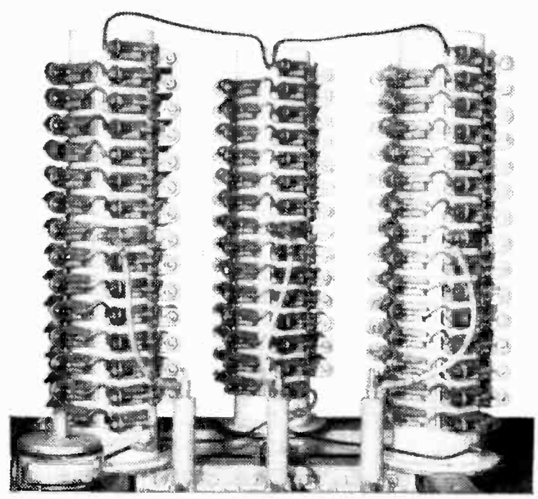

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Too Often "Saved by the Gong"

"CONGESTION in the frequency spectrum exists only on paper" a senior radio engineer said to us the other day. This was not just an idle remark. What he was in fact referring to was inefficiency and waste in the way the radio spectrum is utilized. The fact that frequency allocations are set out very tidily on paper does not mean that the communications capacity thus made available is used to the best advantage. For example, there is the restrictive—some might say dishonest—practice of stations "idling" to keep allocations "warm" (sending out rubbish to ensure that a frequency is not taken away from you because you are not using it). Then there are the anti-social habits of using more transmitter power than necessary and failing to ensure that frequencies are kept stable. Less reprehensible, but still wasteful, is the h.f. technique of sending the same information on two or more frequencies simultaneously, on the "belt-and-braces" principle.

Operators of communications channels may argue that such practices are justifiable in the jungle in which they find themselves. The only way they might be prevented is by an international police force for radio. This is unlikely to be achieved, so we must learn to live intelligently with the existing *laissez-faire* situation. We are not, however, doing this. We are not making use of the electronic techniques available to us sufficiently fast to cope with the demand for communication channels from new countries, organizations and services. For example, it may seem incredible that such an old and well-known technique as single-sideband operation is still in the process of acceptance by professional users. As recently as 1963 a "Panel of Experts" set up by the I.T.U. to advise on more effective use of the h.f. band felt it necessary to point out that s.s.b. had certain advantages, and some of their recommendations for converting d.s.b. transmissions to s.s.b. are not due to take effect until the 1970s. It is our slowness to make use of efficient methods of communication that encourages the malpractices.

Such lethargy in radio engineering probably results from our good fortune in constantly being "saved by the gong" of new frequency bands opening up. The medium-wave broadcasting congestion was relieved by v.h.f.; television has been able to spread out of v.h.f. into u.h.f.; and pressure on the h.f. communications band has been lessened by the arrival of coaxial cables and satellites. But this process cannot go on indefinitely. We shall have to make much better use of economy techniques, such as bandwidth-saving in television and telephony signals, and adaptive techniques such as the automatic adjustment of h.f. transmission characteristics to suit propagation conditions by means of ionospheric sounders and on-line computers. The new generation of h.f. radio equipment designers has, in fact, provided an object lesson in how to get the best out of a frequency band which the users were beginning to give up as a bad job.

We shall also have to abandon our archaic way of thinking only in terms of the frequency dimension, and discrete channels in it. Communication theory has taught us that frequency bandwidth, information rate and signal/noise ratio can be exchanged for each other, and ways in which this principle can be utilized to get improved occupancy of communications space are now being investigated (see, for example, p. 527 of this issue). Here is a complete revolution in thought, because the technique is based on using *more* frequency space than normal for a transmission instead of less.

Electronics grew out of radio engineering. Ironically the advanced information processing techniques it makes possible have been applied with the greatest enthusiasm to automatic control, computers and other industrial systems while the poor communications "parent" has been neglected. The circle has not yet been completed.

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Digital Voltmeter Techniques

A Survey of Current Practice

By H. STERN, B.Sc.

THERE is currently available a large and confusing variety of digital voltmeters. The problem of selecting the best model for a particular application is not helped by the fact that some of the terminology can conceal its own meaning. There are a number of different ways in which d.v.ms digitise their input, overcome interference and present their outputs. A knowledge of these principles is important if the right type is to be selected. The most obvious way in which d.v.ms vary is in the number of digits displayed.

For instance, a true five digit instrument has a full scale capability o 99,999; another type of five digit instrument can only measure up to 11,999. In this latter type the most significant digit has only two conditions, 0 or 1. Although the meter can display 19,999, measurements above 11,999 are inaccurate. The maximum voltage that can be displayed corresponds, in round figures, to 20% above the full-scale value for a true four digit meter. This type of display is, therefore, described more explicitly as a four digit display with 20% over-range. This facility allows an overlap between ranges, reducing the necessity for range-changing without the circuitry needed to display a full nine.

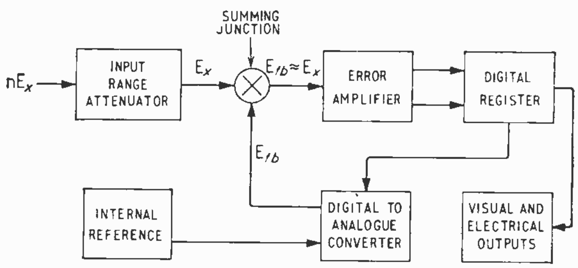

Fig. 1. Block diagram of a continuous balance d.v.m.

Linked with the number of digits displayed is the resolution of which the meter is capable. This should ideally correspond to the smallest digit displayed. Other factors, such as noise, drift and attenuator errors also affect the accuracy of the measurement and care must be taken in assessing the relative importance of each factor. The meter with the largest number of digits is not necessarily the most accurate. The system of logic employed determines such characteristics as speed of operation and immunity to interference. Four different logic systems, their advantages and disadvantages are described in some detail in the following sections.

CONTINUOUS BALANCE LOGIC

The continuous balance d.v.m. uses the principle of balancing the unknown signal against an accurately known standard. The standard is adjusted until equal to the unknown and the value of the standard displayed. Like other potentiometric devices it has a theoretically infinite input impedance in the balanced condition.

Fig. 1 is a simplified block diagram of a continuous balance instrument. nE_x the incoming signal is attenuated if necessary to a suitable level, E_x, and fed to the summing device (electromechanical chopper or a solid state summing junction). Also fed into this junction is an accurately known voltage E_{fb}. The difference between E_x and E_{fb} is amplified by the error amplifier and the resulting output controls the digital register (via the digital to analogue converter) so as to bring E_{fb} nearer to E_x. The process continues until $E_{fb} = E_x$. The value of E_{fb} is then displayed, the decimal point being placed according to the input attenuator setting.

The output from the internal reference is digitally controlled and converted to analogue form for comparison with E_x, as shown in Fig. 2. The output from the precision reference source is fed to a chain of resistors which can be switched in or out of circuit. The resistors are so proportioned that the switch conditions give a direct indication, in binary-coded-decimal (b.c.d.) form (using the 2*421 code) of the analogue voltage E_{fb}.

Although the digital to analogue converter is built on a b.c.d. sequence the control of its output in a continuous-balance meter is such that the value of E_{fb} rises one digit at a time through a decimal sequence starting at the least-significant digit. An illustration will make this point clearer. Let us follow the sequence involved in measuring an input of + 1.2724 V d.c., starting at + 0.0000 V, on a true five digit meter.

1) The meter senses that + 1.2724 > + 0.0000 and starting from + 0.0001 V will increase E_{fb} in 9 steps to + 0.0009 V, in a further 9 steps in the + 0.0010 decade to + 0.0099 V and so on till it reaches + 1.9999 V. At this point, for the first time, $E_{fb} > E_x$. The digital register gives out a 'down' pulse (37 steps).

2) The action of the 'down' pulse is to reduce the appropriate decade to 0. This process starts with the

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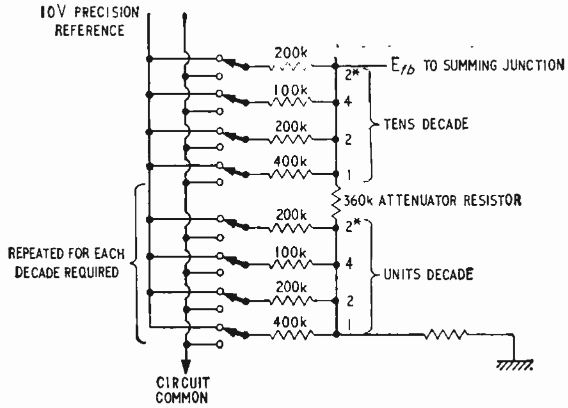


Fig. 2. Simplified bridge diagram.

least significant decade. The next four steps reduce the value of E_{fb} from + 1.9999 V to + 1.0000 V. E_{fb} is now < E_x and the digital register reverts to 'up' pulses (4 steps).

3) The value of E_{fb} rises, in an analogous way to that described in 1, from + 1.0000 V to + 1.299 V. Then $E_{fb} > E_x$ and again a 'down' pulse is produced. (29 steps).

4) In a similar fashion to 2, E_{fb} descends from + 1.2999 V to + 1.2000 V. $E_{fb} < E_x$ and 'up' pulses are produced (3 steps).

The remainder of the process is now obvious and the steps are merely summarised.

E_{fb}:

5) rises from + 1.2000 V to + 1.2799 V (25 steps)
6) falls from + 1.2799 V to + 1.2700 V (2 steps)
7) rises from + 1.2700 V to + 1.2729 V (11 steps)
8) falls from + 1.2729 V to + 1.2720 V (1 step)
9) rises from + 1.2720 V to + 1.2724 V (4 steps)

Now $E_{fb} = E_x$ and a 'display' and/or 'print-out' command from the digital registers is fed to the visual and electrical outputs. The whole process took 116 steps and on a typical c.b. d.v.m. would probably last 50-100 ms. If the voltage E_x were to fluctuate about the original value of + 1.2724 V the voltmeter would follow it with a minimum number of steps. Thus a rise to + 1.2725 V would result in one 'up' pulse to achieve balance. A fall to + 1,2723 V would cause first a 'down' pulse to + 1.2720 V followed by 3 'up' pulses to achieve balance. This facility to follow small fluctuations rapidly is the main advantage of this type of meter and for this reason it is sometimes called a 'tracking' d.v.m.

When a continuous balance d.v.m. is to be used with long test leads there is a danger of erroneous results due to interference, particularly at mains frequency. For this reason a filter is normally incorporated at the signal input to the summing junction, undesirably slowing down the response of the voltmeter seriously.

SUCCESSIVE-APPROXIMATION LOGIC

The successive-approximation type of d.v.m. uses a variant of the continuous-balance principle, it has one significant difference in its mode of operation affecting its suitability for a particular application, therefore it is preferable to place it in a separate category. The difference lies in the sequence of trials made to adjust the reference voltage to equality with the unknown. Unlike the c.b. d.v.m. this meter starts with the most significant digit and progressively adds in or discards increments until balance is reached. The process goes through each decade following a binary-coded-decimal sequence, b.c.d. 2*421 for example. This is how a true five digit meter would proceed to measure + 3.7000 V. In the following description the position of the decimal point is ignored.

1) 2* × 10^4 tried and retained
2) 4 × 10^4 added and rejected
3) 2 × 10^4 added and rejected
4) 1 × 10^4 added and retained
5) 2* × 10^3 added and retained
6) 4 × 10^3 added and retained
7) 2 × 10^3 added and rejected
8) 1 × 10^3 added and retained

This process is summarized in Fig. 3.

We have now attained balance. Should there have been further digits the process would have continued in a similar way through the 10^2, 10^1 and 10^0 decades.

The advantage of this type of logic is that the time required to achieve balance is much shorter. For example a typical modern high-speed successive-approximation meter can reach balance in a maximum of 22 steps in 10 ms. Successive-approximation meters are used where the maximum encoding speed is required and where each encoding is unrelated in value to the previous one, a requirement that occurs frequently in data loggers. Some of the latest designs, however, have such short encoding times that they are displacing the conventional c.b. type for tracking purposes.

Although for both c.b. and s.a. d.v.ms the input impedance at balance is in theory infinite, it is considerably less under other conditions. Moreover no null-balance device can achieve perfect balance; there must always be some degree of off-balance although the actual amount, in a well-designed unit, can be made very small. In the off-balance condition the signal source will be loaded by the meter and erroneous readings can result. The input impedance of the meter may even be negative; current flowing out of the meter into the source. These problems can be overcome by placing a high input impedance buffer amplifier between signal and summing junction (see Fig. 4). This amplifier has a high loop gain and the feedback is adjusted to give a voltage gain of unity. An input impedance of 10 kMΩ under all conditions and on all but the highest d.c. ranges, is obtained. The insertion of the input attenuator reduces this figure to 10 MΩ on the top two ranges. This particular d.v.m. has a number of other interesting features which illus-

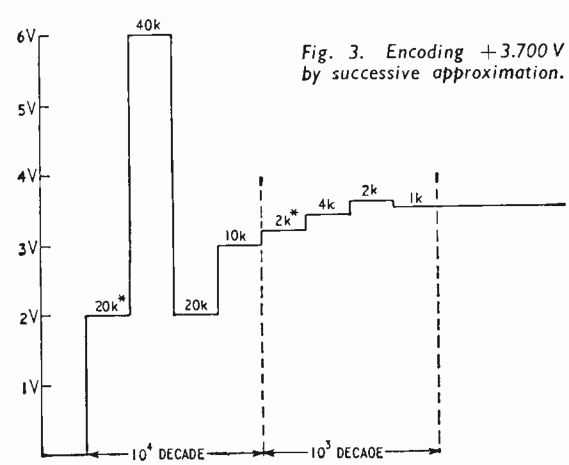


Fig. 3. Encoding +3.700 V by successive approximation.

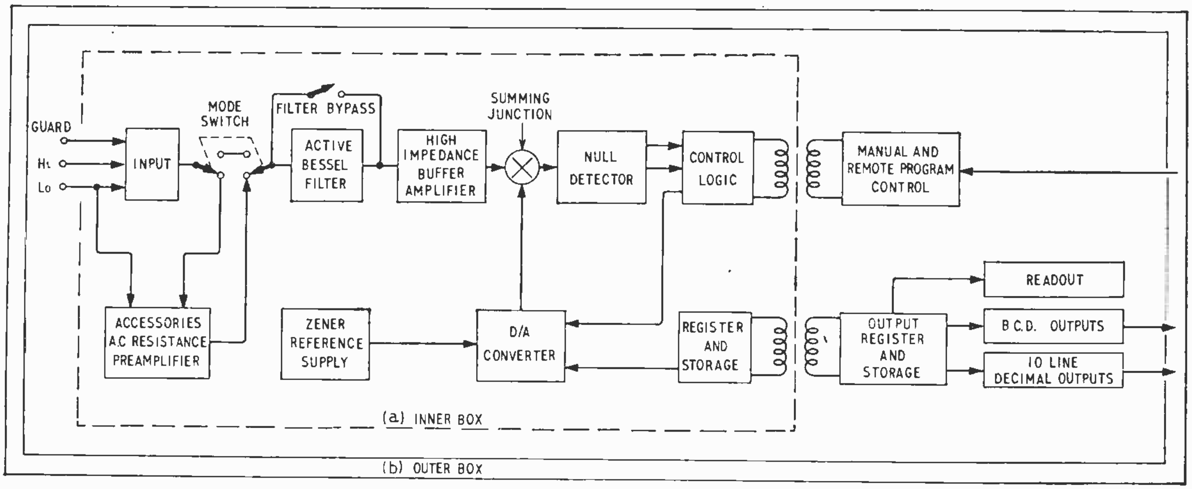


Fig. 4. Block diagram of the Honeywell Model 85 successive approximation d.v.m.

trate some of the techniques employed in modern high-grade s.a. meters.

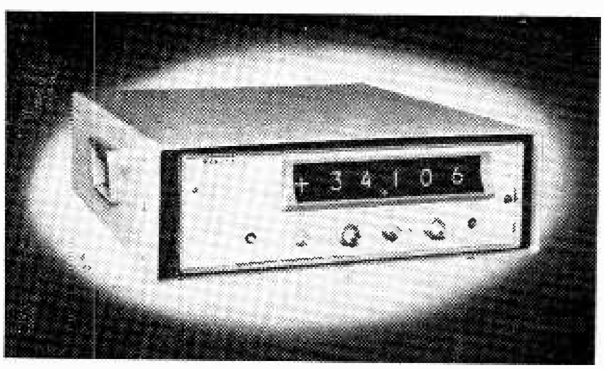
First, it will be noted that it employs a 'box-within-box' construction; the inner box being the guard or Faraday screen. This results in a high degree of attenuation of common-mode interference (130 dB in this case). The output signals cross the guard via transformer couplings; the primaries of the transformers being electrostatically screened (the screen being part of the guard) from the secondary. Other meters employ an optical coupling system consisting of lamps and photo-cells for the same purpose; this system is open to criticism on the grounds that dust can interfere with its operation. Manual and remote programming of the meter is similarly coupled through the guard.

The input connections for the meter are floating and differential. This helps in the reduction of d.c. common-mode interference, and in conjunction with the guard, of a.c. common-mode signals. Up to 500 V d.c. or peak a.c. of common-mode voltage can be handled.

Reed relays are used for the input switching. Apart from the advantage of allowing remote-control of range and mode switching, this gives a measure of protection to the meter and signal source should an excessive input signal be applied in the absence of power as all inputs are open-circuited under these circumstances.

One problem encountered with high-speed d.v.ms., especially when filters or accessory units are in circuit, is the time taken for the input circuitry to settle down after the application of a step function. This effectively slows down the response of the meter and in some cases it is necessary to perform a second encoding as a check on the accuracy of the first. The problem is overcome in the Honeywell Model 85 by the provision of built-in delay circuits which prevent encoding until the input circuits have settled to within ± 0.001% of the final value. In the absence of accessories or the filter this delay is 2 ms and is included on the specification in the total encoding time of 10 ms. When the filter is in circuit this total time is increased to 500 ms. Additional encoding delays occur if an automatic range change command is received since range-changing cannot occur until the magnitude of the unknown has been tried by performing a whole encoding.

Provision is made on the meter to store the displayed result between encodings. This obviates the tiresome flicker which would occur in the absence of storage; the display only changes when the input signal changes. A neon lamp is provided, which flashes, as a check, to indicate each encoding operation



The Honeywell Model 85 successive approximation digital voltmeter.

RAMP LOGIC

In the ramp type of d.v.m. a ramp voltage, that is a voltage rising linearly as a function of time, is generated in the meter, the rate of rise being determined by the meter circuits. The meter also incorporates a precise source of constant frequency. Fig. 5 is a typical block diagram.

Upon receiving the appropriate command signal the ramp starts. As it passes through zero volts a gate circuit is opened by a comparator to permit the oscillator output to be fed to a counter which in turn drives the display. When the ramp voltage equals the input, the gate is closed by a second comparator and the total number of cycles of oscillator signal to have passed through is displayed. By appropriate choice of the oscillator frequency and the rate of change of the ramp voltage the display can be made direct reading in terms of voltage. The placement of the decimal point is again determined by the setting of an input attenuator. The encoding time is directly proportional to the input voltage. On a typical meter of this type the maximum encoding time is of the order of 100 ms.

This type of voltmeter, using a simple type of analogue to digital converter, can be built quite inexpensively. However it is far from easy to achieve high accuracies with this system of logic. In particular, problems are encountered in achieving a really linear ramp, while ambiguity as to the zero point and precise moment of closure of the gate can cause additional errors. False triggering due to noise input is also likely to occur. For these reasons the accuracy is usually of an order lower than the other types described (typically $\pm 0.05\%$) and the use of this type of logic is normally confined to the lower cost type of meter.

INTEGRATING LOGIC

The analogue-to-digital converter in this type of d.v.m. differs completely from those described previously and is based on the charging of a capacitor. In one form the capacitor is charged linearly from the unknown source E_x for a fixed and accurately known time, t_1, controlled by a crystal oscillator (see Fig. 6). The signal is then disconnected and the capacitor connected to the reference source, E_{ref}, the polarity of the reference source connections being opposite to that of E_x. The capacitor now discharges at an accurately controlled rate towards E_{ref}, the process is terminated when the capacitor is completely discharged. The time, t_2, taken for the discharge is proportional to the p.d., E_1, across the capacitor at the end of the charge period, which in turn is directly proportional to the input voltage. Thus by gating an oscillator from the discharge process (normally the same crystal oscillator as controls t_1) and counting the number of cycles occurring during this time a measure of t_2 and therefore E_x is obtained. By appropriate choice of the oscillator frequency the meter can display voltage directly. The use of the same oscillator for control of the charge period and measurement of the discharge time and one capacitor common to both processes serves to eliminate any errors due to absolute errors in the oscillator frequency or in the value of the capacitance. The use of an alternating signal of which the number of cycles gated is the analogue of the input voltage, at this stage in the voltmeter, facilitates crossing the guard since it can be coupled across it by means of screened transformers.

This particular method of analogue to digital conversion has one very great advantage over previous systems in that without recourse to filters it is substantially immune to interference. The charging of a capacitor involves an integrating process and as a result the voltage measured will be the average of the input over the integrating time t_1. If there is an interfering alternating potential superimposed on the d.c. voltage to be measured, its effect will be substantially reduced during the integrating process. Fig. 7 shows a typical alternating interfering voltage superimposed on a d.c. level. The average value of the whole is equal to the area under the curve (allowing for the polarity of alternate half-cycles) divided by the duration of the measurement. The two whole cycles will be self-cancelling and only the shaded portion t_r will remain. It can be shown that the integrating process results in a normal mode rejection R, in dB, given by,

$$R = 20 \log_{10} \frac{\pi f t_s}{\sin \pi f t_s}$$

Where f is the frequency and t_s is the sampling time. This formula can be re-arranged as,

$$R = 20 \log_{10} \pi f t_s - 20 \log_{10} \sin \pi f t_s$$

which shows that the process can be regarded as the resultant of two effects. The first term represents an attenuation directly proportional to ft_s and if plotted graphically will be represented by a straight line with a slope of 6 dB/octave. The second term is periodic in nature, repeating itself between the points when ft_s is an integer. At integral values of ft_s its value will approach minus infinity while midway between these points its value will be zero. Fig. 8 shows the rejection of normal mode interference by an integrating d.v.m.; the dotted asymptote represents the $20 \log_{10}\pi f t_s$ term. Above this line is a peaky curve representing $-20 \log_{10} \sin \pi f t_s$. The two terms have an additive effect, of course, since $\log_{10} \sin \pi f t_s$ is always negative in value.

Since the chief source of interference is the a.c. mains it is normal practise to choose a sampling time t_s such that $t_s = n/50$; the actual value of n is determined by a com-

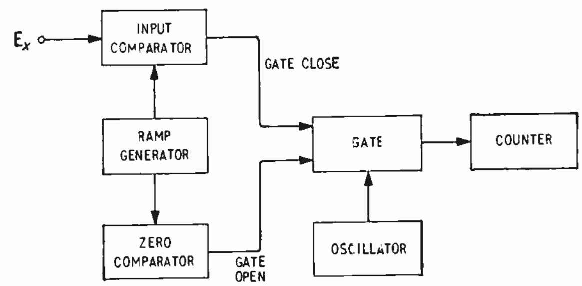


Fig. 5. A typical ramp d.v.m. layout.

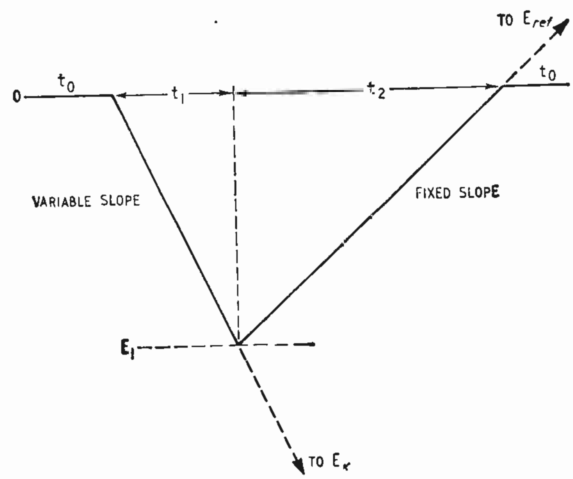


Fig. 6. Showing the charge and discharge of the integrating capacitor.

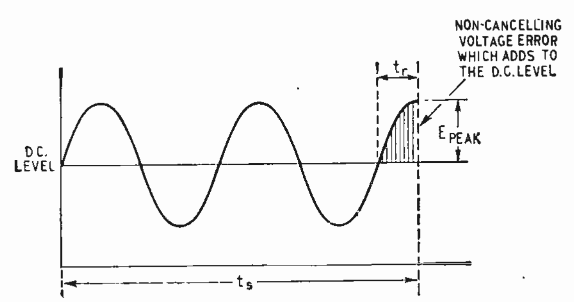


Fig. 7. Cancellation of a.c. by integration.

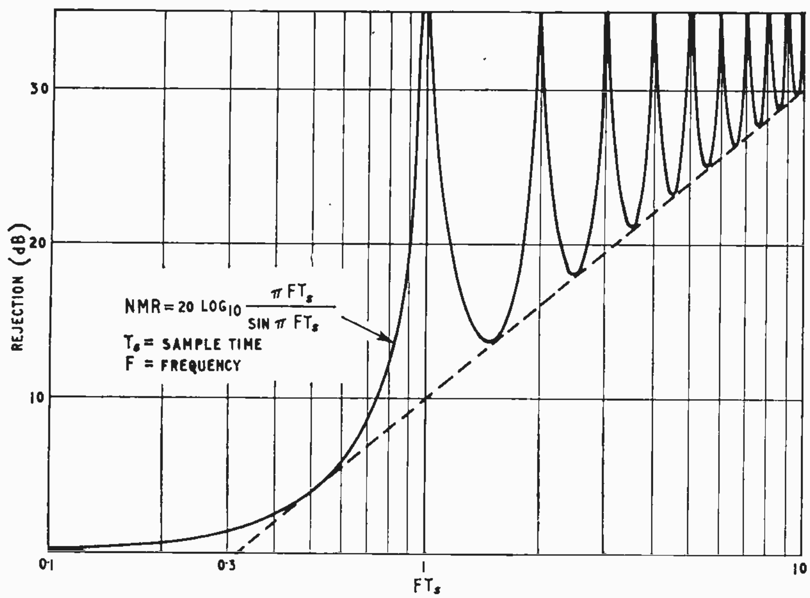


Fig. 8. Normal mode rejections for normalized frequency for an integrating d.v.m.

Honeywell "Autoject" system. In this case the sample time is a fixed 100 ms but is split into two 50 ms portions. The first portion is initiated when the interfering a.c. crosses its own zero (equal to the d.c. level) in a positive-going direction as shown in Fig. 9. At the end of this 50 ms the resulting average voltage is retained and there is an interval until the first negative-going zero-crossing occurs. A further 50 ms sample is then initiated and added to the first. This is the exact inverse of the first sample and complete cancellation will occur. In practise this ideal is not realised but an improvement of 40 dB at all frequencies is achieved as compared with a meter with a normal 100 ms sample time. Although the integrating system just described is used extensively, many of the most accurate d.v.ms currently available employ another system to achieve the longer integrating times needed in order to get adequate resolution.

Fig. 10 is a block diagram of the a/d converter of a typical meter of this sort. The output from the high

promise between speed of operation and rejection of other sources of interference such as random noise. Thus integrating d.v.ms currently available have sample times from 20 ms to 1 s. As will be seen, the peaky curves of Fig. 8 have a very steep rise and fall. This implies that the rejection of mains frequency interference will fall substantially if that frequency deviates far from 50 Hz. Various ingenious ways of overcoming this effect have been devised.

First of all it should be noted that the "brute force" method of increasing t_s is effective in reducing interference at all frequencies: a ten times increase will raise the attenuation at any frequency by 20 dB at the expense of operating speed.

One more subtle system is to strobe the oscillator controlling the sample time (which is also used to measure the discharge time of the capacitor), using the mains frequency, so that the sample time is always an integral number of mains periods (in the particular case one period). However the "strobing" process has no effect on interference at other frequencies unrelated to that of the mains.

A method of overcoming the problem, at the same time increasing the attenuation at all frequencies, is the

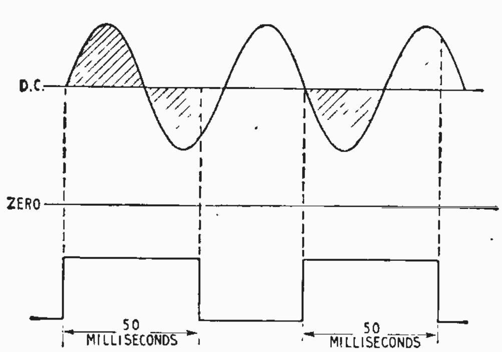


Fig. 9. Operation of the Honeywell 'Autoject' system.

gain (10^7) integrating amplifier controls the frequency of a voltage-controlled oscillator (v.c.o.). This frequency is divided by 64 and controls the frequency of a pulse generator. This pulse generator, in turn, controls an electronic switch which operates on a precise and stable reference voltage source E_r to produce a rectangular wave of identical frequency to the pulse generator and with duty cycle proportional to this frequency. The mean level of this rectangular wave is thus also proportional to the pulse generator and, hence, the v.c.o., frequency. The rectangular wave is fed back to the summing junction at the integrating amplifier input. This feedback is negative since an increase in current into the summing junction will lower the v.c.o. frequency in turn reducing the average voltage of the rectangular waveform, resulting in a closely defined frequency voltage relationship. When the converter is working normally its accuracy, stability and linearity are determined by the stability of a small number of fixed resistors in the attenuator and summing junction system, the reference voltage E_r and the fixed pulse width duration. Unlike the previous type of integrating voltmeter it does not depend at all on the linearity of the capacitor charge/discharge processes.

Since the input voltage is converted to a frequency in this meter it is merely necessary to gate this frequency accurately for a known time to measure the voltage. Suitable choice of frequency will allow the meter to be made direct reading. Again guard crossing is easily carried out via transformer couplings.

A number of variants on this principle of stabilising the voltage-to-frequency conversion by means of a feedback system are possible. On some meters the frequency corresponding to a negative voltage is identical to that corresponding to the same positive voltage (Fig. 11a). This can lead to ambiguity in the reading with a signal which during the sampling period, passes from one side of zero to the other (for instance as a result of an interfering signal greater in amplitude than the d.c. level to be measured). As the frequency, and hence the count, for $-xV$ is equal to that for $+xV$ a count will be added in when it should have been subtracted. The resulting

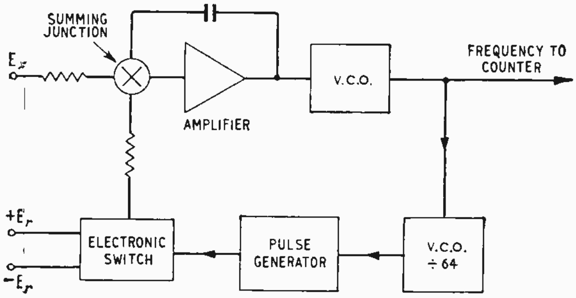


Fig. 10. Schematic of a d.c. to frequency converter.

error is known as the " foldover " error. One way to eliminate this error is to arrange for a continuous change of frequency through the point corresponding to zero volts (Fig. 11b). In the particular case a frequency of 200 kHz corresponds to zero volts; the total excursion for full scale being from 200 to 299.999 kHz for a positive input and 200 to 100 kHz for negative inputs. When the count is displayed for positive inputs the most significant digit is not displayed so that the voltage (from 00000 to 99999) is displayed directly. With negative inputs the frequency is inversely proportional to the d.c. voltage. To overcome this a process known as taking the " 9s complement " of each digit is performed in the meter. This involves substituting for each digit (n) the figure corresponding to $9 - n$, which represents the true value of the input. It is this value that is displayed with an indication of polarity. The net result of this technique is that the meter always displays the true integral of the input signal even when the superimposed interference causes it to cross the zero and change polarity briefly.

Integrating meters do not necessarily have a particularly high input impedance. Several methods are employed to overcome this. The most obvious is to precede the d.v.m. by a buffer amplifier similar to that described earlier; this will raise the input impedance above 1000 MΩ under all conditions. Other more elegant methods are in use. One involves an amplified negative-feedback system within the meter such that, without upsetting the integrating process, the input is effectively potentiometric; the input voltage is opposed by an equal and opposite potential.

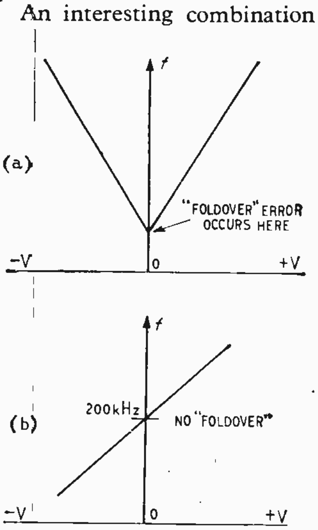
An interesting combination of techniques is used by Hewlett-Packard[1] and effectively combines an integrating and a successive-approximation system in one meter. Two sampling processes take place. In the first a sample is measured by integration in the normal way, but only the four most-significant digits of the count (out of six) are stored for subsequent display. The full encoded information is employed to control a divider chain which adjusts an input from a reference source and the resulting voltage is used to oppose the unknown input. The difference between this reference voltage and the unknown (i.e., the error in encoding) is now measured by means of a second integration process. This measurement serves to correct the fourth significant digit and to supply correctly the remaining two digits. Depending on its polarity it may be added to or subtracted from the first encoding to give the final displayed value. The resulting meter has a constant input impedance of 10 MΩ.

Obviously the improvement in input impedance is not the sole justification for the more complex system of encoding. This meter has the advantage that, as with other s.a. meters, the ultimate accuracy of reading depends on the accuracy of the reference source and of the divider network. Moreover the integrator (in this case a voltage-to-frequency converter) need not be of the greatest accuracy since, in effect when it is performing the second encoding, its full accuracy is being used to measure the error in the original encoding. The final error, due to the voltage to frequency conversion, is the square of the inaccuracy in the converter. Thus a converter with an error of 1 : 1000 will give a reading accurate to 1 : 10^6. (Other errors can, of course, degrade the reading.) The meter combines high speed with reasonably high noise rejection under many operating conditions. Even so, for optimum noise rejection, a lower operating speed must be used.

MEASURING OTHER QUANTITIES

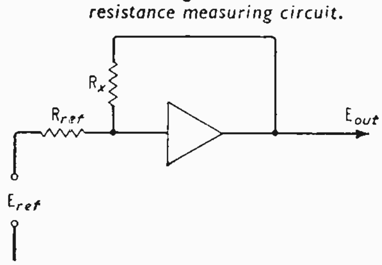
Voltage measurements are common, of course, to all d.v.ms. However, many incorporate facilities to measure other parameters. The following paragraphs outline the techniques used.

A.C. Voltage. Voltage measurements of a.c. are achieved by full-wave rectifying the input and then feeding back the pulsating d.c. into a summing junction where it opposes and is compared with the a.c. input. The feedback is controlled to give a d.c. output (subsequently smoothed) directly proportional to the a.c. input and independent of non-linearity in the rectifying system.



Left. Fig. 11. Illustrating foldover error.

Below. Fig. 12. The basic resistance measuring circuit.



Frequency and period. Integrating meters using voltage-to-frequency converters use a counter-chronometer to measure the resulting frequency. This counter is made available for external frequency measurements. By substituting an unknown signal for the internal gate and using it to gate the built-in timing oscillator period or time interval measurements can be performed.

Resistance. Fig. 12 shows the basic circuit used for resistance measurement. The amplifier is a high gain operational amplifier and the loop gain is, therefore, R_x/R_{ref}. The junction of R_x, R_{ref}, and the amplifier is a virtual earth. The output from the amplifier is E_{out} and

$$E_{out} = \frac{R_x E_{ref}}{R_{ref}}$$

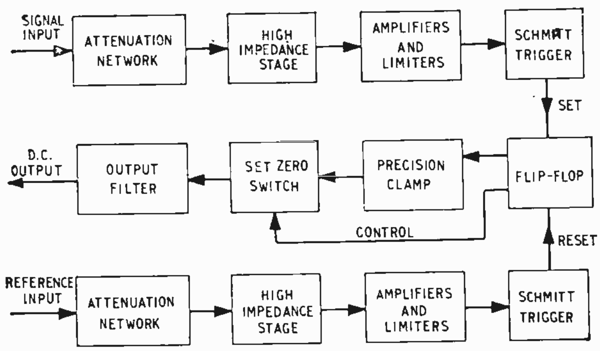


Fig. 13. Block diagram of a phase converter.

By appropriate choice of E_{ref} and R_{ref} we get a direct reading on the meter of the value of R_x in ohms.

Phase. The block diagram of a phase converter is shown in Fig. 13. The square wave from the signal chain starts a flip-flop (bistable) while the square wave from the reference source stops it. Thus the duration of the on period of the flip-flop depends on the relative phasing of the two signals being compared. The mark/space ratio of the resulting pulses depends on the phase relationship between the two incoming signals. These pulses are fed to a low-pass filter the d.c. output of which has an amplitude determined by the mark/space ratio and therefore the phase difference.

Capacitance and dissipation factor. An alternating voltage is applied to the capacitor on test and d.c. voltages proportional to the p.d. across the capacitor and the current flowing through it are derived. The ratio of these two voltages is a measure of the capacitance.

The dissipation factor of the capacitor is the ratio of the power dissipated to the reactive 'power'. A test current is passed through the capacitor, and the induced voltage is separated into components in phase and 90 degrees out of phase with the test current. The product of the current and the in-phase voltage is the dissipated power, the product of the current and the quadrature voltage is the reactive power. Since the current is common to both factors the dissipation factor is obtained by using a d.v.m. to measure the ratio of the two voltages.

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APPENDIX

Rejection of Unwanted A.C.

Series- (or normal) mode pick-up. This type of interference is normally induced magnetically in the loop of wiring which constitutes the input connections. If the wiring is substantially symmetrical the unwanted signal will appear across the input terminals with 180 degrees phase difference. Fig. 14(a) is the equivalent circuit. Obviously the normal precautions, such as keeping the wiring loop small and careful layout of the wiring will help to reduce this effect. A method of reducing this signal is to interpose a filter system cutting off below the mains frequency, between the input terminals and the amplifier resulting in a reduction in the speed of response of the system. Another method, as previously mentioned, is to use integrating techniques.

Common-mode pick-up. This form of interference is induced in parallel with the input leads (due to capacitance and insulation leakage). If the whole input circuit were absolutely balanced with respect to earth, the interference would be self-cancelling. Asymmetry in the circuit causes a partial conversion to series mode which, in turn, is cancelled as described above. The effects of common-mode interference can be reduced substantially by the use of guarded techniques.

Fig. 14(b) shows a simplified equivalent circuit without a guard. (Some capacitance may exist in addition between the "Hi" lead and earth but may be disregarded here.)

Currents I_{cm} and I'_{cm} flow to earth by the routes shown. Since the lower impedance path is via the "Lo" lead and C_{Lo-E} to earth the majority of the current flows through it, resulting in a p.d. between the end of R_{in} and, consequently, an unwanted signal to the amplifier.

If a guard is employed (i.e. a screen isolated from earth) the configuration is as shown in Fig. 14(c), where the capacitance from the "Lo" terminal to earth (C_{Lo-E}) is replaced by two capacitors in series (C_{L-G} and C_{G-E}). Ignore the connection from the guard to the high potential end of V_{cm} for a moment. If the guard were now to be earthed at the instrument (as seems the right thing to do) C_{G-E} will be short-circuited, the circuit will revert to Fig. 14(b) and the guard will have no effect. If we connect the guard to V_{cm} as shown (preferably by means of the inner screen on double screened lead) and assume similar characteristics for the "Lo" lead and the guard connection, it becomes obvious that corresponding points on the guard and the "Lo" connection will at any time be at the same potential and will move in sympathy with V_{cm}. This means, effectively, that C_{L-G} is zero, or, in practice, very low and since C_{L-G} is in series with C_{G-E} the capacitance from "Lo" to earth is low. Thus the majority of the common-mode current will follow the low impedance path, flowing harmlessly via the guard to earth. Because the current in the "Lo" lead is small, a fair amount of resistive unbalance will not affect the above reasoning—only very long leads with appreciable series reactance will upset matters.

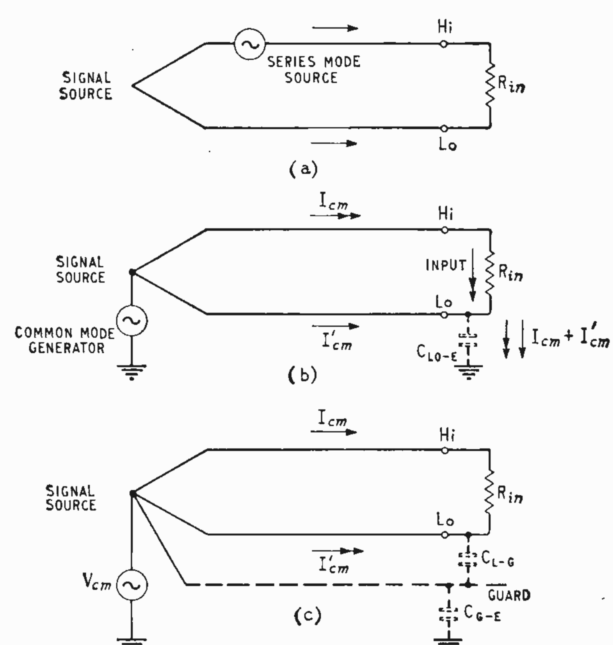


Fig. 14. (a) series mode (b) common mode without guard (c) common mode with guard—equivalent circuits.

Radio Receiver Developments

South Wales Conference on Systems for Long- and Medium-Distance Reception

THE University College of Swansea, overlooking the sea and backed by parkland, provided a pleasant setting for a lively conference on radio receiver systems, organized by the College's Division of Electrical Engineering and supported by the I.E.R.E. Domestic receiver manufacturers, many of whom were noticeable by their absence, came under fire from several speakers. K. R. Sturley (B.B.C.) in an introductory paper, pointed out that British manufacturers could sell large quantities overseas if sets were made competitive and more attention was paid to the v.h.f. and short-wave bands. He also pointed out that British manufacturers succeeded in capturing only 37% of the home market last year. On the other hand Jens Bang (Bang & Olufsen) thought that the trend towards cheapness was a mistake and that Britain should retain her identity with quality at almost any price. He also thought that the home market should be recaptured before trying to sell abroad.

M. J. Gay and M. C. Sucker (Plessey) described an integrated-circuit a.m. receiver on a single chip, the i.c. replacing all the conventional circuitry (including a 3 W a.f. stage), apart from the tuned circuits. It is thought that when in full scale production the chip will cost about half as much as the discrete components it replaces. The mixer provides 40 dB of conversion gain and over 90 dB of a.g.c. control. The audio amplifier uses two n-p-n transistors in class AB output stage.[1]

Modifications to the single-span[2] and the homodyne[3] types of receiver were described by R. C. V. Macario (University College of Swansea) together with an aerial system for domestic receivers aimed at replacing the ferrite rod. This aerial has been found to show " less noise and greater clarity " and does not suffer from the directional properties of the ferrite rod.

The equivalent circuit of a wire aerial of height $=h$ appears as a voltage generator, $e_a = hE_o$, where E_o is the vertical field strength, in series with the free-space capacitance $C_a(h)$, normally a few picofarads. Two ways of matching this are shown in Fig. 1. In either case the need is to have the input capacitance $C_1 < C_a$. If one is prepared to place a coil across this input, which must be tunable, one can obtain Q times the previous voltage (Q = coil Q factor). The chief need is to have low self capacitance. A gyrator circuit could be employed to provide this inductance and be voltage variable.

The circuit employed by Dr. Macario is shown in Fig. 2. The input impedance is approximately 4 pF shunted by about 10 MΩ. The aerial arrangement is two parallel copper plates. C_a is approximately given by:

$$C_a \approx C_{ao} + K \frac{\text{Plate area}}{h}$$

while

$$e_a = hE_o$$

Combining these in the expressions given in Fig. 1 shows that v_a going into the receiver behaves as in Fig. 3.

A multiple-beam receiving aerial system was described by J. T. Starbuck (Plessey). The aim was to produce an all round looking aerial that did not require the large acreage occupied by the more conventional rhombic array. In all 24 mono-pole aerials are used, spaced

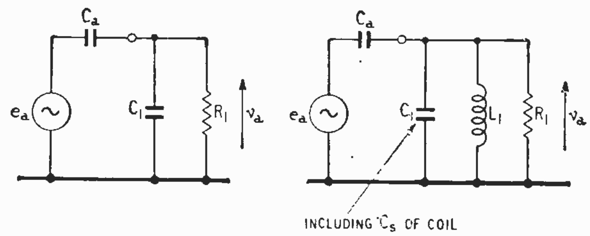


Fig. 1. Aerial equivalent circuits. In the l.h. drawing $v_a = [C_a/(C_a + C_1)]e_a$, and $R_1 > 1/\omega C_1$. In the r.h. drawing $v_a = [C_a/(C_a + C_1)]Q.e_a$.

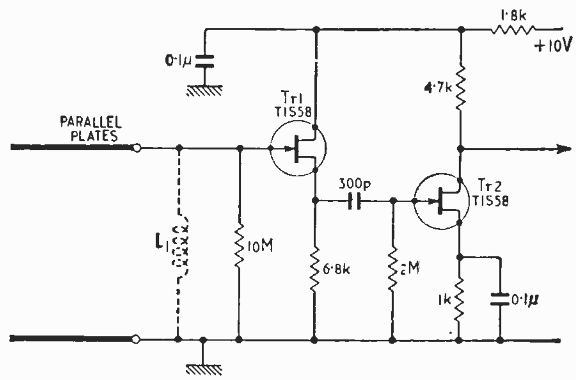


Fig. 2. The broadband amplifier circuit.

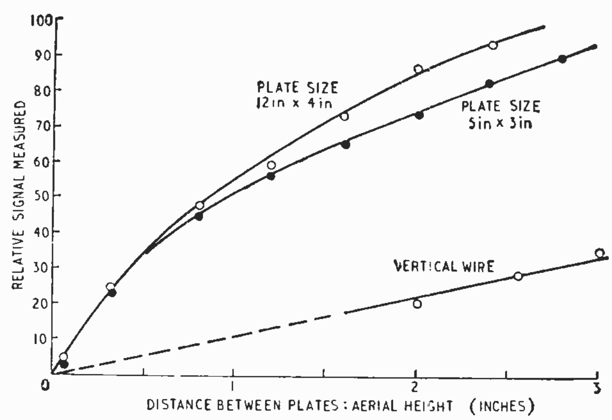


Fig. 3. v_a into the receiver using the aerial amplifier.

equidistantly round the circumference of a 500 ft diameter circle (Fig. 4). The aerials are connected by cables of equal electrical length to a passive beam-forming network. This network, consisting of mixers and delays, synthesizes 24 simultaneous beams at 15° intervals. In Fig. 4, a beam arriving in the direction of the arrows would be received by aerials 3—10, the beam forming

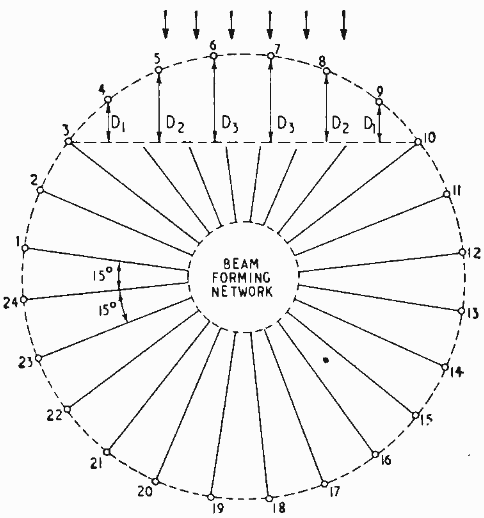


Fig. 4. A plan view of the 24 aerials used in the multiple beam receiving array.

network providing delays corresponding to the lengths D1 to D3. A beam situated 15° in a clockwise direction from the one shown would be formed by combining the signals from aerials 4 to 11.

Another interesting aerial system was an active aerial intended for aircraft use, described by D. E. T. Nichols (R.A.E., Farnborough). It is difficult to site one aerial on an aircraft in such a way as to achieve an omnidirectional radiation pattern, but by combining the signals of two aerials which between them radiate in all azimuths, it is possible to provide all-round cover. To avoid interference effects in the direction in which the aerials operate the signals must be brought into phase, and some

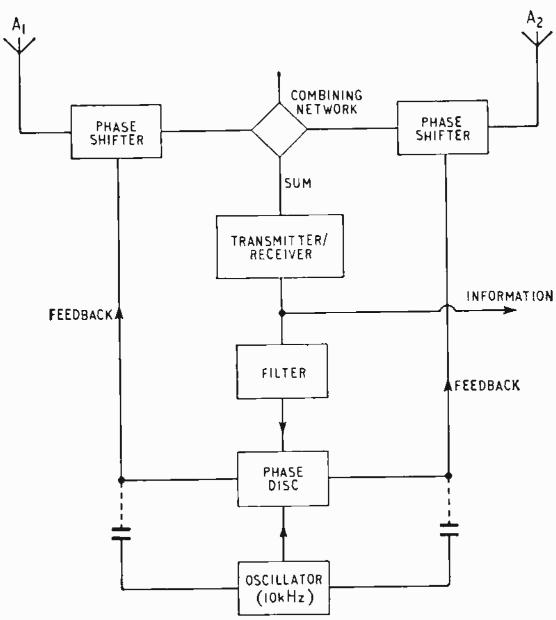


Fig. 5. Showing how the gain of the receiver is used in the control loop of the active aerial system.

form of control loop is necessary to achieve this. Such a loop requires gain and it is a feature of this system that the gain of the aircraft receiver is utilized for this purpose. One system that had been employed is shown in Fig. 5.

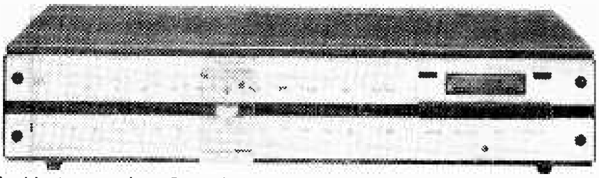
The outputs of the two aerials are fed to the receiver via two varicap diode phase shifters. The carrier of the received signal is phase modulated (about 6°) by the 10 kHz oscillator. At the output the 10 kHz signal is filtered out and compared in phase with that from the original oscillator. Any phase difference results in a d.c. control signal to the phase shifters. This system suffers from the disadvantage of causing distortion when the aircraft is transmitting, because of the non-linearity of the varicap diodes. This has been overcome by using a stepped phase shifter, the phase shifts being achieved by an analogue-to-digital converter in the d.c. control line switching in sections of the phase shifter via p-i-n diodes. This system is said to remove blind spots of up to 20 dB in the aerials' polar diagram.

Professor W. Gosling (University College of Swansea) gave an interesting paper on filters for radio systems based on proton magnetic resonance (p.m.r.). Extremely high-Q resonances occur as a result of nuclear magnetism, and in the case of p.m.r., bandwidths of only a fraction of a hertz are intrinsically possible. The main difficulty in using p.m.r. in radio systems is the fact that the equivalent circuit is that of a high-Q series resonant circuit shunted by a large non-resonant admittance. A possible solution to the problem is the use of dynamic polarization (Overhouser effect) to enhance the p.m.r. effect. Enhancement of two orders of magnitude is possible with a reversal in sign. These effects are achieved by including a suitable dissolved paramagnetic substance in the proton-bearing fluid and pumping with r.f. power at paramagnetic frequency. The resulting filter has frequency selective limiting properties and bandwidth and centre frequency can be adjusted independently.

There was a good deal of discussion on the problem of making the best possible use of the radio frequency spectrum. In broadcasting, R. A. Rowden (B.B.C.) said that the medium-wave band was probably here to stay but greater advantage could be taken of it by using a compatible single-sideband system. This had already been tried experimentally in some countries. Other speakers commented that although a compatible s.s.b. system might be necessary during the change-over period it implied mediocrity. Non-compatible s.s.b. would be one way of killing off the trade in cheap imported transistor receivers. Mr. Rowden said it might be possible to manufacture dual-purpose receivers, just as dual-standard sets have been provided for television, if there were sufficient demand. He also pointed out that s.s.b. and stereophony were compatible with each other. Another type of modulation system which possibly could be used was pulse code modulation, and this was particularly useful for broadcasting from satellites (see p. 527).

Meanwhile (it emerged from the discussion) consideration is being given to getting more broadcasting stations into the medium-wave band by cutting off sidebands and making the channels narrower. This approach was being taken, said Mr. Rowden, on the principle that listeners who wanted high-quality sound programmes turned automatically to the v.h.f. services, so it would not matter very much if the m.w. transmissions were restricted in this way. He believed that one European station had already tried sideband cutting for a period and there had been no reports of complaints from listeners.

A. J. H. Oxford (Plessey) considered the problem of congestion in the bands used for h.f. communications. He



In his lecture Jens Bang briefly described this latest product of his company, the Beomaster 5000, a stereo f.m. tuner of advanced design. It has an r.f. amplifier with four gang-tuned circuits; separate oscillator and mixer functions; five i.f. stages (bandwith 300 kHz) giving good selectivity; and automatic mono/stereo switching with adjustable switching level. Sensitivity is 1.5 μV. The tuner is actually a part of a complete hi-fi system, Beolab 5000, just introduced by the company.

said the h.f. band was not as saturated as was generally thought, in terms of actual occupancy of the channels allocated, and mentioned that his company had built monitoring equipment operating between 1.5 MHz and 30 MHz to get some idea of what this occupancy was. They had been astonished to discover how low it was. One big problem was the restrictive practice of users putting out " idling " transmissions merely to keep their allocations " warm," but many radio communications systems were not technically efficient and it was this fact that led to the restrictive practices.

Allocation of frequency bands was done on a three-dimensional basis—frequency, space (geographical) and time—but there was also a fourth dimension which could be exploited by the use of codes. Communication signals could be carried by means of pseudo-random codes[4], and although each code, being of the character of noise, would require a wide frequency band (about 1 MHz), a number of coded transmissions could be superimposed within that band. At each receiving station the wanted signal would be selected by correlation technique, using a local p.r.c. corresponding to that transmitted, while the other, unwanted transmissions in the band would be present merely in the form of noise. Thus, in a given frequency band allocated to a number of stations in this manner, the occupancy of the band would be higher than with the present system. Another speaker also pointed out that since the ability to receive a wanted signal would depend on the number of stations operating at the time, the restrictive practice of " idling " would be discouraged.

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Direct Broadcasting from Satellites

WITHIN the next ten years broadcasting services from stationary satellites using transmitter powers up to 10 kW may become practicable, according to R. A. Rowden of the B.B.C. Research Department. These would be essentially for large areas such as Australia and the U.S.A. where they would be of great value because they would not be subject to the fading and other effects experienced with terrestrial broadcasting. Mr. Rowden, speaking at the University of Swansea Radio Receiver Conference reported above, presented some theoretical figures indicating what frequencies, powers and other transmission parameters might be feasible for sound broadcasting, and these are given in the accompanying table.

It will be seen that three main bands have been considered—short-waves, v.h.f. and microwaves—with channels wide enough to allow good quality sound. The big problem, of course, is the restriction on the amount of transmitting equipment that can be carried in a satellite, and this means a restriction on transmitter power and size of aerial. Where the largest possible area has to be covered the aerial beam must be wide (e.g., the 17.5° shown in the table) and consequently the aerial diameter can be small but the transmitted power must be large. For smaller area coverage (e.g., the 2.5° beam width), the aerial diameter has to be large but the transmitted power can be quite small. In the short-wave section the power and aerial diameter requirements look unrealistic at present. Between the extremes shown in the table, however, there are conditions which allow moderate powers and aerial sizes (indicated in heavy type) and Mr. Rowden said it would probably be these that would be the first to come into use.

At the receiving end, the figures assume the use of a single half-wave dipole aerial for the short-wave transmissions, a multi-element array for the v.h.f. and a microwave dish for the s.h.f. At present many short-wave broadcast receivers are not capable of picking up the frequencies shown (actually two bands: 21.47-21.7 MHz and 25.6-26.1 MHz). Mr. Rowden pointed out that a distinctive feature of satellite transmissions was that all receivers in the service area got practically the same signal strength. This meant that reception conditions might compare unfavourably with those experienced by large numbers of people in the vicinity of terrestrial broadcasting stations. As a result it was necessary to lay down higher signal-to-noise ratio requirements when planning satellite broadcasting systems.

CHARACTERISTICS OF SATELLITE TRANSMISSIONS

Service and frequencies	Channel width	No. of channels	Satellite Transmitter			Receiver aerial gain (relative to ½λ dipole)
			Beam width (deg.)	Aerial dia. (m)	Power (kW)	
High-quality a.m. sound on short waves 21.45 to 26.1 MHz	20 kHz	37	17.5 7.0 2.5	60 150 420	1250 200 25	0 (simple dipole)
F.M. sound on v.h.f. 87.5 to 100 MHz	200 kHz	62	17.5 7.0 2.5	12 30 84	1.6 0.25 0.032	6
F.M. sound on microwaves 11.7 to 12.7 GHz	200 kHz	5,000	17.5 7.0 2.5	0.1 0.25 0.7	60 10 1	30

AUTOMATIC LANDING IN AIRLINE SERVICE

Recent British developments

By R. E. YOUNG, B.Sc.(Eng.), F.I.E.E, A.F.R.Ae.S.

THIS winter will see British airliners being landed automatically as a normal service operation, according to Smiths Industries Ltd. It will be the culmination of a unique ground/air development project "with an automatic landing capability extending to 'zero-zero' operation."* In other words, the system should ultimately provide complete blind landing to touch-down. Probably automatic landing will become a routine service occurrence from 1970 onwards.

It has been recognized for many years that unrestricted all-weather landing is necessary to a completely reliable air transport service. Here "reliability" has two major components: the overriding one of safety (avoidance of accidents), and availability of the service. Apart from fatal accidents, where loss of life cannot be measured by monetary standards, safety and availability can be considered in terms of their economics. Thus, even in 1962 it was stated that for B.E.A. alone more than £60,000 per year could be saved if full all-weather landing could be achieved and diversions to other airfields could be avoided.

The other main incentive to the adoption of a blind landing system is the gain resulting from the avoidance of accidents. The assessment of this gain must necessarily be based on some arbitrary reliability criterion which will be accepted operationally. At present this is a failure rate of less than one failure in 10 million landings; and it applies to the overall ground and aircraft control loop. This figure of 1 in 10^7 for an automatic landing system is usually quoted as having been established as "one order better" than the risk associated with conventional pilot operation (taken as 1 in 10^6). There has been discussion, however, on whether this failure-rate criterion should be raised, perhaps to 1 in 10^8, because of the ever-growing number of aircraft landings. For a single airline these may well total more than 100,000 landings per year.

By using all-weather automatic landing to reduce accidents a single airline might expect to save nearly £2M over a seven-year period. If this figure is multiplied by the number of airlines making regular landings at, say, London Airport only, it enters the tens of millions of pounds region, and amply justifies the large expenditure of money and effort which has been made on all-weather landing in the U.K.

Another pressure behind the development of blind landing is the fact that journeys on the ground between city centres and airports usually take an unreasonably long time relative to the duration of the flights themselves, and as a result, other means of transport, such as high-speed trains, become extremely competitive. As soon as fog delays take-off or causes aircraft to be diverted this competition increases.

It is therefore logical that B.E.A., with its large proportion of short-haul work, should have declared its intention at an early stage to adopt an automatic landing system. B.E.A. Trident aircraft have been used for the proving flights, and they received passenger-carrying certification for landing to touchdown under automatic control of "flare-out" as early as June 1965.

THE BASIC LANDING PROCESS

Transfer to landing usually begins at a distance where the runway is in view under normal "visual" conditions with the aircraft at a height of 1,500-1,000ft. Prior to this, approach will have been under I.L.S. (Instrument Landing System) guidance along a course length determined by local Air Traffic Control requirements, and with a maximum "Cat. III" limit of 25 nautical miles.

Under automatic control the pilot selects "land" at a height of about 1,000ft; and the first phase of descent takes place with I.L.S. guidance in both azimuth and elevation. The next part of the descent is a "constant-attitude" phase lasting from some 200ft to roughly 50ft above the runway; during this phase the rate of descent is held at a value determined by the attitude of the aircraft in pitch. The final descent to the runway, the "flare-out" under the control of the radio altimeter, takes place from the critical height of 50-60ft to touch-down (Fig. 1).

The desired flare-out path, which is exponential, is expressed in a relatively simple control equation:

$$\theta_D = h + \tau \ (dh/dt)$$

where θ_D is the pitch attitude (demanded) and h is the height of the aircraft. The time constant τ is made

R. E. Young, after serving in industry as a graduate apprentice, joined the B.B.C. He served for six years as a headquarters staff officer in R.A.F. 60 (Radar) Group. He went to Rank Cintel in 1947 to work primarily on radio links for television. In 1949 he joined the Hawker Siddeley Group as chief electronics engineer and later was electronics manager for Sir W. G. Armstrong Whitworth Aircraft. Since 1961 he has been a consulting engineer.

* The ability to land under adverse weather conditions is related, in effect, to a descent through cloud. Thus the two values in the international "Category" system give the height below which the aircraft must be out of cloud (the cloudbase), and the forward visibility. These figures consequently become "zero-zero" for the "blind" conditions of thick fog down to runway level.

relatively short—about 5 seconds—in order to avoid the build-up of excessive servo lags.

In addition to manoeuvring control, variation in throttle setting is required during landing; and an automatic throttle control system is responsible for adjusting engine speed throughout the descent.

Thus, once the automatic landing equipment is engaged, the pilot is completely "out of the loop," and British philosophy is that he will not be called upon to take back control at any point during the ensuing landing sequence. This thesis—that the pilot's direct authority is surrendered entirely during all-weather landing—is in marked contrast to that adopted in the U.S.A. in the past[1,2]. It should be remembered that conditions are very different in America—an obvious example being the weather—and generalization is dangerous. Nevertheless, the American attitude can be largely summed up in the concept of the pilot being a "systems manager," and that even with automatic landing he should not be in a subordinate position to the machine.

Considering the two distinct landing control processes, in the vertical and horizontal planes, it becomes evident that the former is appreciably more complex, both technically and operationally. Whereas three specific phases are encountered in vertical control during landing, continuous operation with a single—I.L.S.—transmitting system is now being offered for lateral control. Certain problems with I.L.S. were discussed in the May 1967 issue of *Wireless World* ("I.L.S. for Automatic Landing"); and two possible solutions due to R.A.E., the "down-wind localizer" and "correlation protected I.L.S.," were described. A further alternative, developed by Standard Telephones and Cables Ltd., has been under evaluation test for a considerable time, and will be outlined later in this article.

During the descent of the aircraft the change-over between phases must be as smooth as possible in order to avoid discontinuities in the control signal. This is important, not only because of the momentary disturbance which may follow and must be guarded against in the system design, but also because of the introduction of noise at the switching transitions. The control errors associated with these effects can be significant during the last hundred feet of descent and particularly during flare-out from the critical height down to the runway. There is consequently a good case for the retention of the pilot in so far as he is both continuous and adaptive as a master control mechanism during landing. However, as has already been indicated, an equivalent standard of performance can be reached with an automatic landing system, and this brings with it the pronounced advantage of being consistent in performance. This means, for instance, that landing can be expected to be always along the same—optimum—path of descent, so that excessive application of reverse thrust and braking do not become necessary as in the extreme case of a late touch-down. This leads in turn to the reduction of stress on both aircraft and passengers.

THE "AUTOLAND" SYSTEM

Stemming from the original work of the Blind Landing Experimental Unit (B.L.E.U.) of the Royal Aircraft Establishment, and developed under their aegis, the Autoland system has now over 20,000 aircraft landings to its credit. The fundamental system has been little changed since its inception, except in azimuth guidance. I.L.S. glide path and radio altimeter information have always been employed for the controlled descent path, but initially lateral control from the runway entry onwards was by magnetic induction from a "leader cable."

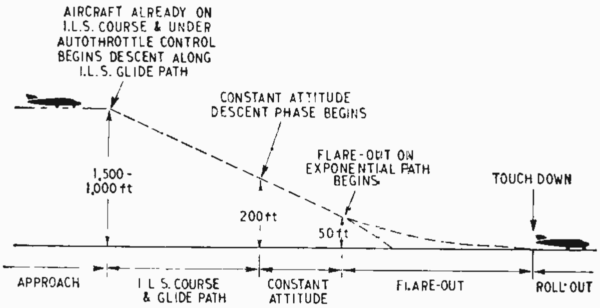

Fig. 1. Vertical plane diagram of the automatic landing sequence (not to scale). I.L.S. azimuth guidance is provided throughout.

It is likely that Autoland would have proved a much more intractable project if the leader-cable technique had not been carried on when extremely difficult problems of installation were encountered. The technical performance of the leader-cable method was such that it provided a necessary "climate of confidence."

Two advantages of the leader-cable method are:—

(a) Practically noise-free signals due to the relatively close proximity of the aircraft to the emitting source, and also due to the narrow signal bandwidth (1 kHz) of the rotating loop pick-up system.

(b) Constant sensitivity (not a direct property of radio beams) over the whole length of the cable runs.

The installation problems mentioned above arose mainly from the need for the cables to extend at least a mile beyond the approach end of the runway, and this ruled out the system for a surprisingly large number of civil airports. In many instances buildings or other obstacles were in the way, and there were the extreme cases where approach was over an estuary or inlet, or the runway was built out into the sea as at Hong Kong and Wellington, N.Z.

Nevertheless leader-cable techniques may still remain in use to give guidance from the end of the runway to the terminal building—an extremely valuable aid for ground handling during thick fog.

Other problems arise when attempts are made to achieve full azimuth guidance for blind landing entirely with I.L.S. equipment. The basic trouble is the distortion of the I.L.S. guidance pattern (transmitted signal polar diagram) set up by reflections from buildings and imperfections of the site. This distortion is described as "beam-" or "course-bend" (azimuth) and is expressed quantitatively in terms of the spurious modulation signal which it produces. The value of this spurious signal, and also the legitimate I.L.S. "deflection" guidance signals, is given as a d.d.m. (difference in depth of modulation) figure. This is usually a percentage and represents the (angular) deviation of the aircraft from the ideal flight lines in azimuth and elevation. These become zero deviation, and hence zero d.d.m., lines for a conventional I.L.S. system, and correspond with runway centre line and I.L.S. glide path respectively.

The almost complete elimination of these reflection effects, with a consequent ability to give "all the way" azimuth guidance, has been claimed by Standard Telephones and Cables Ltd. for a system using a technique called "quadrature clearance." This system, disclosed at the time of the 1966 Farnborough Show, radiates both the narrow "course" beam and the much wider "clearance" beam (see front cover) from a single transmitter and aerial array, in contrast to the two separate transmitters with their individual carrier frequencies as used in the past. The beam-width requirements (to null points) for the radiated pattern are $\pm 11.5°$ for the precision "course" zone, and $\pm 35°$ for the inward directing "clearance" zone.

The aerial array comprises 12 horizontal dipole elements backed by an 18 ft (5.4 m) high by 85 ft (26 m) wide reflector in the vertical plane. This array, which is a non-duplicated part of the system, has a predicted m.t.b.f. (mean time between failures) of 250 years, or 10 years for the special condition of worst-case corrosion. A major feature of the array (constructed from aluminium sheet bonded to balsa wood girders) is the "frangibility" which has been built into the structure to ensure its collapse if struck by an aircraft in difficulty, e.g. during an "overshoot," or if suffering distortion due to wind sufficient to cause significant beam bending (60 m.p.h. steady or 100 m.p.h. gusting). Collapse takes place as a folding action relative to a horizontal axis on the failure of nickel-silver shear pins, which behave as mechanical fuses.

"Quadrature clearance" is the radiation of the clearance beam "tone" 90° out of phase (in phase quadrature) with the course beam "tone." This is achieved by a mechanical modulator unit in which the various forms of modulation are locked solidly in phase relationship to one another by means of common drive shaft. (Fig. 2.)

The development of this quadrature separation technique has made it possible to impose the "course" and "clearance" tones as individual signals upon the 110-MHz single carrier frequency transmission. A constant phase relationship is therefore maintained between the various frequencies emitted from the one radiating source, so that, in contrast to the two-transmitter configuration, differences in their effective path lengths between the common source and any reflecting features are, in this sense, kept small and relatively constant. This means that the reflection errors themselves are kept down. A beam-bend of 0.4% d.d.m. with the two-frequency method is said to be reduced to 0.14% d.d.m. by a change to the quadrature-clearance technique.

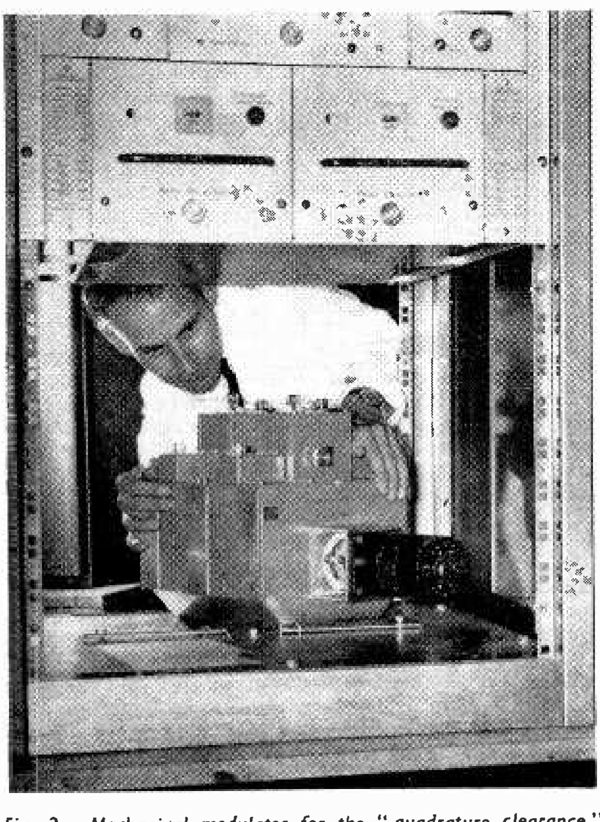

Fig. 2. Mechanical modulator for the "quadrature clearance" system used in I.L.S. ground equipment recently introduced by S.T.C.

The azimuth guidance (localizer) transmitter (Fig. 3), as with the other ground equipment, is completely solid-state, and is believed to be unique in not having to use thermionic valves in the output stage. The localizer ground installation has a failure rate claimed to be 1 in 10". This results from a dual system arrangement in which both main and standby transmitters are continuously under power, and automatic changeover to standby in the event of a fault is initiated by a triple redundancy monitoring group working on a two-out-of-three agreement basis. Feed change-over takes place in 10 milliseconds with full operational facilities restored in less than $\frac{1}{2}$ sec. Monitoring equipment is fed from a set of equipment internal parameters, and two radiated-signal probes—a local "aperture monitor" and a separate "near field monitor" (Fig. 3). Maintenance is based on a "lock-up and leave" philosophy in which purely routine inspection visits are made at 6- or even 12-month intervals. Separate battery supplies are provided for each of the transmitters and the monitors. The batteries are floated across constant-voltage chargers, consumption being such that the equipment will continue to function for at least two hours without fall-off in performance should mains failure occur.

A similar systems layout is adopted for the glide-path installation, triple monitoring and automatic change-over of the dual transmitted chains being carried out in the same way. The tower-mounted aerial array for the 330-MHz glide-path band consists of two vertically separated dipole groups with two near-field monitoring probe assemblies.

The dual transmitter marker beacon is of advanced design, using integrated circuits, to give an extremely compact mechanical assembly which makes the minimum demands on the facilities. The two-element aerial and monitoring probe system are carried as an extension of a single mounting pole to which the beacon equipment is attached. Power supply is by batteries, which are trickle-charged at 60 mA over the remote control lines from the main station. Service operation is possible without external supply for at least a week. The aerial arrangement is such that the radiation polar diagram is shaped to give a more sharply defined lobe pattern than with earlier types of beacon.

THE RADIO ALTIMETER ASPECT

Throughout the development of the Autoland system, the radio altimeter has been of the frequency modulated c.w. type due to Standard Telephones and Cables Ltd. A mean transmitter frequency of 4,300 MHz swept over a 100 MHz band has been adopted for most models; in the STR 52 set, for example, this f.m. rate was 300 Hz and the counter integrating time about 0.25 second.

Few alternatives to this operating principle appear to exist. A possible method is to measure rate of change of height (vertical velocity) by a Doppler radar method; and work has been done on such systems in the U.S.A. The great advantage claimed for this method is that the velocity data is largely free of noise, particularly trans-

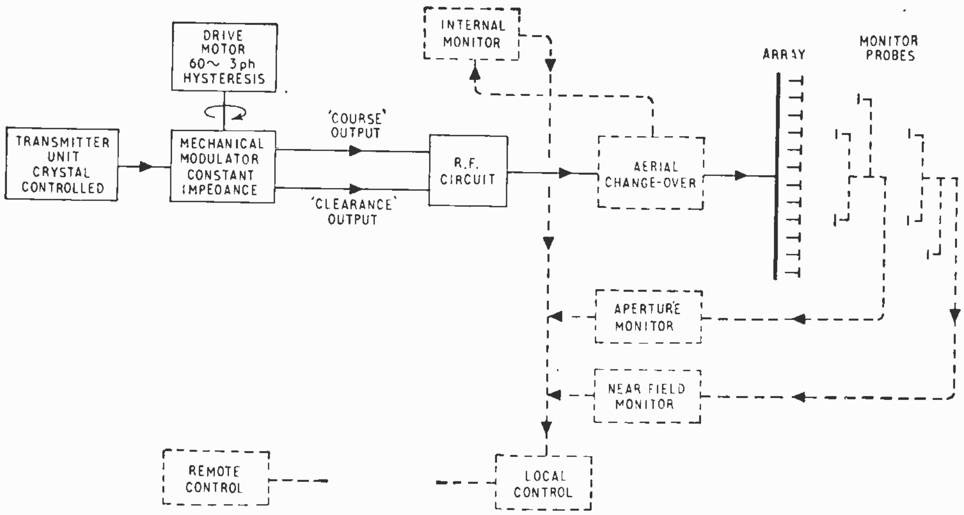

Fig. 3. I.L.S. "quadrature clearance" system; block schematic of the localizer transmitter equipment.

ient responses obtained from hangars and similar changes in surface level as "seen" during the passage of the aircraft along the runway. This is contrasted with the conventional f.m. radio altimeter which gives absolute height as primary data, and from which velocity is obtained by differentiation. In this case there is a tendency for differentiation of the transient signals to produce appreciable noise, and for the filtering which is employed to be responsible for some wander in the derived value of velocity.

However, these effects can be kept to a satisfactory minimum with the f.m. type of instrument, which gives the good height accuracy necessary for automatic landing, particularly at touchdown. Thus with the STR 52 and the latest STR 70P radio altimeters, height accuracy is ±3% or ±3 ft (whichever is greater) within the height range of 0 to 500 ft, becoming ±1 ft at touchdown. This value at touchdown is of great importance because of the practical requirement to have a small residual dh/dt at this point. Consequently, the zero height datum has to be set below ground (specific runway) level. Thus, with a virtual datum at about −2 ft, altimeter wander must be kept well inside the 1-ft tolerance.

Therefore a problem exists with the Doppler method in that an accurate height must be found, and, in doing this by integrating dh/dt, the constant of integration must be determined by some means to give the absolute height value. The solution in this case is by no means clear. It is understood that the use of two Doppler altimeters with carrier frequencies separated by a small difference has been suggested to give sufficient additional information to enable the constant of integration to be extracted. An immediate objection is the additional cost and complexity of the dual scheme.

The latest S.T.C. radio altimeter, the type STR 70P, is of microminiaturized construction, the complete transmitter-receiver unit weighing 6 lb (Fig. 4). Interchangeable plug-in modules enable eight variants to be made available for various flight control system requirements. The equipment is totally solid-state with varactor transmitter modulation. Specially designed wave-guide type aerials with coaxial line feed are arranged for flush mounting on the skin of the aircraft fuselage. An in-flight confidence check is provided by switching in r.f. delay line units, one to each aerial, to simulate a ground return signal path over which a test can be made corresponding with a given critical operating height.

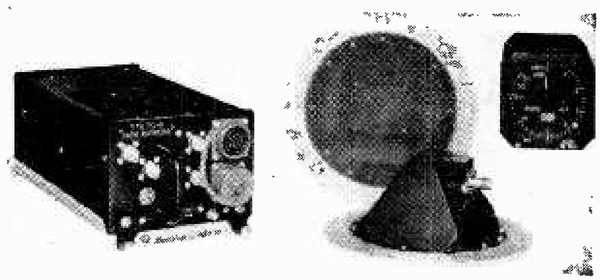

Fig. 4. Radio altimeter used in automatic landing.

THE NEXT FIVE YEARS

The stage has been reached where major decisions must be taken on the introduction and certification of automatic landing in airline service. Safety is an over-riding consideration, and, just as the failure rate criterion of 1 in 10^7 has been established on statistical grounds, so the final assessment of the reliability of the system must be made in terms of the statistics of actual operation. Thus, on the assumption that the technical capability of the system has been accepted, a decision must be made as to the form and duration of the testing programme which will justify official approval. Obviously data can be collected under other than nominal blind landing conditions and fed into the assessment process, so that the progressive stages of clearance may be speeded up. It may be possible to remove quite early on the requirement for "runway visual range" (of the order of 50 yards) still to be available to the pilot before an automatic landing is permitted.

As already indicated, the figure of 1 in 10^7 is under scrutiny, particularly in the U.S.A.; but it may be that within the next five years more emphasis will be placed on the 1 in 10^9 criterion for specific system blocks as adopted, for instance, for the complete I.L.S. localizer installation. This would get away from the difficulty of defining the "spread" over which the former should apply, and would be in line with the trends which can now be discerned in the assessment of equipment reliability.

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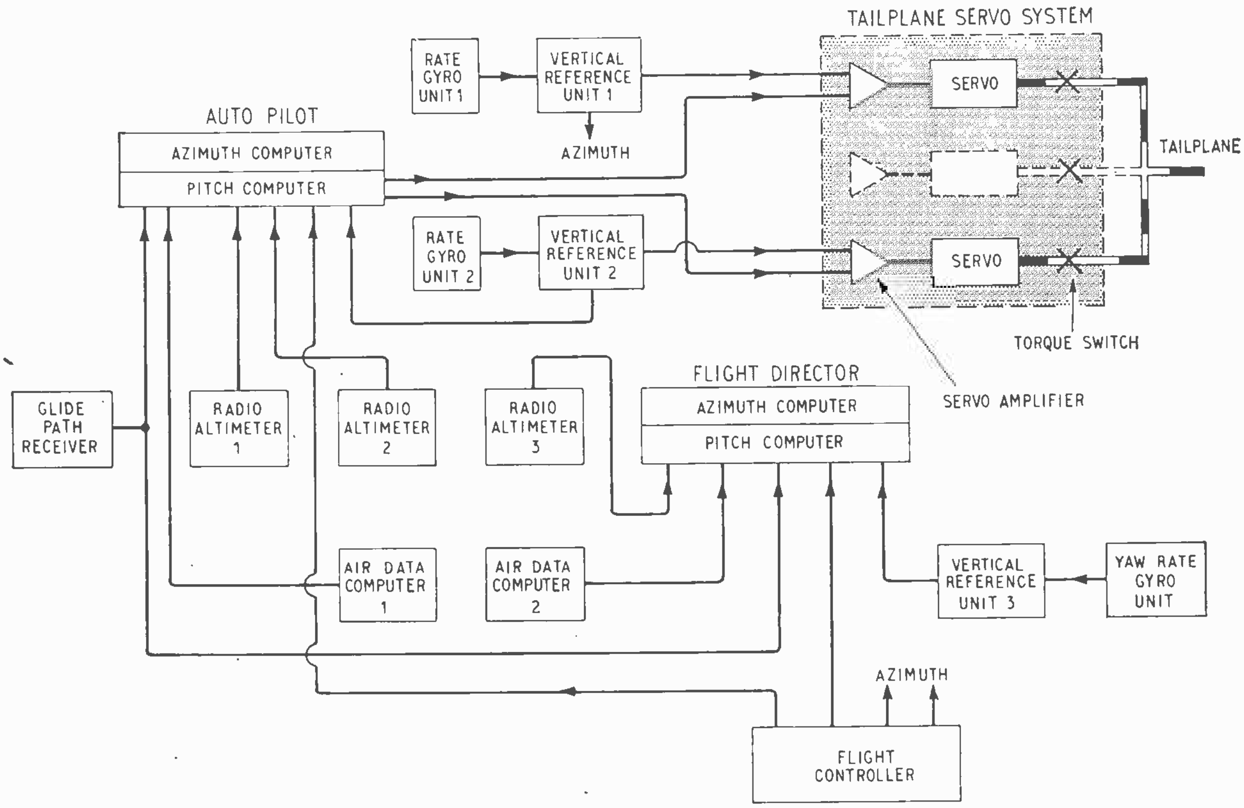
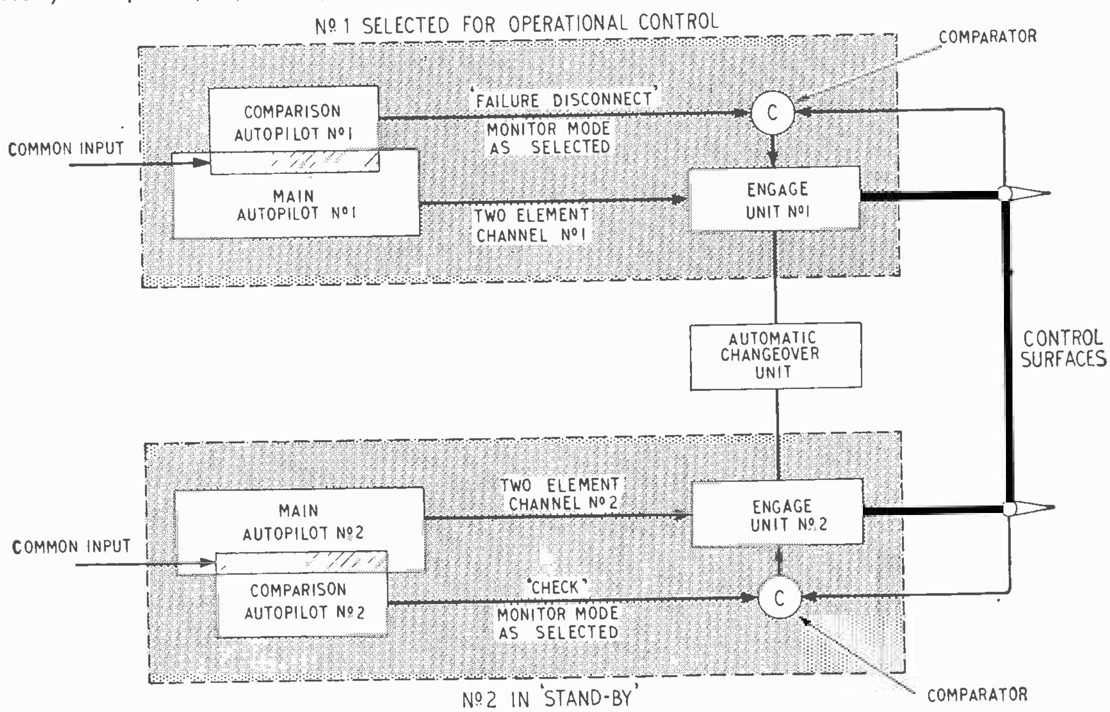


(Above) *Fig. 5. Part of Smiths system for the Trident. There are four servo " streams," for aileron, rudder, tail-plane and automatic throttle control. The tail-plane system is shown here at duplex level (it is actually triplex), working with three radio altimeters and three vertical reference units. Executive computation is done in the autopilot units, the corresponding process in the flight director computers being for display.*

(Below) *Fig. 6. Elliott's " monitored duplicate " system for the VC 10. Each control chain is self-contained, and 100% redundancy is provided " selectively " in areas where failure is likely to occur. Only one chain is in control of the aircraft at any time, the other being in the stand-by condition ready to accept transfer of control if demanded by the " failure disconnect " monitoring on the operational chain.*



These extremely high reliability figures demand considerable system redundancy. Thus in the airborne case, the Smiths flight control system, centred on the SEP5 autopilot, is fixed at triplex level for "zero-zero" landing with the Trident. With, basically, three complete control chains operating together, internal monitoring is arranged between all three of the sub-channels. Failure of one sub-channel causes an automatic change-over to the duplex level, which has already been shown in test and in service to have high integrity. Similarly, in the unlikely event of failure at duplex level, the faulty sub-channel is switched out completely to give simplex operation. Thus faults are cleared by switching out defective elements rather than by changing over to stand-by equipment, the design being such that no disturbance is caused to the control of the aircraft, i.e., the system "fails soft".

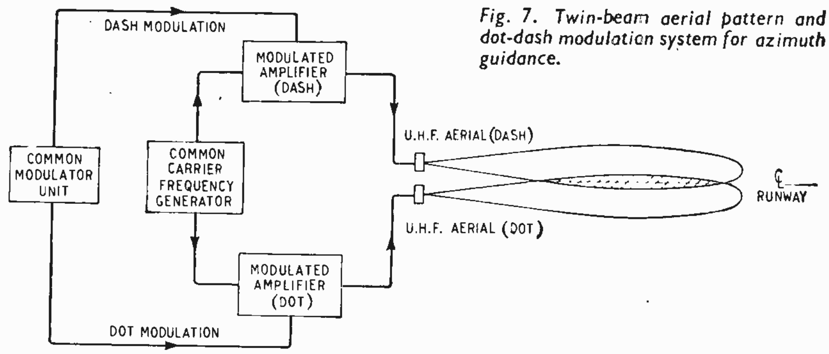


Fig. 7. Twin-beam aerial pattern and dot-dash modulation system for azimuth guidance.

"Pilot monitoring" will probably receive considerable attention during the next five years. At present, the general attitude with Autoland is that a series of simple presentation confidence checks are made just before going over to automatic control, and that no provision is made for any form of pictorial display corresponding with the pilot's clear-weather view. The argument for confining monitoring to a "system display" of autopilot serviceability is strong. Even assuming abnormally short reaction times, it is extremely unlikely that pilot intervention would be successful in the period left to him if a fault occurred at a height below 100ft. Three major decisions are required immediately—the incidence of trouble must be recognized, its nature must be determined, and the proper corrective action must be taken.

Nevertheless, there is an equally strong case for providing the pilot with a "head-up" visual presentation of the equivalent of a runway lighting pattern. This is not only to give him a much more easily appreciated display of the behaviour of the aircraft and its "situation," but also to contribute to flexibility of A.T.C. operation. Thus, if he could "go in" on such a pictorial indication on a path not strictly along the straight course dictated by I.L.S., some help might be given, for instance, with regard to approach over bad noise areas.

Such a presentation system can be fed from the control equipment itself, but this means that the display is suspect, if not useless, when it is most wanted—during an emergency. The alternative is a completely independent system, for which two possible schemes[3] will now be discussed.

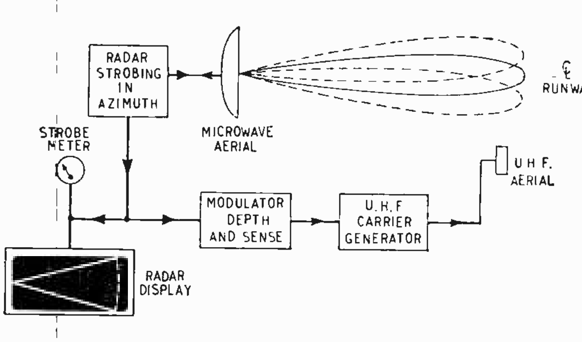


Fig. 8. Radar strobing system for azimuth guidance.

The two schemes—a "derived information" system, and one employing a primary radar principle—have been included here because they represent the outcome of talks with both aircraft designers and pilots, and therefore may have value on this score alone.

The derived information system presents ground-derived guidance intelligence to the pilot in two ways. For the vertical plane, the display of a pulse height-finding radar is passed to the pilot over a ground-to-air television type link. This would be presented to him on a cathode-ray tube screen with his own aircraft appearing as a "blip" against a scaled range and height grid. This information is that seen by a G.C.A. controller, but is passed to the pilot without delay and without transfer errors. Azimuth guidance is transmitted to the aircraft in audible "dot-dash" or similar form, being derived either from a twin-beam pattern (Fig. 7), or from a microwave radar system strobing in azimuth (Fig. 8).

The visual presentation radar method would employ a primary radar in the nose of the aircraft giving a television form of display of passive beacon runway markers. A number of major problems exist in the development of such a system, particularly regarding radiated beam scanning, but it is felt that these are not insuperable. It might be possible to exploit mechanical resonance effects in order to obtain the necessary high aerial oscillation rates in both azimuth and pitch, on the basis of using mechanical scanning with a Cassegrain or similar type of aerial system.

The other outstanding problem which emerges from a design study is that of signal strength in relation to returns-per-scan and the small magnitudes obtained from conventional passive reflectors. However, improvements have been made in passive reflectors (e.g. the spherical microwave reflector developed by the British Aircraft Corporation) which should produce better performance in range compared with, say, equivalent corner reflectors. Also a useful margin for working through the worst condition of heavy tropical rain (two-way attenuation for a 6-mile path reaching 30 to 40 dB) is offered by magnetrons developed by Ferranti giving peak powers of 1 MW at X band (7-12 GHz), and from 100 to 150 kW at Q band (26-40 GHz).

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2. "Why U.S. Lags Europe in Automatic Landing" by R. E. Young. *Electronics, August* 23, 1963.
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Amateur Radio Show

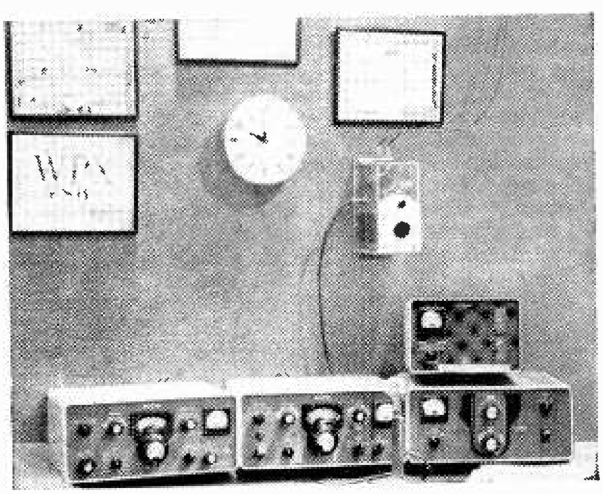
R.S.G.B. International Radio Engineering and Communications Exhibition

THIS year's amateur radio exhibition was at the Royal Horticultural Society's New Hall in Victoria, London, S.W.1. Dr. J. A. Saxton, Director of the Radio and Space Research Station at Slough, in his opening remarks compared this year's location with "previous exhibitions at the somewhat smaller Seymour Hall". It would also appear that there is a direct relationship between the size of the exhibition and the length of its title, which for 1967 (quoted above) seems a rather pretentious appellation, being not only lengthy but also misleading, imparting a professional status to a show that is surely devoted to the *hobby* of amateur radio.

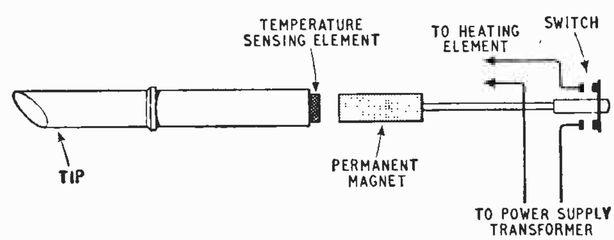
Sophistication in exhibits was manifest in the very well designed amateur equipment such as A. L. Mynett's v.h.f./u.h.f. receiver (described later on) as well as in the commercially available equipment. In this latter class there was truly a profusion of items for the amateur to choose from. Specially designed for radio communications is the new Shure 444T magnetic communications microphone seen on the Radio Shack Ltd. stand. It possesses a two-transistor pre-amplifier in the base stand where a volume control is also housed. A finger-tip control bar at the front of the base for the press-to-talk switch has a lock/non-lock action. The frequency response is 200 c/s to 6 kc/s, and the polar pattern is semi-directional. Output impedance is less than 1 kΩ and the output level is adjustable from 2 to 45 mV for one microbar input.

The Paros 22-TR is one of several transceivers (made in Japan) which were on show. This set covers the three bands 80, 40 and 20 metres and possesses a built-in 100 kc/s calibrator and switchable sidebands It also has a solid-state linear v.f.o. pre-mixed oscillator and a vernier control employed in both modes of operation; there is an adjustable noise limiter. P.e.p. is 80 W, sensitivity is 0.5 μV and carrier suppression is 40 dB with unwanted sideband at 50 dB. This set was shown complete with p.s.u. and speaker cabinet. Another transceiver, this time from K.W. Electronics Ltd., was the Atlanta, designed with the export market in mind. This set has frequency ranges 3.5 to 4, 7 to 7.5, 14 to 14.35, 21 to 21.5 and 28 to 29.7 Mc/s. In the transmitter section, a high impedance microphone feeds the microphone amplifier which in turn drives the exciter balanced modulator. The balance control is adjustable from the front panel. A carrier oscillator voltage is obtained from a crystal oscillator which also functions as the b.f.o. in the receiver mode. The signal is then shaped by the crystal lattice filter (used on receive), amplified and passed to the transmitter mixer which combines the signal with the variable frequency oscillator to produce the output frequency. This is then amplified by the transmitter-driven valve and passed to the final power amplifier. Distortion products are said to be down approximately 30 dB, carrier suppression is greater than 50 dB, and sideband suppression is greater than 50 dB. Included among the many features of this Atlanta transceiver are built-in noise limiter and crystal calibrator, automatic linearity control, grid block keying, steep slope crystal filter, and calibrated "S" meter. Facilities for operation on a.m., s.s.b. and c.w. are provided. A range of American kits that is being marketed by Electroniques was introduced at the exhibition. Initially the kits will be imported and then anglicized; later on, however, they will be manufactured in this country. The range caters for a wide variety of needs and includes teaching aids, test equipment, audio equipment and electronic novelties.

Although soldering irons are not generally regarded as exciting or inspired in their conception, the Weller irons with constant temperature control at the tip were certainly worth examining. Here was a sophisticated approach to solving some of the aggravating problems pertinent to soldering—damage to heat sensitive components, "cold" soldered joints and dry joints. These Weller W series irons use magnetic temperature control. This method of control takes advantage of the Curie point of nickel-iron (the temperature at which this alloy loses its magnetism). As can be seen in the diagram,



The installation shown here is the London end of the link for the R.A.F. J.S.E.W.C.A. 1967 mentioned in this report. Operated and maintained by the R.A.F. Amateur Radio Society, the actual voice transmissions made during the expedition were recorded on tape, and played back at the exhibition.



Using the Curie point principle, and operating as described, the tip temperature controls the switching of the iron. The switch and permanent magnet are housed in the handle of the iron.

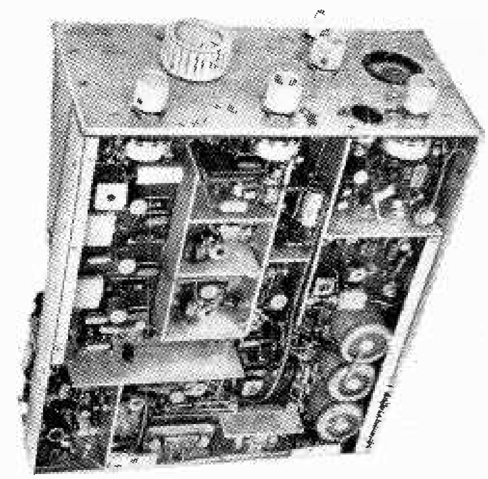
a temperature sensing element made of this alloy is welded to the rear of the soldering tip. When the iron is cold, the permanent magnet remains attracted to the temperature sensing element, maintaining the switch in the handle in the "on" position. As the tip reaches its Curie point, the sensing element is no longer able to hold the magnet which in turn retracts and pushes the switch off. When the tip cools slightly, the magnet is again attracted to the sensing element, thus resuming heating. Interchangeable tips in three or four controlled temperatures from 500 to 755°F (260 to 400°C) are available for the 60, 100, and 200 W models. Problems that beset satisfactory reception of broadcast stereo programmes such as multi-path effects are greatly reduced by the use of properly designed aerials. Many amateurs interested in optimum stereo reception will be interested in the stereo aerial shown on the J Beam Engineering Ltd. stand. Known as the F.M.48, it is a four-element unit designed to give satisfactory results in each of the stereo transmission frequency areas. A folded reflector in addition to the folded dipole gives a high front-to-back ratio. The elements are of ½ in. diameter aluminium, with a 1 in. diameter crossbar.

Military radio communications equipment was displayed on the Royal Signals stand and similar to last year, a crystal checking facility was available to amateurs. An interesting display of IDEX equipment was also at this stand. This is in the form of a highly mobile satellite communications ground station capable of two-way working via specific satellites to Ministry of Defence ground stations in the U.K. and abroad. A demonstration of a tunable bandstop filter for the 25 to 60 Mc/s band, complete with 'scope display, showed the use of such a filter to prevent unwanted second harmonics of a fundamental frequency of 28 Mc/s from causing television interference. Constructional details of this filter were available at the stand. The Joint Services Expedition West Central Australia 1967 was the central theme of the Royal Air Force exhibit. Early this January, the R.A.F. Amateur Radio Society was asked by the Ministry of Defence to provide a direct radio voice link to the expedition, which was to explore the central deserts in Australia. Military call signs and frequencies were allocated, enabling the Society to handle dispatches and signals between the leader, Wing Commander C. R. Alexander and the expedition committee in London. During the five months the expedition was in Australia, daily communication using voice transmissions faded once as a result of severe ionospheric disturbance. About 150 signals were handled, and 50 detailed situation reports passed to the committee.

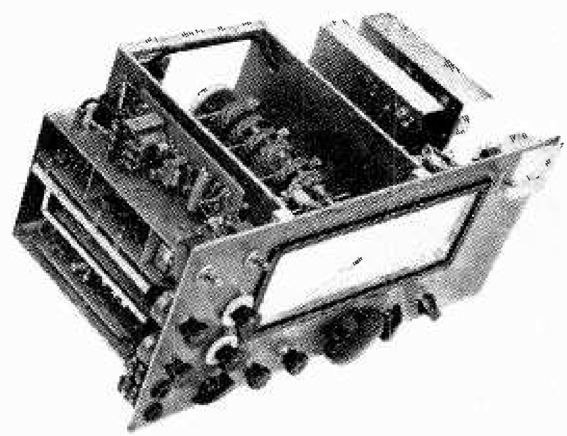
K. W. Electronics won the manufacturer's award with their KW2-20 two-metre transceiver (144-148 Mc/s) which is suitable for operation on s.s.b., a.m. and c.w. The receiver section uses two f.e.ts in a cascade r.f. amplifier; oscillator injection for the first mixer (another f.e.t.) is provided by one of four front panel selected crystals and a silicon integrated circuit provides amplification in the later stages. The transmitter delivers 20 W (s.s.b.), 6 W (a.m.) or 20 W (c.w.) to the final amplifier.

The organizer's silver plaque for home constructed equipment was awarded to D. L. Bowman for his 80-metre transistor transceiver. Significant features of this twenty-five transistor unit are:—size 8 in. × 7 in. × 3 in. (including mains power pack!); 20 W p.e.p. output into 50 Ω load; and wide-band circuits with one knob frequency selection (v.f.o.).

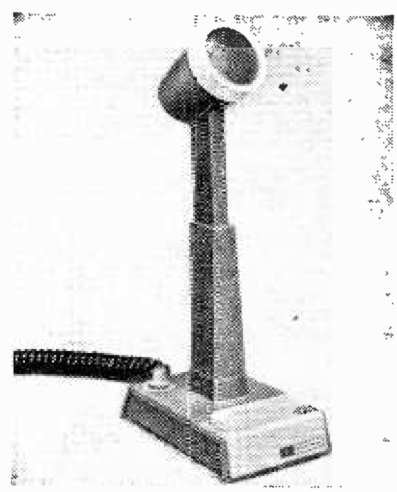
A transistor receiver for use on the amateur v.h.f. and lower u.h.f. bands designed and constructed by A. L.



D. L. Bowman's transistor transceiver showing the clean under chassis layout.



The Horace Freeman Trophy was awarded to A. L. Mynett for this u.h.f./v.h.f. receiver.



This Shure microphone may be connected to an amplifier of 1 kΩ input impedance or more. With a battery current drain of 0.7mA, it is stated that a battery will last over 300 hours. The cable is three-conductor (one conductor shielded).

Mynett won the Horace Freeman Trophy. It incorporates three crystal-controlled converters covering the 70, 144 and 432 Mc/s bands. The frequency coverage of the tuner is 2 - 4 and 2 - 2·7 Mc/s in switched ranges whilst the i.f. is centred on 455 kc/s. A novel system is used to achieve a variable i.f. passband with one knob control. The i.f. chain comprises four stages arranged alternately as mixers and amplifiers coupled together by means of pairs of selective filters tuned to 455 kc/s and 500 kc/s. The local oscillator used for the two frequency conversions is arranged to be tuned near to the sum frequency of the i.fs, i.e. 955 kc/s. Under these conditions the passbands of the filters overlap and the i.f. bandwidth is maximum. As the oscillator is tuned away from the sum frequency the degree of overlap of the passbands is reduced, in this way an effective i.f. bandwidth variable from 0·9 to 4·5 kc/s is produced.

The Science Research Council had a most interesting exhibit demonstrating their recent work carried out to relate meteorological conditions with radio propagation in the lower atmosphere. Refractometers flown in aircraft, balloons and helicopters have shown that very large changes of temperature and humidity occur over distances of only a few feet; these being caused by small pockets of air, sometimes only a few feet across, of higher (or lower) humidity than the surrounding atmosphere. Due to the abrupt change in the refractive index that these pockets represent they cause very significant scatter effects. In principle the method of measurement employed is to have two resonant cavities, one of these, the reference, is completely sealed, the other is open to the atmosphere. The resonant frequency of this latter cavity depends upon the nature of the atmosphere through which it is passing. Both cavities are swept through a band of frequencies, the time interval between the responses of the two cavities being a measure of the difference in refractive index between the air contained within each cavity. More complex combinations of cavities are used in practice, the various outputs being transmitted to a ground station by a telemetry link and analysed by computer. The result is a three dimensional picture of the pocket being examined.

It is perhaps sad that the days of the radio amateur's improvisation appear to be numbered but it is to be hoped that the present glut of professional equipment and components does not kill the ingenuity that has led to the many new ideas—later taken up commercially—that have originated from the amateur fraternity.

LITERATURE RECEIVED

Foil strain gauges and foil yield strain gauges of Japanese manufacture are described and illustrated in two four-page brochures from Environmental Equipments Ltd., Denton Road, Wokingham, Berks. Bonding methods for these foil strain gauges are also fully described.
WW 327 for further details

Quartz crystal filters ranging in frequency from 100 kc/s to 10.7 Mc/s are fully specified in the catalogue **Quartz Crystal Filters** received from Salford Electrical Instruments Ltd., Peel Works, Barton Lane, Eccles, Manchester. Applications for these filters include s.s.b./l.s.b.; s.s.b./u.s.b.; bandpass; carrier; a.m./d.s.b.; and for channel spacing in v.h.f. communications systems. Each individual filter's application, dimensions, and weight are stated. A mechanical drawing for each filter is given, with its specification, including reference frequency, pass band (3 dB loss points), stop band, losses, termination impedance, and insertion loss. Each type also has its own performance graphs.
WW 328 for further details

Solid State STR-150 Single Sideband Radiotelephone (3J5168) is an 8-page brochure released by R.C.A. Broadcast and Communications Product Division, Front and Cooper Street, Camden, N.J.08102, U.S.A. It describes the 150-watt instrument in detail, its programmed channel facilities, and the versatile modular system upon which the radiotelephone is constructed.
WW 329 for further details

Cerberus Elektronik No. 29, the latest issue of a quarterly devoted to cold cathode tubes and glow lamps, has been received from Cerberus Ltd., 8708 Männedorf, Switzerland. This particular issue discusses electric timing circuits that employ switching diodes of sub-miniature design. Characteristics of these diodes and circuit examples are also considered.
WW 330 for further details

Low voltage isolating and auto transformers is a six-page brochure (GT.17) describing in full the above mentioned types of transformers for use in the home and industry. Issued complete with price lists by Gardner Transformers Ltd., Christchurch, Hants.
WW 331 for further details

Going Metric (PD 6245) is an attempt by the B.S.I. to answer in booklet form some of the more frequent inquiries about the British change to the metric system. Including the background information to the Government's decision (1965) to support the change to the metric system, this booklet also explains B.S.I.'s programme for the metrication of British Standards, the co-ordination of the change in various sectors of industry, and lists useful B.S.I. metric publications. Although single copies may be obtained free of charge from the B.S.I. Press Office, 2 Park Street, London, W.1, bulk orders (10s for 25 copies) should be sent to the B.S.I. Sales Office, 101-113 Pentonville Road, London, N.1.

NOVEMBER CONFERENCES AND EXHIBITIONS

Further details can be obtained from the addresses in parentheses.

LONDON

Nov. 8-10 — Savoy Pl.
M.F., L.F., and V.L.F. Radio Propagation
(I.E.E., Savoy Pl., W.C.2)

Nov. 13-17 — Royal Lancaster Hotel
American Electronic Production Equipment Show
(U.S. Trade Centre, 57 St. James St., S.W.1)

Nov. 17-Dec. 2 — Mullard House
Colour Television Fair
(Mullard Ltd., Torrington Place, W.C.1)

Nov. 21-23 — Savoy Pl.
Servocomponents
(I.E.E., Savoy Pl., W.C.2)

TEDDINGTON

Nov. 14-16 — N.P.L.
R.F. Measurements & Standards
(I.E.R.E., 8-9 Bedford Sq., London, W.C.1)

Manchester Electronics Show

FOR many years the Institution of Electronics, which has a membership of the order of 3,000 (the majority of whom live in the Midlands and North of England), has held an annual exhibition in Manchester. Originally it was closely linked with the electrical engineering faculty of the University (where it was held) and therefore had something of an educational flavour about it. Latterly it has tended towards industrial instrumentation and recently broadened its interests still further by extending its title to include components—the full title being Electronics, Instruments, Controls and Components Exhibition—and was housed for the third time in one of the Belle Vue Halls, Manchester.

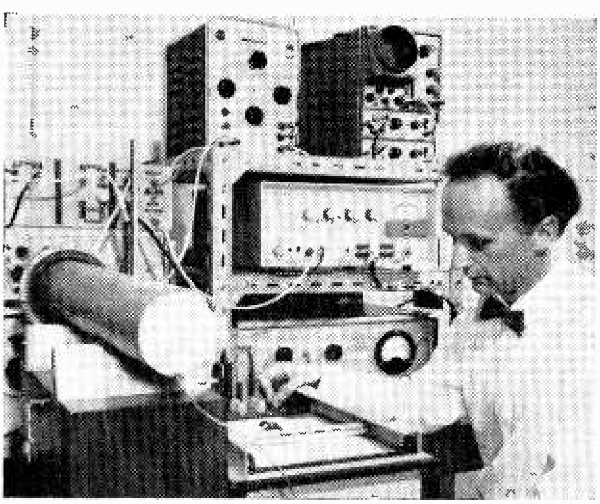
With its 120 exhibitors (50 more than last year) in an area of 40,000 sq. ft. it could justifiably be considered as the Northern counterpart of the London I.E.A. and Components Shows. although not as large. The exhibitors were not just northern agents for a multiplicity of overseas and British manufacturers, but, with few exceptions, U.K. equipment and component manufacturers and, incidentally, from as far afield as Hants, Wilts, Gloucester, Devon, Dorset, Kent and Fife, and one company from the Continent.

Although some exhibitors feel that the diversification is a weakness, the consensus of opinion was that it was very well worthwhile. Attendance exceeded 12,000.

In addition to the exhibition there was also a concurrent convention at which some 30 papers were presented. One of these (by T. D. Towers) was concerned with the rationalization of semiconductor nomenclature. He referred to the biannual handbook published by Derivation and Tabulation Associates Inc., of New Jersey, which gives tabulated characteristics of some 15,000 separate type numbers. The difficulties of the circuit designer are still further aggravated by the fact that so many types are discontinued after a short life and the organization has found it necessary to publish a separate *yearbook of discontinued types*; the latest edition containing over 3,500 entries.

Navigation Aids For Aircraft

IN Milan recently, NATO'S Advisory Group for Aerospace Research and Development (AGARD) Technical Symposium heard forecasts concerning long-distance navigation aids for aircraft. The navigation manager of the Air Transport Association of America, Siegbert B. Poritzky, read a paper on this subject. Among the items discussed in this paper was the trend in airline long-range navigation planning toward self-contained systems, Doppler today, but inertial in new aircraft. A major system advance is the ability to have continuous display of position and steering information by means of properly instructed, dead-reckoning computers. The author asked the question whether there will continue to be a requirement for a back-up "station referenced" aid to supplement the inertial navigational information, also was it probable that any station-referenced system could become so attractive as to displace self-contained navigation systems?



Professor D. V. Osborne, Dean of the School of Mathematics and Physics at the University of East Anglia, demonstrates the mathematical nature of **correlation functions,** *and the practical use of such techniques employing a Honeywell time delay correlator.*

The capabilities of self-contained navigation systems were discussed in this context, and it was concluded that unless major problems arise, which are wholly unforeseeable, then self-serviced aids will become the sole means of long-distance air navigation. Should such a system fail, then the requisites of a back-up system would include complete independence from other systems, simplicity, and capability for the crew to determine position at any time without prior knowledge.

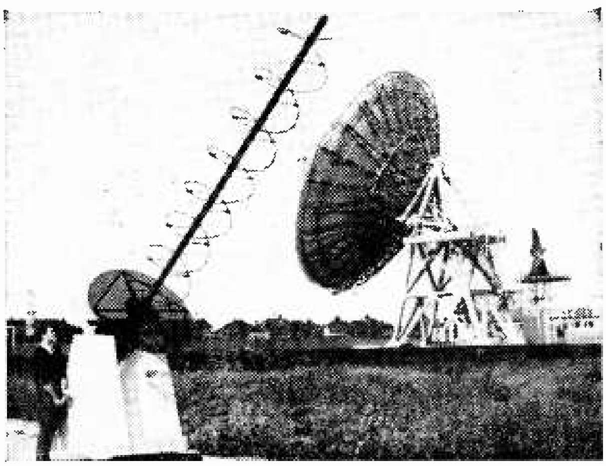
The use of satellites for communications over oceans and for air traffic control was also discussed.

Weather Ship Report

A REPORT on weather ship activities for 1966 has been received from I.C.A.O. (International Civil Aviation Organization). The North Atlantic network consists of nine stations manned by 21 ships supplied or paid for by 22 of I.S.A.O's member nations whose airlines fly the North Atlantic routes. A large number of statistics are given in the report, covering activities which range from life saving and medical assistance, through navigational assistance for aircraft, to the more mundane but relevant duties of weather observation. Meteorologists on board these ships made eight surface weather observations, four upper wind observations, and two radiosonde observations each day, with special surface observation when required. Average terminal height reached by radiosonde balloons from every ship was above 61,000 feet, while balloons from more than half the ships reached above 83,000 feet. In addition to beacon transmissions made continuously by some of the ships, 28,073 non-scheduled radio beacon transmissions and 3,733 d.f. bearings were made for providing navigation assistance to aircraft. In spite of adverse North Atlantic weather conditions, these ships in the network were able to stay on station (ten-mile square) 98.4% of the time in 1966.

Balloon-borne Radiation Detector

SINCE gamma radiation does not easily penetrate the earth's atmosphere, measurements have to be made above this air blanket, and scientists at the Smithsonian Astrophysical Observatory, Cambridge, Mass., U.S.A., have developed a detector, that can be employed in balloon- or orbital satellite-borne high-energy gamma ray investigation. In this system a spark chamber is used to make the electron-positron pair visible to a television camera (in this instrument, a Cohu Electronics Inc. miniaturised television camera) by causing a spark to form along the ion tracks left by these particles. The Smithsonian spark chamber has 23 aluminium plates for determination of gamma ray flux arrival, direction, and interaction mean free path. Energy is determined from the electron-positron shower in a Cerenkov detector (below the plates) that has ten radiation lengths of lead glass. When an electron-positron pair has been formed (due to pair production), the particles pass through subsequent plates, leaving a trail of ions in the gas mixture between the plates. Switching on a high voltage (10 kV), to alternate plates will cause a spark discharge to occur only along the path of the ions, providing very bright traces of these paths. These tracks are easily recorded and stored on the cathode of the vidicon tube with a resolution of 1 part in 350.



***Apprentices** of Plessey Radar on the Isle of Wight, designed and built this helix aerial, and the supporting electronics constituting a ground tracking station (for receiving signals from meteorological satellites) in six months, working within a budget of £100. The aerial can be elevated through 180° and its pedestal is mounted on castors to give 360° azimuthal scanning. Processing incoming signals from the American satellites Nimbus and Tiros via a low-noise pre-amplifier, a superhet receiver, and then displaying them on a c.r.t., this system has reproduced clear pictures of cloud formation and other weather phenomena over an 800 to 1450 square nautical mile area of the Earth's surface.*

More information on the Mullard **colour television fair** (*Wireless World*, October, page 479) has been received. Sets by ten manufacturers will be seen receiving normal "on-air" B.B.C. colour programmes; material from the Lime Grove Studios via Post Office landlines; and programmes supplied by Independent Television companies. There will also be a continuous showing of the Mullard 16-minute film, "Colour Television" (in the company's theatre), which deals simply with the subject, and explains the function of the camera and picture tube. It is hoped that there will be an Aerial Information Centre where visitors can obtain guidance on types of aerial needed to receive colour services. The fair will open at 10.00 each day from November 18th to December 2nd (excluding Sundays) and will close at 18.00 and 20.00 hours on alternate days, except on December 2nd when closing time will be determined by the official opening time of the B.B.C. colour service. Public admission will be free of charge, and without tickets, but for the all-day trade preview on November 16th, and the trade evenings on November 23rd and 29th (18.30 and 20.30 hours) tickets will be required. These will be distributed free to dealers by the set manufacturers.

Six officers in the Post Office Engineering Department have been granted **post-graduate awards** for 1967 by the G.P.O. The awards are tenable at universities which have facilities for research or advanced studies relevant to Post Office problems, in telecommunications science and engineering. Most of the awards will allow the holders to qualify for M.Sc. or Ph.D. degrees. Among the recipients are P. James, of Bristol, who receives a one-year award for an electronic circuit and system engineering course at Bath University of Technology; T. F. Smith, of St. Albans, Herts, who has a three-year award to study economic and information theory aspects of general purpose telecommunications systems at the University of Essex; and P. A. Watson, of Chiswick, London, with a one-year award for the final year of a Ph.D. course at Durham University, following two years' research at the Dollis Hill Research Station on parametric amplifiers for use in satellite earth stations.

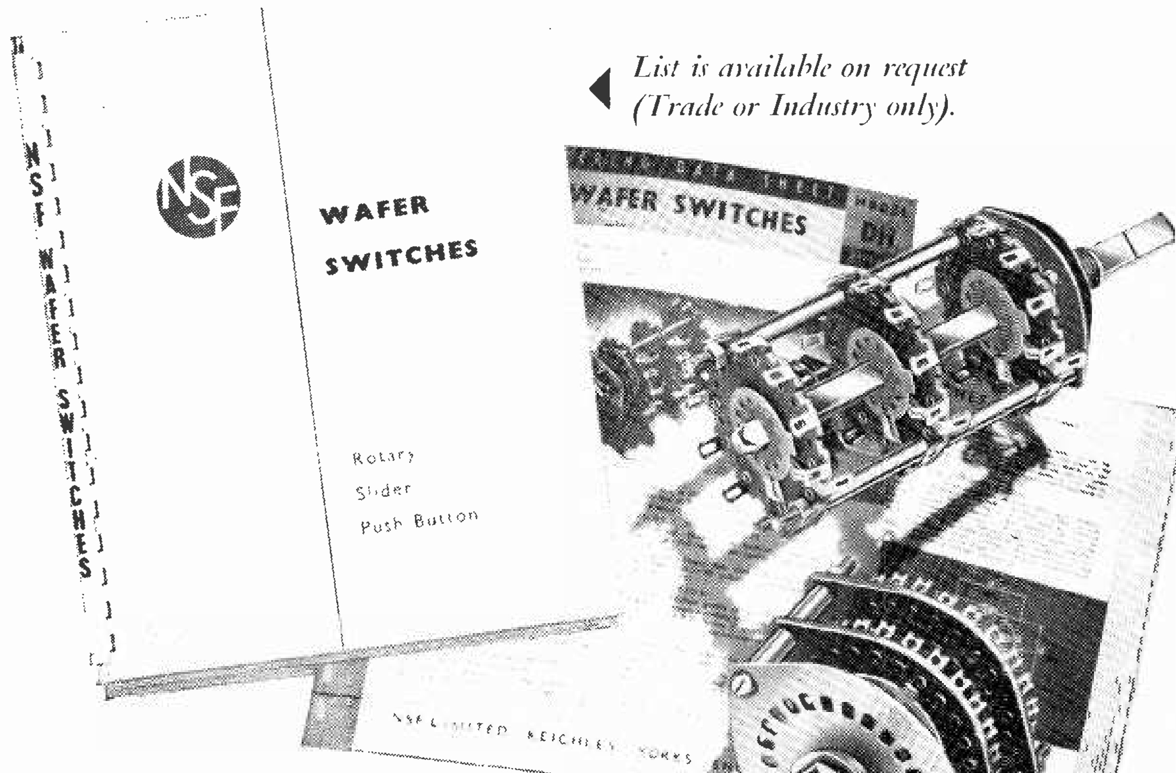
Now that an agreement has been reached on the sharing of the costs and work for the **Mallard project,** the U.K. has become a partner with Australia, Canada, and the United States. The Mallard project is a tactical trunk communication system for the field armies of the countries named, and also for their navies and air forces. This system, it is understood, will provide secure, fully automatic, switched communications in the battlefield area from army h.q. down to battalion level. Facilities will be available for the transmission and reception of voice, telegraph, data and facsimile. The initial development phase will take the form of competitive system design studies by the U.K. and U.S.A., electronics industries. Supporting technique studies will be conducted by Australia, Canada and the U.S.A., and the U.K. industry will also undertake a share of this work. The cost to the four governments is estimated (at the present time) to be about £45M, and the work will take eight years to complete.

When the B.B.C. started its new sound service **Radio 1** on September 30th, it employed all the existing medium-wave transmitters formerly used for the Light Programme. The full list of transmitters (including six new transmitters shown in italics) for this service, which operates on 1,214 kc/s (247 metres) are *Brighton*, Brookmans Park, Burghead, *Droitwich*, *Fareham*, *Hull*, Lisnagarvey, Londonderry, Moorside Edge, Newcastle, Plymouth, *Postwick*, Redmoss, Redruth, *Washford*, and Westerglen. The Droitwich transmitter on 200 kc/s (1,500 metres) will continue to operate for the Light Programme, now Radio 2, which is also available on local v.h.f. transmitters.

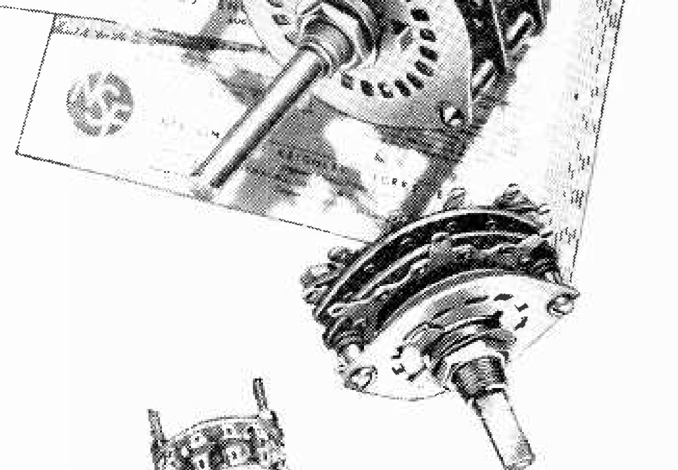
A biography of **Sir Edward Appleton** is to be written by R. W. Clark, who is anxious to hear from anyone who possesses letters, or other material relevant to Sir Edward's life and work. Write to 10, Campden Street, London, W.8.

Speed Control for D.C. Model Motors.—In the article by H. M. Butterworth in the September issue two bridge diodes in Fig. 5 were shown incorrectly connected: the upper right-hand and lower left-hand diodes should be reversed. The author also asks us to point out that the left-hand 150 μF capacitor should be reversed and further, if the short-circuit condition is expected for periods which are not momentary, 2 A diodes should be used.

Schmitt Trigger Design.—In A. E. Crump's article, "Design of Schmitt Trigger Circuits" (March and April issues), certain errors were not corrected. In Fig. 6 the expression for V'_T should be $V_T - V_{BE1} + V'_{BE2}$, i.e., as it appears in the summary panel. Equation 7 should have the terms up to the multiplier dot in parentheses and a -1 included within. The positive sign preceding the last term in the equation should be changed to minus. The bracketed terms in equation 8 should also include -1. It is regretted that the denominator of equation 10 was not shown: this is V'_T/R_c. In expression C appendix 7 the dividing rule was omitted from the first part of the equation.



List is available on request (Trade or Industry only).



All switches include double-contact, self-aligning clips which preserve the contact surfaces over thousands of operations. Rotary type switches include rotors of floating type, which render each section self-aligning—a feature of prime importance in the multi-section switch. The same principle is incorporated in the exclusive floating slide used in the push-button switches.

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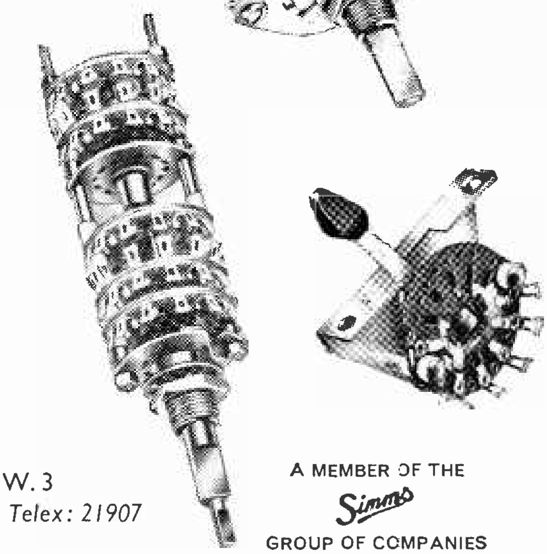

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WW—125 FOR FURTHER DETAILS

PERSONALITIES

Major General Sir Leonard Atkinson, K.B.E., B.Sc., president-elect of the Institution of Electronic & Radio Engineers, graduated at University College, London, in 1932, and after serving a graduate apprenticeship was commissioned in the R.O.A.C. in 1936 and transferred to R.E.M.E. on its formation in 1942. Among the appointments he has held since the Second World War are:—deputy director electrical and mechanical engineering at the

Major General Sir Leonard Atkinson

War Office; commandant of the R.E.M.E. Technical Training Organization at Arborfield (1959-1963); and from 1963 until his retirement in 1966 Major General Atkinson was Director of Electrical and Mechanical Engineering (Army) in the Ministry of Defence. Earlier this year he was appointed Colonel Commandant of R.E.M.E.

Aubrey Harris, M.I.E.E., for the past nine years staff engineer with Ampex, latterly at Redwood City, California, has become chief television engineer at the University of California, Santa Cruz. Mr. Harris, who is 38, started his career at the Post Office Research Station, Dollis Hill (1946-52), and then spent five years with Marconi at Chelmsford. For a year prior to joining Ampex he was chief engineer of the television station ZBM-TV of the Bermuda Broadcasting Company. Mr. Harris has frequently contributed to *Wireless World*, and elsewhere in this issue discusses some of the papers presented at the recent WESCON show.

Geoffrey B. Shorter, B.Sc., who has been a member of the editorial staff of *Wireless World* for the past three years, has been appointed editor of a group of quarterly journals to be published by our associate company Iliffe Science & Technology Publications. After graduating at Manchester University he was with Marconi's for a short time immediately prior to joining *W.W.*

Frank H. Scrimshaw, B.Sc., A.Inst.P., has become director-general of electronics research and development in the Ministry of Technology, in succession to **C. P. Fogg,** B.A., who is now deputy controller, electronics. A graduate of University College, Nottingham, Mr. Scrimshaw, who is 50, entered the Scientific Civil Service in 1939 at the R.A.E., Farnborough. He was transferred to the headquarters post of director of scientific research (electronics and guided weapons) in 1959, and two years later went to the R.R.E., Malvern, as head of the guided weapons group. Since May, 1965, he has been head of the Military and Civil Systems Department at R.R.E. Mr. Fogg, who is 52, has been director-general of electronics research and development since 1964. He joined the staff at the Bawdsey Radar Research Station in 1937 and two years later was made a group leader responsible for research and development of radio receivers. He went to Malvern in 1945 and, after taking charge of three divisions—working on transmitters, aerial test gear, and receivers and display—he became head of the ground radar department in 1956. Three years later he transferred to the Ministry of Aviation (now Min. of Technology) headquarters to become director of guided weapons.

Norman N. Parker-Smith, B.Sc., M.I.E.E., has been appointed to the new post of technical manager of Marconi's Broadcasting Division. He joined the company in 1947 as a development engineer. He spent several years in the United States studying the N.T.S.C. colour television system and, on returning to the U.K. in 1953, was appointed to lead an advanced development team working on colour television. In 1956 he became head of the television development group and latterly was studio engineering manager. His successor in this position is **A. N. Heightman.**

N. N. Parker-Smith

O. W. Humphreys, C.B.E., B.Sc., F.Inst.P., F.I.E.E., vice-chairman of the General Electric Company Ltd., has retired, but is remaining on the board as a non-executive director. Mr. Humphreys, who is 65 and a graduate of University College, London, joined the scientific staff of the G.E.C. Research Laboratories (now the Hirst Research Centre) in 1925 and became director of the laboratories in 1951. He was appointed to the board of G.E.C. as technical director in 1959. He was from 1957-62 chairman of the Radio Research Board of the D.S.I.R. (now the Science Research Council) and until recently was chairman of the Conference of the Electronics Industry.

Marconi Instruments have appointed **N. W. White** as chief design engineer (television) responsible for the combined activities of the company's television instrumentation and image intensification design groups. Mr. White joined the

N. W. White

company from A. C. Cossor Ltd. (where he was concerned with television receiver design) in 1958. Since 1965, he has been chief design engineer (television instrumentation).

Norman A. Twemlow, M.B.E., who has been with the Pye organization since 1934, latterly as director, has joined Radio Rentaset Products Ltd., the manufacturing company of Radio Rentals Ltd., as chairman. He replaces J. W. C. Robinson, who will remain a director.

OBITUARY

Raymond J. Tobin, known affectionately throughout the radio industry as "Toby," died on September 21st, aged 81. He recently retired from the staff of *Music Trades Review* after over 30 years' service, the last eleven as editor. He was the 1965/66 president of the Radio Industries Club.

LONDON'S BROADCASTING CONVENTION

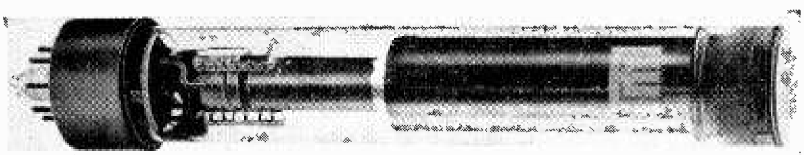
Impressive Rival To The Montreux Symposium

A NEW event in the electronics calendar is the International Broadcasting Convention, a combined exhibition and conference for those concerned with the manufacture and use of studio, distribution and transmitting equipment. Organized by the Electronic Engineering Association and the Royal Television Society (in association with the I.E.R.E.), it is an occasion after the style of the well-known National Association of Broadcasters' Convention in Chicago and is avowedly in competition with the Montreux Television Symposium.

The first I.B.C. was held at the Royal Lancaster Hotel, London, 20th-22nd September, and was opened by Lord Hill, Chairman of the B.B.C. Board of Governors. With over 400 delegates, 40 papers and 28 exhibitors (three of whom had television studios in operation) the Convention got off to a good start. Whether it will succeed in truly living up to the "International" in its title remains to be seen. On this first occasion, about one-fifth of the delegates and one-third of the papers were from abroad and only one of the exhibitors was from overseas (Canada), although there were a good many foreign manufacturers represented by their British agents. (It is perhaps a pity that the organizers have not broken away from the "International" description, which has become a hackneyed word in the context of exhibitions and conferences, usually signifying a bare minimum of foreign participation.)

Among new products on show was a development sample of Britain's first competitor to the Philips Plumbicon photoconductive television camera tube.* Made by the English Electric Valve Company and named, not very felicitously, the Leddicon, it has a lead oxide photoconductive layer of p-i-n structure measuring 12mm × 16mm. The limiting resolution of this tube is 600 television lines, the visual equivalent signal-to-noise ratio 200:1 and the dark current 3 nA, while the spectral response has a peak at a wavelength of 0.5 μm. E.E.V. say that facilities for manufacturing the tube are being installed at their works and regular production will start towards the end of 1968.

*See "Appendix on the Plumbicon," *Wireless World*, February 1966, p. 60.



English Electric "Leddicon" photoconductive camera tube.

"Videocruiser" for recording outside events, shown by Ampex.

Other television camera tubes shown by this company were a vidicon with electrostatic focusing and two Image Isocons, which are tubes similar to the image orthicon but designed for operating at extremely low light levels. The P880 3-inch Image Isocon, for example, is claimed to produce "good" pictures when the photocathode illumination is only 10^{-3} lux and "acceptable" pictures when it is as low as 10^{-5} lux.

When colour television broadcasting gets under way it is likely that we shall be seeing a good many colour films, but experience has shown that the colour fidelity of these films is often inadequate for broadcasting purposes. There can be a constant colour bias resulting from faulty film processing and colour temperature balance errors may arise because film is usually balanced for tungsten or arc lamp projection whereas television film scanning equipment uses an Illuminant "C" light source. Rank Cintel were showing an electronic processing equipment called Tarif (originally devised by the B.B.C.) which allows the RGB video outputs of film and slide scanning equipment to be modified in order to correct these errors. The operator first runs the film through and views it on a monitor to form a subjective impression of the constant colour errors, then makes suitable corrective adjustments on the Tarif calibrated controls. There are independent colour correction controls for high and low light balance and also master controls for overall signal adjustment after colour balancing.

The first thing one saw on reaching the Ampex stand was a large American motor car, actually a Chevrolet Impala. Closer examination showed a television camera sticking out of the roof, and this was, in fact, a mobile unit for producing sound and vision recordings called the "videocruiser." The camera, which has a 10:1 zoom lens, can be mounted on a tripod or on a pneumatic ram which will raise it to a height of 8ft 9in to shoot pictures over the top of crowds. Space in the vehicle has been saved by adapting the front seat so that it will face forwards for travelling and backwards when using the television equipment. A standard 19in rack is used for the electronic equipment and this can be serviced through the rear passenger door. The mobile unit is designed so that it can operate without any external connections. It is normally powered by a generator in the engine but an external mains supply can be used if required. Whenever an external mains supply is applied a relay system operates and automatically changes over the system from the internal generator to the external supply.

A noticeable trend in the design of studio equipment is the increasing use of automation techniques to simplify the task of operators in handling a variety of programme sources. Joseph Stern of C.B.S., for example, described in a paper how all programme switching and assignment of machines will be controlled by a small desk-top computer at three new television studios being built at St. Louis, U.S.A. This results in efficient utilization of equipment and great accuracy of timing. The operator in charge of this centralized control system works with an "electronic log sheet" provided by alphanumeric c.r.t. displays. At each film scanner and video tape recorder there are means for transmitting to the computer the location of films and tapes to be broadcast. All switching operations are printed out with time verification as programmes go on the air.

Another automation technique was a v.t.r. system by which individual frames on a video tape could be identified for the purpose of selecting particular sequences, such as goals scored in football matches. Described by Karl-Otto Baeder (Elektromesstechnik), it allows the frames to be numbered by means of coded decimal digits recorded on the cue track of the video tape or on the pilot track of an associated audio tape. During reproduction the digits are decoded and displayed on a numerical indicator.

NEWS FROM INDUSTRY

MARINE MONITORING SYSTEM

Decca Radar Ltd. have released details of their Integrated Ships Instrumentation System (ISIS 300) following the receipt of the first orders for the equipment. Orders have been placed for installations in three new container ships being built for Manchester Liners Ltd. and the British Railways Board have ordered the equipment for the Harwich train ferry M.V. *Cambridge Ferry* as part of an automation programme.

The principle functions of ISIS 300, of alarm monitoring, centralized indication and data recording, are performed in a central processor occupying less than 3 ft^3 to form an integrated ships instrumentation system. The equipment receives input information from transducers situated around the ship, scanning them at a rate of 400 a second. Outputs can be provided by audible and visible alarms, digital displays, electric typewriters and line printers. To reduce the number of cables from remote transducers to the central processor, thereby reducing cost, local scanning units are employed. These are controlled via a single cable from the central processor and will accept inputs from 20, 40 or 60 transducers.

The equipment employs silicon logic throughout and will operate to the specified accuracy up to temperatures of 65°C nullifying the need for air conditioning equipment. The system is tested in accordance with the principles established by the American Government's Advisory Group on the Reliability of Electronic Equipment (AGREE) which sets rigorous standards.

FINANCIAL REPORTS

The Metal Industries Group have announced that their consolidated trading profit before tax for the year ended April 2nd, 1967, amounted to £1,112,766 compared with £1,519,767 for the previous year. Among the members of the Group are Avo, Cutler Hammer, Industrial Automation Controls, International Rectifier, Taylor Electrical Instruments and Waveforms.

Racal Electronics have announced that their group net profit, before taxation, for the year ended 31st January 1967 was £503,000 compared with £730,000 for the previous year. The directors are recommending a final dividend of 30% making a total of 40% for the year.

Decca Ltd. have announced a 1967 profit before tax of £4,451,000 compared to £4,323,000 for 1966. The company's turnover amounted to £40M (1966, £36.3M) including exports of £11.9M (£9.6M).

Thorn Electrical Industries Ltd. announce a profit before tax of £10,297,000 for the year ended March 31st, 1967. This compares with £10,420,000 for the previous year.

The annual accounts of **A.B. Metal Products Ltd.** for the year ended 30th June 1967 showed a profit before tax of £231,299 compared with £211,225 for the previous year.

Standard Telephones and Cables are to install a 4 Gc/s radio link between Puerto Rico and St. Thomas in the Virgin Islands. The link consists of two hops, the first over a distance of 20 miles between San Juan and El Yungue, Puerto Rico, and the second over the 60 miles of water between El Yungue and Magens Bay on St. Thomas Island. For this extended over-water hop space diversity techniques will be employed using two sets of aerials to combat the effects of unfavourable conditions, particularly fading. S.T.C.'s latest solid-state equipment type RL4H will be used providing 960 telephone circuits.

The National Research and Development Corporation supported S. Davall & Sons Ltd. in the development of a new **aircraft crash recorder** known as the "Red Egg." It is a low cost serial digital recycling wire recorder built to withstand temperatures of 1,100°C for 30 minutes, vibration of up to 10*g*, a crush load of 5,000 lb and a shock load of 1,000*g* for 5 m sec. The machines can have a recording time from 4 to 55 hours, depending on individual users' needs.

The Cyprus Telecommunications Authority has signed a contract with the Marconi Company for the supply of a **Marconi Automatic Relay System** (MARS). The equipment will be used to speed the transfer of telegraph messages in the new aeronautical fixed telecommunications network at Nicosia Airport, and will result in an improvement of efficiency in civil aviation communications in the eastern Mediterranean area. The Cyprus Telecommunication Authority have also decided to automate their public telegraph network by integrating it with the aeronautical switching centre. MARS is an automatic telegraph switching system based on the Marconi Myriad II computer. All incoming messages are handled automatically, eliminating the delays caused by the manual handling of messages in paper tape form and by ensuring that messages are transmitted via the first available line to their destination.

A quarter of the area of Transitron Electronic Limited's 25,000 sq. ft. factory at Maidenhead in Berkshire is to be used for a **silicon planar diffusion plant** with a production potential of 750,000 integrated circuits a week. The plant, which will initially concentrate entirely on t.t.l. circuits for the U.K. and European markets, will be in production by Christmas.

The Japanese Government has approved the formation of a new Tokyo-based company to be set up by Varian Associates (49 %) and Nippon Electric Co. (51 %) and to be known as **Nippon Electric Varian Ltd.** (NEVA). The new firm will engage in the development and manufacture of scientific instruments and vacuum products for the domestic and export markets.

Varian Associates have purchased Mess und Analysen-Technik (MAT) division of Fried Krupp, of Essen. MAT, who develop and manufacture scientific instruments, will become a wholly owned subsidiary of Varian and will be known as Varian-MAT GmbH.

Plessey Radar Ltd. (Britain), AEG-Telefunken (W. Germany) and CSF (France) have established an equally-owned Belgian subsidiary company, which is known as **Eurosystem,** with a capital of 4.5M Belgian francs. The object of Eurosystem is to supply software services and to study and analyse general systems associated with data information for Eurocontrol and other European organizations.

Pye TVT have been awarded a contract, worth about £1M, by the B.B.C. for the supply of six colour television mobile control rooms with an option on a further three. The vehicles, which will be delivered from November 1968 onwards, will be fitted with the "System 70" range of equipment recently selected for display at the Design Centre.

Air France are equipping their fleet of twenty-one Boeing and Fokker aircraft with a dual installation of the **Marconi** AD 370 automatic direction finder. A feature of the equipment is its solid-state crystal-controlled, electronic tuning system with no moving parts.

An £80,000 order has been placed with **G.E.C. (Telecommunications) Ltd.,** by Swiss Posts, Telegraphs and Telephones Department. The order is for 2,000 Mc/s equipment that will be used to connect 18 television stations in various parts of Switzerland.

G.E.C. (Telecommunications) Ltd. have received an order worth nearly £50,000 for diversity receiving equipment to be used on the microwave telephone link between Melbourne and Adelaide. The equipment combats loss of quality in telephone conversations due to fading.

Astaron-Bird Ltd., Poole, Dorset, who manufacture a range of marine radar equipment, have taken over the design, manufacture and marketing of a range of professional television monitors previously handled by Television Instruments Ltd., of Boreham Wood, Herts.

The Transmission Group of **Standard Telephones and Cables** have received an order from the Central Electricity Generating Board for their microwave communications system, type RM15A. The equipment, operating in the 1500 Mc/s band will provide four speech channels between the Yorkshire power stations at Ferrybridge and Eggborough and a substation at Monk Fryston.

G. and E. Bradley Ltd. have obtained a repeat order, bringing the total to nearly $500,000, for X-band solid-state sources from Lockheed Electronics Inc. of Plainfield, N.J., U.S.A. The sources, which exhibit high-stability and reliability under adverse environmental conditions, are being used as local oscillators in a doppler system intended for the U.S. Army.

The contract, worth £300,000, to supply sound and vision switching and routing equipment and four colour TV cameras (type 2001) for **Yorkshire Television's** new studio at Kirkstall Road, Leeds, has been awarded to E.M.I. Electronics.

Beckman Instruments Ltd., the Glenrothes based company, are expanding their facilities in London by taking over new premises at Sunley House, 4 Bedford Park, Croydon. This building will be used for demonstrations, lectures and as a sales centre.

The British audio stand covered 300 sq. metres at the **15th International Electronic Exhibition** (FIRATO) held in Amsterdam on 21st September for 11 days. The stand included a demonstration room where the public were able to hear the various equipments. The British firms, participating were as follows: Acoustical (Quad), Armstrong, Brenell, Decca, Goodmans, Grampian, KEF, Pye, Leak, Lowther, Richard Allan, Rogers, Wharfedale, Jordan Watts and Sugden.

A new British company, Data Research Ltd., has been formed backed by substantial American investment. Most of the company's initial development programme has already been completed and two low-cost digital voltmeters are expected to be announced shortly.

The strike and trainer aircraft for the Royal Air Force, the Jaguar, is to be equipped with Head-up Display equipment designed and manufactured by **Specto Avionics.** The contract, which is thought to be worth more than £6M over the next ten years, is the second that the company have received from the British Government, the first being for a similar equipment for Hawker Harrier aircraft.

The range of domestic tape recorders manufactured in Japan by **Oki Electrical Industries, Tokyo,** is to be marketed by Denham & Morley Ltd., Cleveland Street, London, W.1. All the models in the Oki range, which consists of one mono and four stereo recorders, have two speeds (3.75 and 7.5 i.p.s.) and accommodate up to seven-inch diameter spools.

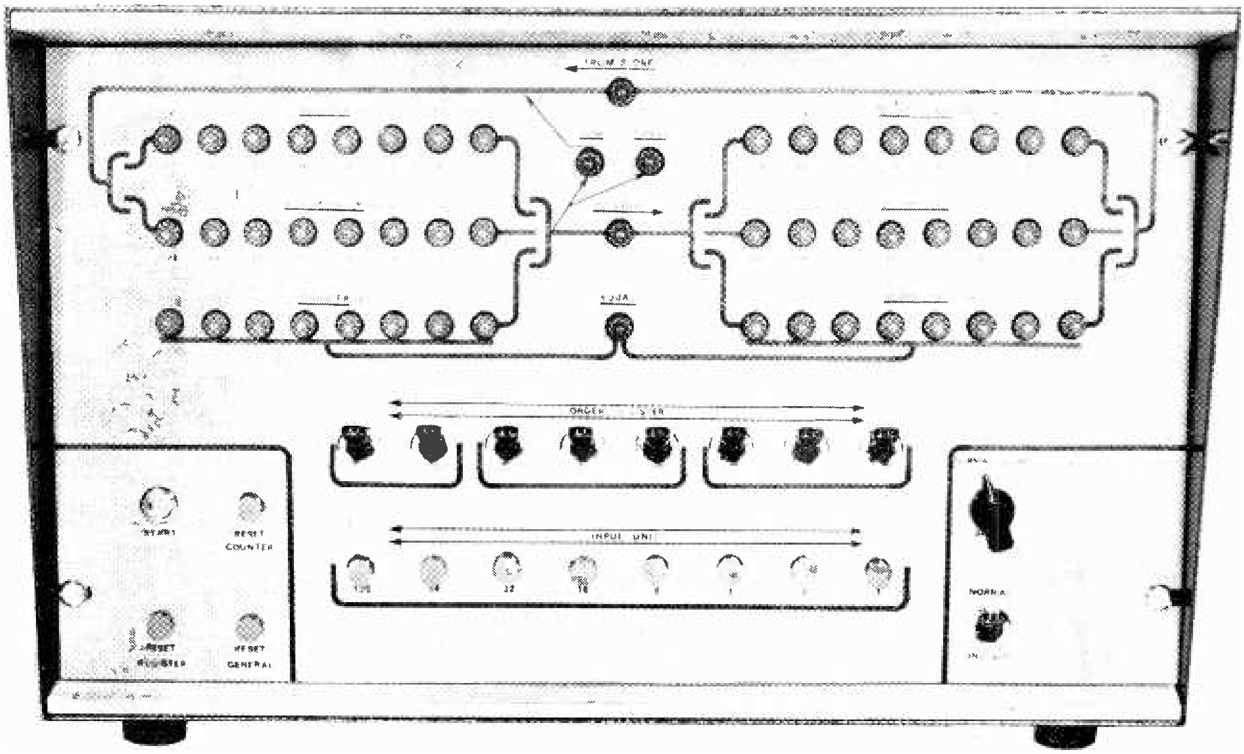
A range of digital shaft encoders and decoders manufactured by Harrison Reproduction Equipment of Farnborough, Hants, is now available from **Racal Instruments Ltd.** who have signed a marketing agreement with Harrisons. The digitizers are of the discrete mechanical type, allowing reading during rotation, providing a large output signal. They use the Petherick b.c.d. cyclic reversible code, which eliminates ambiguity when slow changes are involved, and allows left hand, right hand or centre zero points.

The Collins Radio Company, California, have appointed G. A. Stanley Palmer Ltd., Island Farm Avenue, West Molesey Trading Estate, Surrey, as British agents. The range of products will include the complete range of Collins mechanical filters, crystal filters (5 c/s-20 Mc/s), LC filters (sub-audio-100 Mc/s) and toroidal inductors (1-36 H).

Integrated circuits manufactured by Westinghouse Electronics Electric International SA, will now be available from Ultra Electronics (Components) Ltd. as a result of a recent agreement between the two companies.

Polyester Film Capacitors manufactured by the German company of Ernst Roedenstein are now available from G. A. Stanley Palmer Ltd., Island Farm Avenue, West Molesey Trading Estate, Surrey. The capacitors are available in values from 1000 pF to 0.33 μF with working voltages of 160 or 400 V d.c.

Newport Instruments Ltd., Newport Pagnell, Bucks, have purchased the design and manufacturing data for the **Mullard range of electromagnets** and associated sweep and power supply units. Mullard have announced that they will meet their commitments as far as existing orders and those under negotiations are concerned. It should be noted that all enquiries regarding these products should now be addressed to Newport Instruments.



WIRELESS WORLD DIGITAL COMPUTER

4: Advice on construction and testing

IT is not proposed to give any practical component layout diagrams for the computer, as all the circuit blocks used are small and simple and the layout of them is non-critical and a matter of personal preference. Readers who think they would find it difficult to plan layouts for the individual gates, bistables, etc., would be unwise to attempt to construct the computer, because of its overall complexity.

A word or two about the performance of the prototype. Because reject transistors were used throughout about a dozen of these failed prematurely during the first couple of weeks' service. After this "dead wood" had been located and removed the computer proved to be very reliable in operation. No proper temperature testing facilities were available, but some rough checks were made. For example, the computer was placed in a small room with a large gas fire turned full on. When the temperature in the room had risen to an uncomfortable level the computer was subjected to a thorough testing, which it passed with flying colours. When the machine had returned to ambient temperature almost the entire contents of a tin of an aerosol freezer were sprayed on all

The title illustration shows the layout of the front panel of the computer. On top can be seen the banks of neon lamps indicating the contents of the accumulator, stores, register and counter. Beneath them is the row of eight toggle switches by which instructions in code form are given to the machine. At the bottom (middle) is the row of eight push buttons by which numbers are entered. At the bottom left are the "start" switch and reset push buttons, and at the bottom right the two switches for selecting speed and mode of operation.

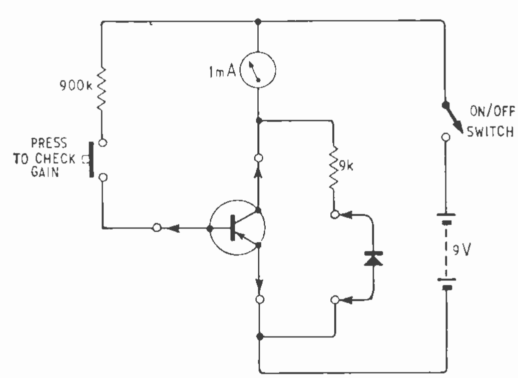


Fig. 32. Circuit for testing transistors and diodes.

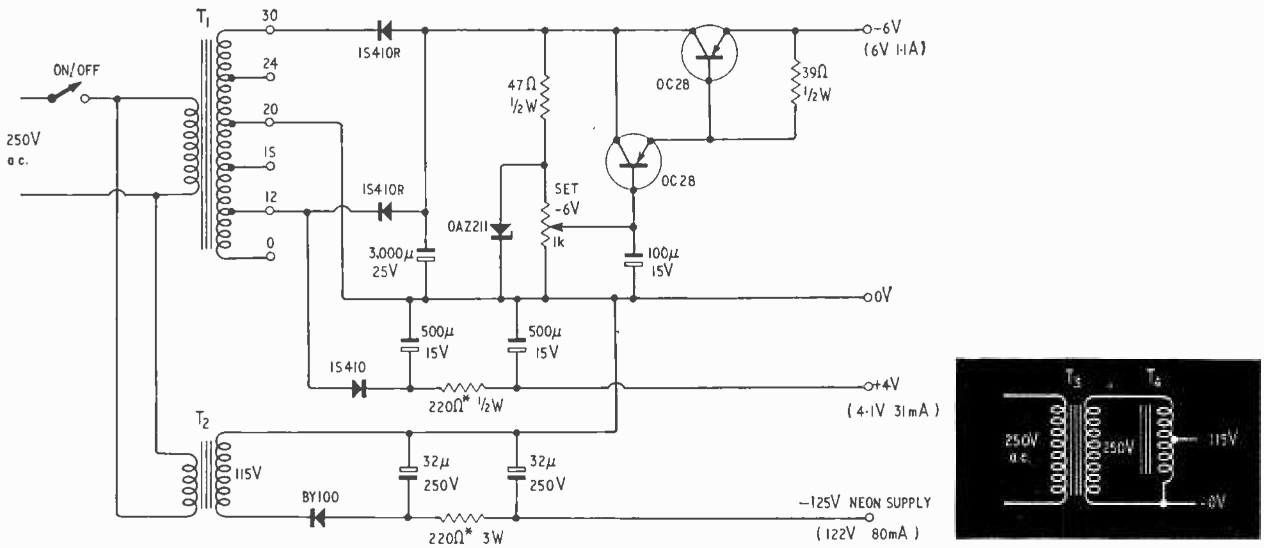


*Fig. 33. The computer power supply. If a double wound 115 V transformer (T_3) cannot be obtained, use an isolating transformer and an auto-transformer (T_3 & T_4) as shown in inset. Resistors marked * must be increased in value when the power supply is used for test purposes.*

components and mounting boards, coating them with a thick layer of frost. This also had no effect on computer performance. Finally, an old electric drill was obtained that had a rather "sparky" commutator, and this was rapidly switched on and off in close proximity to each component mounting board—again without any detrimental effect on the operation of the computer.

Semiconductor testing.—The semiconductors used were obtained from LST Components Ltd., 23 New Road, Brentwood, Essex. The transistors used are a sub-standard type 2G 371 and have been given the suffix D1476 by Texas Instruments. However, only specimens that have been selected for gain should be used. The reader is advised to construct the simple test circuit shown in Fig. 32 and test each transistor and diode before it is used. If a 1-mA meter is used as specified and it is scaled 0-100, a direct reading of gain will be obtained when the button is pressed. All transistors with a gain of less than about 40 should be rejected. With the transistor in the test circuit and the button not pressed the meter will read leakage current Ico. Any transistor with a leakage current of more than about 100 μA should be rejected. Diodes can be checked by placing them across the diode test terminals. The meter should read about full scale with the diode connected as shown and zero with the diode reversed.

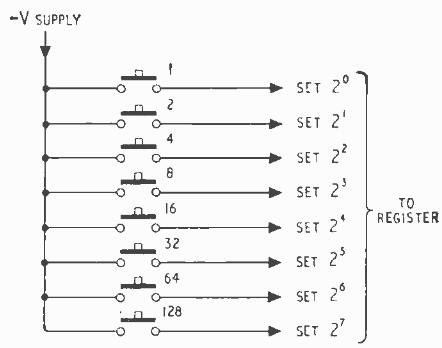


Fig. 34. The input unit for entering data.

Indicator lamps.—Two types of neon were tried in the prototype and both gave satisfactory results. The first of these was a small wire-ended type available from LST Components. If these are used the series resistor should be 1 MΩ and the supply ≈ 150 V. The second type, used in the final design, are more expensive but lend a more professional appearance to the completed computer. They are the Bulgin Type D795 and should be used with a 470-kΩ series resistor and a supply voltage of 125 V.

Power supply unit.—This is the first unit that should be built if a suitable bench supply is not already available. The overall power requirements of the computer are:—

125 V at 80 mA
−6 V at 1 A
+4 V at 30 MA

A circuit that will fulfil these requirements is shown in Fig. 33. It is entirely conventional. The −6 V line is stabilized. The prototype unit was built on an Eddystone aluminium diecast box, this forming an adequate heat sink for the transistors.

Testing the computer.—Each section of the computer should be tested as it is built before incorporating it in the machine. For this reason it would be advantageous to build about a dozen or so of the indication amplifiers at an early stage in the construction to facilitate this testing. Also, some of the units will require that special test circuits be built to ensure correct operation. These circuits and individual tests of units will be discussed as they arise. It is also recommended that the computer units be interwired "bread-board" fashion and tested before they are installed in a cabinet, as this will make for easy fault location.

Numbers are fed into the computer by eight push buttons that set individual bistables in the register as shown in Fig. 34. It was found convenient in the prototype to provide separate reset buttons for various parts of the computer as this made the machine easier to operate. These extra reset circuits are shown in Fig. 35, and the actual push buttons are mounted at the bottom left of the front panel. The reset facilities provided by the eight control switches, however, are useful if it is ever decided to add some form of sequential programming device.

The prototype was constructed on eight sheets of 17in × 3¾in Veroboard, leaving plenty of room to spare. Readers may find advantage in using smaller boards. The units were distributed amongst the boards as follows:—

1. Register and control gating.
2. Accumulator and adder/subtracter.
3. Counter, Store 1 and comparator.
4. Store 2, Store 3 and control gating.
5. Counter transfer gating.
6. Decoder (minus shift-pulse flip-flops).
7. Control unit and shift-pulse flip-flops.
8. Indication amplifiers.

Some of these boards are shown in the accompanying photographs. The method recommended for construction is to find out what is required on each board in the way of different gates and bistables, etc., build these as separate units on the board sharing common supply lines, and then wire up the separate units by following the logical diagram.

Adder/subtracter test circuit.—A suitable test circuit for the adder/subtracter is shown in Fig. 36. The input and control requirements are provided by double-pole change-over switches and a multivibrator, the output states being displayed by the standard indication circuit. A single-pole switch determines whether clock pulses from the multivibrator are fed to the adder/subtracter or not. The outputs should conform to the addition and subtraction tables given earlier. An example of a test would be as follows:—

(1) Open clock-pulse switch.
(2) Set input switches to "add," A and B. (Input to circuit ABc). Output indications should be $\overline{\text{SUM}}$, $\overline{\text{CARRY}}$.
(3) Apply clock pulses. Outputs should now be SUM, CARRY.
(4) Switch off clock pulses. Output should still be as in (3) above.
(5) Set input switches to $\bar{A}$, $\bar{B}$. (Input to circuit now $\bar{A}\bar{B}$c). Outputs from circuit should be SUM, $\overline{\text{CARRY}}$.
(6) Apply clock pulses. Outputs should now be $\overline{\text{SUM}}$, $\overline{\text{CARRY}}$.

In this example the procedure for testing the operation of two gates (1 and 9) and the carry store has been given. Further similar checks should be carried out until all the gates have been tested. These tests can either be compiled by referring to the appropriate truth tables or to the adder/subtracter logical diagram (Fig. 14, September issue). If a fault is apparent it is a fairly easy task to locate which gate is responsible; then a little judicious prodding with a meter should reveal the cause without much difficulty.

Register test circuit.—When the adder/subtracter is working correctly, the next task is to build two eight-bit shift registers that will form the register and accumulator. The same method is used for testing both of these and is shown in Fig. 37. The 4.7-kΩ resistor on the end of the flying lead will prove to be an invaluable piece of test equipment. It enables individual bistables to be set and reset without having to wire in push-buttons and switches that would complicate the wiring and cause confusion at this stage.

To test a register, first press the reset button. All indicator lights should go out. If any do not check the indication circuit before examining the associated bi-

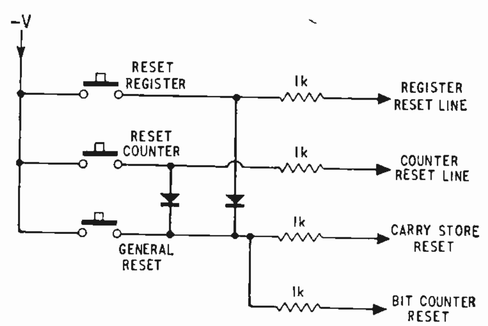
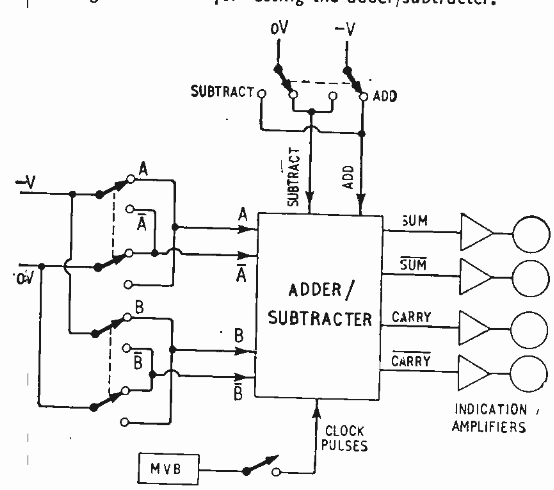


Fig. 35. Auxiliary reset press-button circuits.

Fig. 36. Circuit for testing the adder/subtracter.



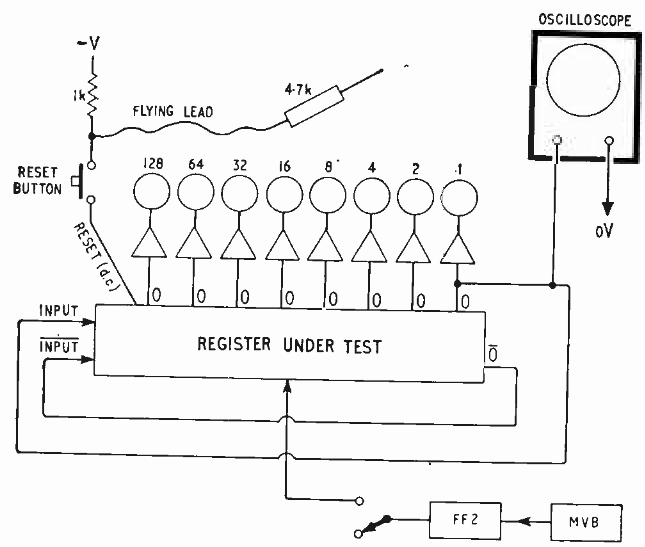
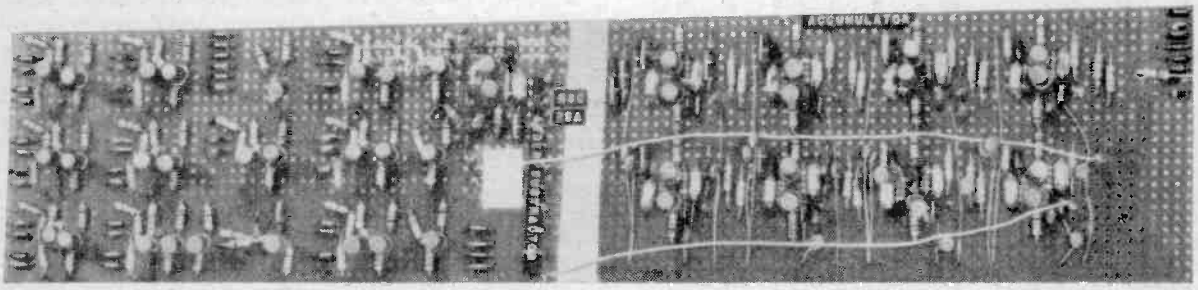


Fig. 37. Shift register test circuit.

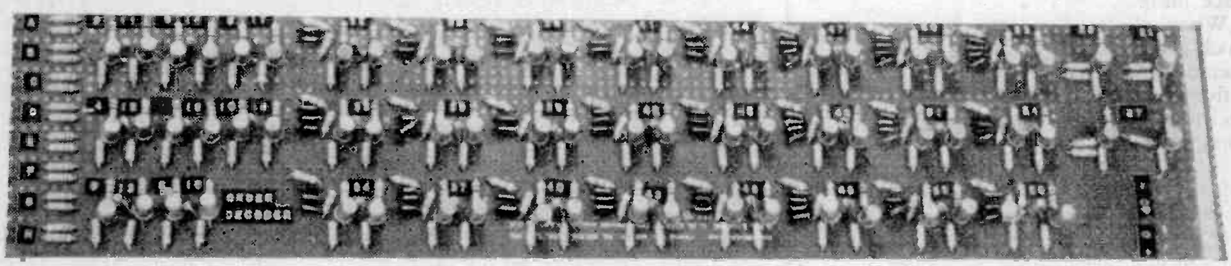
stable. When all is in order, set each bistable in turn using the 4·7-kΩ "wand" and ensure that the corresponding lamp lights. Wire a couple of 10-μF, 15-V electrolytics across the multivibrator capacitors to slow down the m.v.b., taking care to connect them the right way round (negative end to collector). Press the reset button and set one bistable in the register. Close the clock pulse switch. Each Bistable should set in turn and the light should travel down the row of indicators with successive pulses from the flip-flop. After the 2^0 bistable indicator is lit and extinguished the 2^7 light should light. If all the lights come on in turn and do not go out it is possible that the input connections to one or more of the bistables have been reversed. If the light gets to a certain bistable and then disappears, suspect the components coupling the two bistables or the commutating capacitors in the following bistable (C_1 and C_2). If no shift occurs at all, make sure that the multivibrator is working and is triggering the flip-flop satisfactorily. If the flip-flop is not triggering and is correctly wired, try increasing the value of the flip-flop C_1. Instead of just setting one bistable, try setting several bistables and make sure the pattern is preserved as they shift down the register. For those who have never seen a shift register in operation before the effect is quite fascinating.

When satisfactory operation has been achieved, remove the 10 μF capacitors from the multivibrator and ensure that the register will operate at the higher speed by observing the output waveforms on the oscilloscope. If faults occur do not forget to check the indicators and the multivibrator.

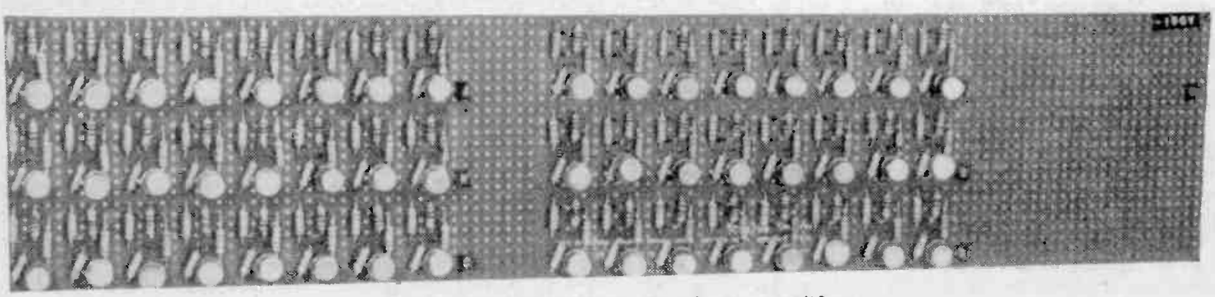


Circuit boards carrying the adder/subtracter (left) and accumulator (right).

Circuit board carrying the comparator, Store I and the counter.



The order decoder (without shift-pulse flip-flops).



Circuit board holding 48 of the 53 indication amplifiers.

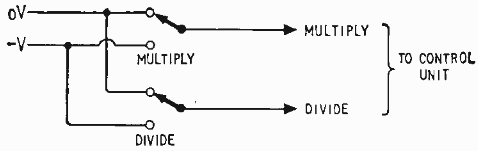


Fig. 38. Test input switches for checking control unit.

Now that both the register and accumulator are working satisfactorily, connect them to the adder/subtracter as shown in Fig. 18 (September) and also connect the add/subtract control switch of Fig. 36. The outputs of all bistables in the register and accumulator should be provided with indicators, as should the SUM and CARRY outputs of the adder/subtracter. It would be a good idea to have also some sort of reset facility along the lines of Fig. 35.

One cannot do much with this set-up as it stands unless a means of providing eight shift pulses is available, and for this reason the part of the control unit shown in Fig. 27 (October issue) should be constructed. Do not omit the normal one-bit switch. Connect an indicator to the output of gate 69 in Fig. 27 and with the switch in the "slow" position check that on pressing the start switch the indicator flashes eight times. It is difficult to predict all the faults that could occur in this circuit and to advise the reader accordingly. Provided a sensible approach is made and the operation of the circuit is understood, no real trouble should be experienced. If, for instance, the indicator does not flash at all, check that the multivibrator is working. If this is all right, set bistable 4 using the "wand". If the light still does not flash and bistable 4 is working the fault must lie in gate 69. If it does flash check bistable 3 and the coupling to bistable 4. If, on the other hand, when the button is pressed the light flashes continuously, check the bit counter by testing each bistable in turn and also suspect bistable 4 and possibly AND gate 69. The flip-flop can be checked by observing the output on an oscilloscope with the circuit operating at normal speed, the eight pulses being sufficient to make the trace jump.

When all is well with the control unit, connect the clock-pulse output to the shift-pulse input of the register, accumulator, added/subtracter set-up. The output of a flip-flop 2 should be found adequate to drive the two registers. If it is not, however, build a flip-flop 3 and connect it into the shift-pulse line. By setting numbers into the register and accumlator with the "wand" one can now add and subtract at will by pressing the start button. The reader is advised to try several arithmetic problems, carefully checking the results to ensure that no obscure faults exist.

Counter, store and comparator testing.—The next items to be constructed are the counter, store 1 and the comparator. When built, store 1 is tested in exactly the same way as a register. The counter is connected to a set of indicators and the operation of each bistable is checked as was done for the registers. If all is well, couple the input to the shift-pulse output of the control unit. For each press of the button the counter should count eight pulses. Try it at slow speed—the binary count will be easily recognized. Connect the comparator to the outputs and NOT outputs of the counter and store 1. If any faults that did not exist before show themselves the trouble could be in the input circut of one of the comparator gates, or it could be that the counter or store 1 were operating without any safety margin, indicating a component well outside tolerance. The comparator is checked by observing the EQUAL output while varying the contents of the counter and store 1. The EQUAL output should only be "up" when the contents of store 1 and the counter are identical. Each gate in turn should be checked by setting and resetting the appropriate bistables with the "wand".

Checking arithmetic operations.—The rest of the circuits should be added to the control unit so that it conforms to Fig. 29 (October)—see correction note—and the various inter-unit connections made between the control unit, adder/subtracter, accumulator, register, store 1, counter and comparator. It will be necessary to connect two single-pole change-over switches to the "multiply" and "divide" inputs of the control unit as shown in Fig. 38. The control unit is perhaps the most difficult for "trouble-shooting". Should trouble be experienced a good knowledge of the circuit, an oscilloscope and perseverance are the tools that will ensure success.

We now have a circuit that will multiply and divide as well as add and subtract. Reset all bistables, set 00001000 in store 1 and 00000001 in the register, select "add" and "multiply" and press start button. Continuous additions should take place and the counter should advance by 1 for each addition until it holds 00001000. The computer should then stop. The accumulator should now hold 00001000 and the register 00000001. In other words we have multiplied $1_{(2)}$ by 1000_2 and the result, 1000_2, is held in the accumulator. If the counter counts the first addition but the computer does not restart after the first word has been added and it is proved with a meter (slow speed) or an oscilloscope (normal speed) that the e.w.t. pulse is available at the AND gate 70 output, check the trigger stage or try the effect of increasing the value of the input trigger capacitor.

Provided all is well, with 00001000 in the accumulator and 00000001 in the register, clear the counter to 00000000, select "substract" and "divide," and press the start button. Repeated subtractions should take place and at the end of the operation the counter should hold 00001000, the register 00000001 and the accumulator 11111111; and the carry store should be set indicating that the accumulator contents are negative. Switch off the "divide" input to the control unit, reset the carry store and select "add," and press the start button. The accumulator should now hold 00000000 (the remainder), the carry store should be set and the register should still hold 00000001. What we have done is to divide 00001000 by 1. This was performed by continuous subtraction until one too many subtractions took place, resulting in the accumulator going negative. The counter counted the subtractions and held the result (quotient). We then cleared the redundant carry and added, to compensate for the fact that one too many subtractions took place, and the remainder, which was 0, was held in the accumulator.

Do not proceed any further with the construction until all circuit arrangements described so far have been thoroughly tested and are working satisfactorily.

The registers that form stores 2 and 3 may now be built and tested, the data routing gates can be built and the computer rewired to conform to the logical diagram of Fig. 22 (September). This circuit should be tested on its own with the aid of switches as shown in Fig. 39. This means that quite a large amount of wiring has to be done that will be of no use when the decoder is

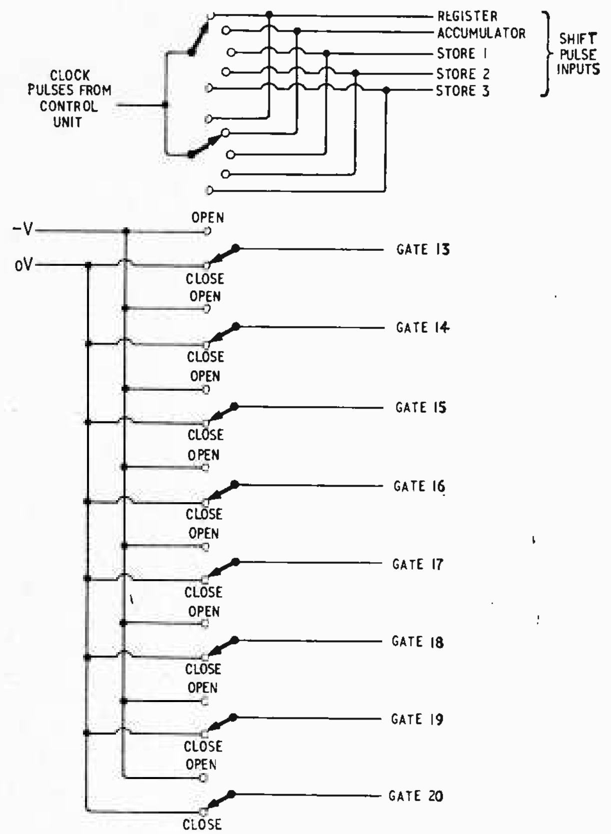


Fig. 39. Arithmetic and data transfer test switching.

added. However, the time so spent may well be repayed, since, if faults are discovered when the decoder is added, one will know immediately that these faults are confined to the decoder.

Checking data routing.—Once the computer and the test circuit are wired up all the tests that were previously carried out on the arithmetic unit should be repeated. It is now necessary to take into account the data routing control signals as well as the "multiply," "divide," "add" and "subtract" signals. To perform the arithmetic checks, all gates with the exception of 13 and 15 should be closed and the shift-pulse switches should be set to supply the register and accumulator. The transfer gating should next be checked. For example, close gates 13 and 15, open gates 14 and 18, set shift pulse switches to store 3 and register, ensure that "multiply" or "divide" is not selected, and press the "start" switch. The contents of store 3 should transfer to the register. Perform similar checks until all possible transfer instructions have been tried, i.e. each store to the register, each store to the accumulator, and the reverse, register to each store, and accumulator to each store. The gates that should be open can easily be deduced from Fig. 22. If any faults occur first make sure that the test control switches have been correctly set.

Decoder testing.—The decoder may now be built according to the logical diagram of Fig. 26 (October). Testing is quite simple. Couple up the power supplies to the decoder and connect the clock-pulse input to a single-pole changeover switch so that the clock pulse input can be switched to either the negative or the OV line. Check the operation of each gate in turn, referring to the logical diagram, Fig. 26, and manipulating the input switches accordingly. For example, put switch S_8 "on," so that the input to the decoder is ABCDEFGH, then operate the clock-pulse switch to connect the clock-pulse input to the negative line. Conditions should be as follows:—AND gates 46, 49, 63 and NOR gates 34, 31 all "up," NOR 33 "down," all other AND gates down. Connect the clock-pulse input to the OV line and check that the output of AND gate 63 goes "down." While testing the decoder check not only for the correct "up" outputs but make sure also that lines are "down" at the right times.

Disconnect the test circuit of Fig. 39 from the computer and fit the decoder in its place. Using the control orders table on p. 489 of the October issue, check each function of the computer in turn. Should a fault occur, locate and cure it and repeat all previous tests until the computer will perform all the operations in the table with the exception of transfer-from-counter instructions.

Only one further unit remains to be built, and this is the counter transfer gating unit as in Fig. 23 (September). By this time the reader will have gained sufficient experience to devise a means of testing this unit himself as it only consists of a number of AND-gates. When the counter transfer gating unit has been built and tested connect it to the computer as shown in Fig. 25 and once again go completely through the repertoire of control orders.

The computer may now be mounted in a cabinet. The Imhof Type 1100A was used in the prototype and found ideal for the purpose. The circuit boards were mounted on an angle alloy framework in four banks of two, care being taken to prevent short-circuits occuring between this framework and the copper strips of the Veroboard. The front panel layout may be seen in the photograph. If the specified push buttons are used it should be noted that one side of these are common to chassis. This common connection must be made the negative line. As a result the case is connected to the negative line and must not be connected to anything else. 53 neons are mounted on the front panel. One neon is used for each bistable in each register and the counter, making 48 of the total. The other five neons are connected as follows:—

(1) CARRY output of adder/substracter.
(2) SUM output of adder/subtracter.
(3) EQUAL output of comparator.
(4) AND 51 (decoder) output, indicating a "to store" instruction.
(5) AND 52 (decoder) output, indicating a "from store" instruction.

Neons (4) and (5) are interposed in two of the lines drawn on the front panel forming a simplified flow diagram of the computer, and they indicate when lit which line is "open." The power unit was not mounted in the cabinet.

Corrections. (1) Page 492, Fig. 29 Input of AND 73 should be connected to the output (not NOT output) of bistable 4. Trigger stage output is still connected to bistable 4 NOT output as shown. (2) Page 492, Fig. 30. Second waveform should be labelled output FF2 (not FF1). (3) Page 422 Fig. 25. NOR gates 8 and 9 change to $\bar{1}$. (4) Page 490 Fig. 26. Bottom l.h. NOR should be 29 not 28. Also, transpose 18 and 20 to data control gates.

Colour TV Test Equipment

A survey of the test equipment used for setting up, adjusting and repairing colour TV receivers

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

GOOD radio engineers have been heard to boast, "Just give me an Avo and I can fix any radio receiver." A time may come when this will be the same for a colour TV set, but he would be a bold one who would venture to say so just yet. Until colour circuitry settles down, most workers are tending to lean heavily on quite an array of test equipment, to be described in this article.

TEST BENCH ACCESSORIES

Before we go on to look at the more complex colour TV instruments such as pattern generators and oscilloscopes, we might look at the simple gadgets that seem to collect on the bench because they are so useful. An obvious one is a mirror at the back of the bench so you can work on the back of the receiver and conveniently see the effect of your adjustments on the reflected displayed picture.

A similar sort of convenience is the "line cheater," i.e. a length of mains flex fitted with male and female mains plugs, to be used when the set mains lead is permanently fixed to the back cover of the receiver. With this it is possible to remove the cover and insert the extra length of mains lead so that the cover can be tucked out of the way as you work on the set. Equally useful are a set of short, 1½ ft, insulated wire leads with insulated crocodile clips on each end.

Many engineers who work with a.c./d.c. sets install a multi-tap, isolation, mains transformer so that they do not have to bother about whether the chassis being worked on is live. A further useful little transformer gadget is the c.r.t. "brightener." This is a small heater transformer with a voltage step-up ratio of about 1.2:1, used to raise the heater voltage on a "failing" picture

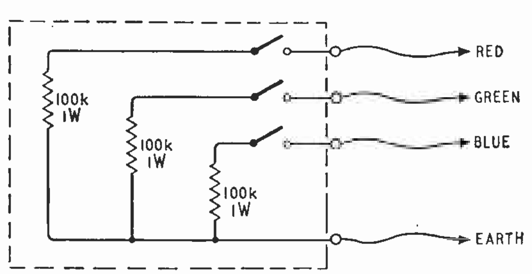


Fig. 1. "Gun-killer" switch box circuit: insulating flexible crocodile-clipped leads arranged so that, by clipping to the three grids of the colour picture tube and to chassis, signals on any grid can be shorted out via a 100kΩ resistor to earth.

tube or give a new lease of life to a tube with a heater-cathode short.

Many engineers find a "bias-box" useful. This is a source of variable d.c. up to about 12 V with which you can vary the bias voltages on different stages of a TV set. In particular you can set the d.c. bias on an a.g.c.-controlled stage and disable the a.g.c. Bias boxes are commercially available, but an easily contrived substitute is a grid bias battery with croc-clip flying leads.

All the above aids have been in common use with black-and-white receivers. With colour television, two new gadgets tend to find their way on to the bench rack. The first is a magnifying glass for inspecting the fine structure of the colour display on the picture tube. The other is a "gun-killer" switch box. This is simply three 100 kΩ resistors connected through separate switches from an earth lead to separate, flexible, insulated, leads terminated in crocodile clips as shown in Fig. 1. In use, the red, green and blue leads are clipped to the corresponding grid leads of the picture tube and the earth lead is connected to chassis. It is then possible, by closing any switch, to kill (i.e. not reproduce) the colour controlled by the corresponding grid. Commercial gun-killers are available that simply plug directly into the picture tube socket, but most workers in this field end up making up their own gun-killers.

METERS

Anyone working with TV sets usually has a multimeter of some sort, but often too he has a d.c./a.c. valve voltmeter. A useful accessory to the latter is an e.h.t. probe to simplify c.r.t. electrode voltage measurements (so critical in colour receivers).

For colour work, it is convenient to have separate d.c. meters of 2 mA f.s.d. for setting the e.h.t regulator valve standing current, and 500 mA f.s.d. for setting up the line-output valve drive.

For ordinary black-and-white work, an r.f. valve voltmeter with a 6 Mc/s bandwidth is handy for servicing video circuits. In colour work it becomes almost an essential, because of the added complication of wide-band circuits in the chrominance, colour oscillator and decoding sections of the receiver.

Another a.c. instrument finding wider use nowadays is the field strength meter. As an aid to rapid efficient setting up of aerial systems, this is common in colour work because aerial orientation is more critical than

*Newmarket Transistors Ltd.

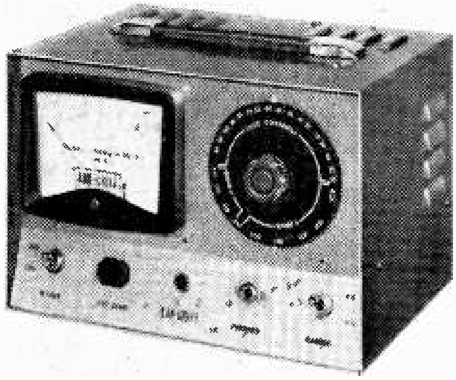


Fig. 2. Representative examples of commercial TV field strength meters: (left) Labcraft u.h.f. Type 415 valved; (right) Labgear u.h.f./v.h.f. Type E5185, transistorized.

with black-and-white. Field strength meters are readily available commercially. Fig. 2 shows two representative examples suitable for colour work: the Labcraft u.h.f.-only Type 415 and the Labgear u.h.f./v.h.f. Type E5185.

OSCILLOSCOPES

Except in very well equipped shops and experimenters' labs, the oscilloscope is not commonly used in Britain for dealing with black-and-white television sets, but you are likely to see it more used with colour. It is required mostly for dealing with the stages after the video detector of the receiver, where wideband signals up to over 6 Mc/s are handled. This immediately means that the ordinary low-frequency 'scope is not much use. Basically a vertical amplifier bandwidth of at least 7 or 8 Mc/s is called for, and you find people using such instruments as the Solartron CD1400 (which has a sweep-delay, timebase, plug-in suitable for TV measurements), the Marconi Instruments TF220A (with the TM6457A TV-differential unit for examining TV waveforms), and the Telequipment S51. The horizontal timebase requirememnts on a 'scope for television work are undemanding. It is customary to display only a few cycles of horizontal sweep at line frequency, and thus a sweep rate of 100 kc/s in the 'scope is more than adequate.

It is possible to carry out some work on colour circuits with a low frequency 'scope by disconnecting the vertical amplifier and feeding signals directly into the vertical deflection plate terminals. Any 'scope, when signals are fed direct to the deflection plates, becomes a wideband one, but, of course, the deflection sensitivity is low. However, there are still some video signal levels towards the output end of the receiver which can be displayed directly in this way on a slow-speed 'scope.

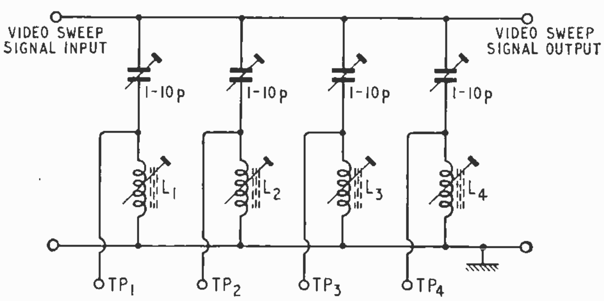


Fig. 3. Video sweep absorption marker-box circuit.

SIGNAL GENERATORS

Some sort of signal source is required when probing into the circuits of a television receiver. At worst, you can make do with the test card transmitted at various times during the day from television stations. Both black-and-white and colour patterns are available. As these test cards are not transmitted continuously, serious workers supplement them with some form of signal generator.

A well equipped lab which has been dealing with black-and-white television sets, may have one or more of the following types of signal generators:

(a) **V.H.F. signal generator.**—A v.h.f. signal generator covering 30 to 220 Mc/s is typical. This should be fitted with a reliable attenuator with an output up to 100mV when terminated in 75 ohms. There is usually provision for modulating the signal to a depth of at least 50% with a sinewave. It should have an easily read scale, whose calibration can be checked fairly simply against the carrier frequencies of television stations.

(b) **A.F. signal generators.**—Although the v.h.f. signal generator may have an a.f. modulation output terminal, many workers prefer a separate a.f. signal generator. There is great convenience in having both a.m. and f.m. provision in the one generator. To be useful in aligning the f.m. intercarrier sound channel, the f.m. side of the generator should have a 6Mc/s output of up to 100 mV, with a frequency deviation of about ± 50 kc/s corresponding to 1 kc/s audio.

(c) **H.F. (v.h.f./u.h.f.) sweep generator.**—The lining-up of tuned amplifier stages in a television receiver is facilitated by the use of an "h.f." sweep generator. Its principal use is for i.f. stage alignment, so that it must at least have a sweep range of not less than about 10 Mc/s around the i.f. frequencies. Lining up is made even easier if the sweep generator has crystal oscillator marker generator circuits giving i.f. markers at least for 33.15 Mc/s (adjacent vision), 33.5 Mc/s (sound), 35.07 Mc/s (colour), 39.5 Mc/s (vision), and 41.5 Mc/s (adjacent sound). In addition to i.f. frequencies, more exotic versions of the sweep generator cover Bands I and III (and ultimately Bands IV and V) for tuner adjustment.

(d) **Video sweep generator.**—If a v.h.f. sweep generator is allowed to beat with the fixed i.f. vision frequency of 39.5 Mc/s from the v.h.f. signal generator, a video signal sweep from low frequency to 8 Mc/s can be created for aligning the post-video-detector circuits of a colour television receiver. In a busy workshop, you will sometimes find a separate self-contained video sweep generator. This avoids the need to lash up the v.h.f. sweep and the v.h.f. signal generators together. Such a video sweep generator with a sweep response flat out to 7 or 8 Mc/s is an effective tool for adjusting the back end of a colour receiver.

(e) **Marker Adder.**—If a video sweep generator is not fitted with internal marker circuits, a useful accessory is the absorption, marker-adder box, using some circuit arrangement of tuned circuits across the signal line, as in Fig. 3. This is inserted in series with the sweep generator output. The inductor circuits, tuned to the required marker frequency, act as traps and give rise to blips in the oscilloscope display of the response of the circuit being adjusted. Any tuned circuit in the marker box, when switched in, reduces the sweep generator output at the resonance frequency. The centres of the tuned circuits are brought out to terminals so that, by touching the terminal for any inductor, you can identify the corresponding marker on the screen by the change that takes place in the blip.

Except for the video sweep generator, the signal sources discussed so far have been fairly commonly used with black-and-white television for some time. We now come to two types of generators which both play a special part in colour set work: black-and-white pattern and colour-pattern generators.

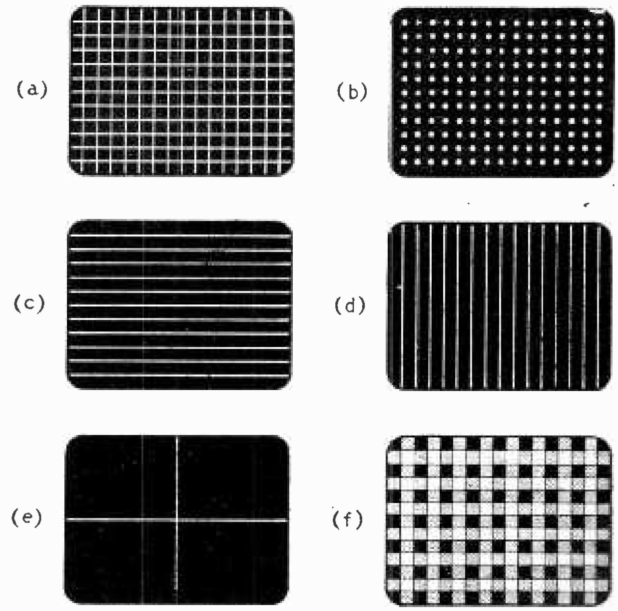


Fig. 4. Patterns commonly used in commercial crosshatch/dot generators: (a) crosshatch; (b) dot, (c) horizontal lines; (d) vertical lines; (e) crossed lines; (f) grey scale checkerboard.

CROSSHATCH/DOT PATTERN GENERATORS

The crosshatch/dot pattern generator provides a signal which, when fed into the TV receiver, produces a pattern on the screen to enable you to adjust accurately the centralisation, width, height, and linearity of the picture whether the receiver is black-and-white or colour.

While the crosshatch/dot generator is a useful instrument for adjusting black-and-white receivers, it is an *essential* for adjusting the extra colour circuits found in a colour receiver controlling the colour convergence. Colour convergence is the alignment of the three electron beams in the picture tube (which has a separate gun for each colour—red, green and blue). Each gun fires a stream of electrons at the tube screen to produce the picture. The three streams must pass through holes in a perforated metal plate called the shadowmask and fall on the appropriate phosphor dots on the screen. Colour convergence ensures that all the electrons from the blue gun fall on to the "blue" phosphor dots, and similarly with the other colours. These three beams are very sensitive to changes in magnetic fields in and around the receiver. As a result it is not possible for the manufacturer to set up colour convergence in the factory and be sure that it will not need further adjustment in the position in the viewer's home where the set is actually used.

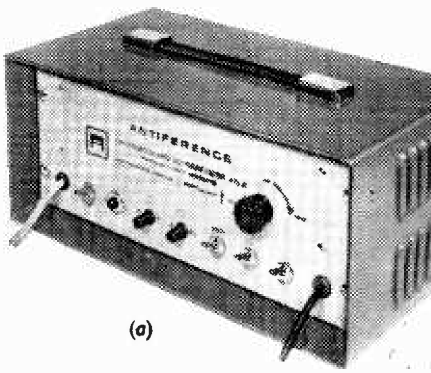
Many types of crosshatch/dot generators are available commercially, but in general they produce some at least of the patterns shown in Fig. 4. Almost invariably they have the "crosshatch" pattern of Fig. 4(a), but different makes provide different numbers of vertical and horizontal lines in the pattern. The crosshatch usually appears as bright lines on a black background. Most commercial instruments also produce a pattern of dots, as shown in Fig. 4(b), where the dots occupy the same positions as the intersections of the horizontal and vertical lines of the crosshatch of Fig. 4(a). Many generators also provide horizontal lines as shown in Fig. 4(c) and vertical lines as in Fig. 4(d). A few generators have the special single-line cross pattern of Fig. 4(e) for easy centring of the display. An additional convenience sometimes found is the checkerboard pattern of Fig. 4(f), which is most useful for setting up the grey scale on the receiver. It has three brightness levels from black in the background through grey on the individual bars to white on the bar intersections. Further patterns sometimes used are a blank-screen constant-white, a bar sequence of grey levels from black to white and a single dot in the screen centre.

In most crosshatch/dot pattern generators, the complete composite video pattern signal is usually modulated on to a carrier oscillator to provide a signal output adjustable across some or all of the v.h.f. and u.h.f. channels. For example, the Labgear E5180 provides 405-line patterns on Channels 6-13 and 625-line on Channels 26-52. Some pattern generators also provide a video output directly for injecting into the video stages of the receiver, if it is not convenient to feed a v.h.f./u.h.f. signal into the front end.

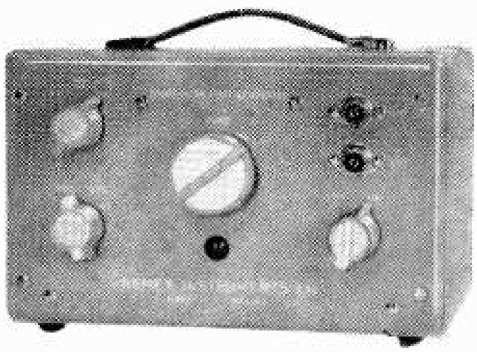
In the U.S.A., over a dozen companies market crosshatch/dot generators, but because of the different transmission standards used, these are not usable in the U.K. without modification. At present, companies marketing pattern generators for the British PAL system include Antiference (Video-Circuits), Bemex, E.M.I., Gresham-Lion, Labcraft, Labgear, Marconi, M.E.L. Equipment, Peto-Scott, Rank-Bush-Murphy, RCA, and Solartron. Some of these specialize in very refined equipment for broadcasting purposes, but a number produce economical instruments for general lab and servicing use. Fig. 5 illustrates three commercial crosshatch/bar generators aimed at the lower-priced, general-purpose market. The Antiference instrument in Fig. 5(a) provides 405-line output on Chs 6-13 and 625-line output on Chs 29-43; mains-driven, it provides positive and negative vision modulation, with both crosshatch and dot patterns, the number of vertical and horizontal lines being variable from 5 to 25. The Bemex crosshatch/dot generator in

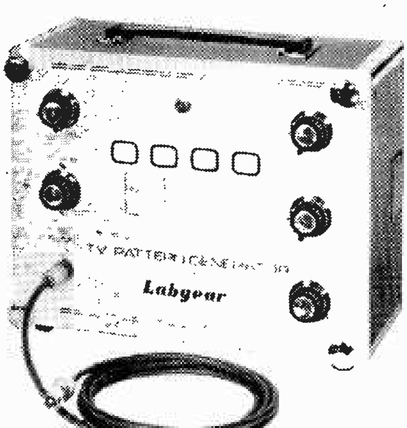
Fig. 5(b) has 405/625 line provision with separate v.h.f. and u.h.f. output sockets covering Chs 7-13 and Chs 31-42; it gives both crosshatch and dot patterns, together with the useful facility of a blank white raster. The Labgear E5180 generator in Fig. 5(c) is portable, transistorized and battery driven with the main accent on practical simplicity. It provides both 405-and 625-line patterns with crosshatch and dot patterns together with separate patterns of vertical and horizontal lines; the output covers Chs 6-13 and Chs 26-52.

It is probable that Anglicised versions of American crosshatch/dot generators will in time become available from such manufacturers as Heathkit. Similarly it is likely that the Continental instrument manufacturers such as Grundig, Nordmende, and Metrix will bring out 6 Mc/s-sound English versions of the pattern generators they now market for the Continental 5.5 Mc/s-sound 625-line swinging burst PAL system.



(a)

(b)




(c)

Fig. 5. Examples of British commercial crosshatch/dot pattern generators: (a) Antiference; (b) Bemex; (c) Labgear.

COLOUR BAR PATTERN GENERATORS

A crosshatch/dot generator of itself is not sufficient for adequate adjustment of colour TV receivers. Once the convergence has been checked and adjusted with it, some form of colour bar generator is needed to check the adjustment of the separate colour channel circuits in the receiver, such as the chrominance, colour reference oscillator, and decoding circuits.

In the U.S.A., most commercial crosshatch/dot generators also have colour bar facilities. This so far has not been the case in the U.K., except for the M.E.L. Equipment PM5507 referred to later below. This is because, with the American N.T.S.C. system, which does not have the complication of swinging burst, it is relatively easy to add an extra colour oscillator to the crosshatch/dot generator circuits to provide a colour bar output. In the U.K., with swinging-burst PAL, providing a colour bar extra on a crosshatch/dot generator adds considerably to the complexity and cost of the instrument.

When models of colour bar generators come more freely on the English market, it is to be expected that the bar patterns they provide will follow fairly closely those that have been common in the United States for many years now. Basically in the lower priced generators the bar patterns fall into one of three main categories. The most expensive to produce, and thus the least common, is what is known in the U.S.A., as the "N.T.S.C." pattern and is likely to become known here as the "PAL(AB)" (AB=Alternating Burst) pattern. This provides a pattern similar to the test pattern put out by transmitters, i.e. a row of eight equal-width vertical bars across the face of the tube with the colour as shown in Fig. 6(a).

Easier to produce circuit-wise, and therefore cheaper and more common, is the "keyed-rainbow" pattern shown in Fig. 6(b). Each of the ten colours appears in discrete bands separated by other dark clearly defined bands. Another version is the even simpler "rainbow" pattern, where the colours display a gradual transition from yellow to green from left to right in the same order as in Fig. 6(b) but without the intermediate black bars. The lack of dividing bars makes it less useful than the keyed-rainbow generator pattern.

If instrument practice follows here the path it took in the U.S.A., it is to be expected that most low-priced colour bar generators eventually appearing in this country will be keyed-rainbow ones.

The output from a colour bar generator can be a v.h.f./u.h.f. signal for feeding directly into the set aerial socket or a video signal for feeding directly into the back end of the receiver.

The M.E.L. Equipment colour bar and crosshatch/dot generator type PM5507 shown in Fig. 7 is the only general-purpose colour pattern generator suitable for the British system on the market at the time of writing. Its output is u.h.f. only, covering channels from 500-900 Mc/s, and provides ten keyed-rainbow colour bars and a continuous unkeyed-rainbow pattern as well as crosshatch, dots, vertical lines, and horizontal lines. It does not provide, however, as so many of the American instruments do, a separate unmodulated sound carrier at the standard distance from the vision carrier, a most useful facility for adjusting the receiver fine tuning accurately before proceeding to adjust the various receiver circuits.

If you are interested in the more technical details of

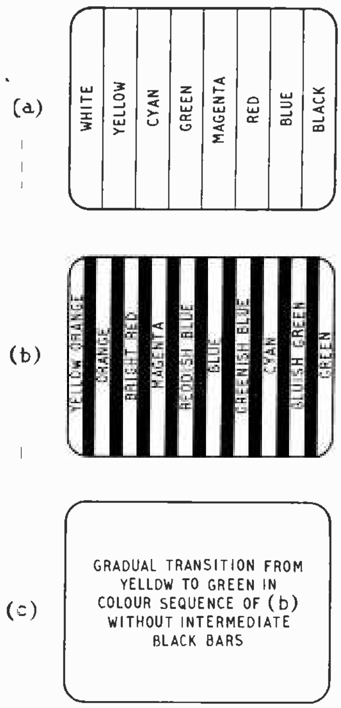


Fig. 6. (left) Commoner patterns in commercial colour bar generators: (a) PAL (test card); (b) keyed-rainbow; (c) simple rainbow.

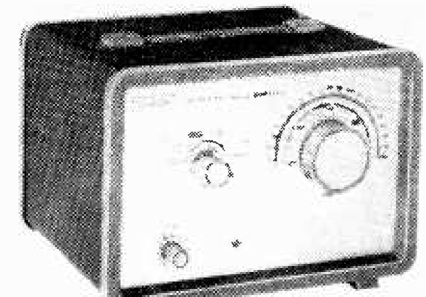
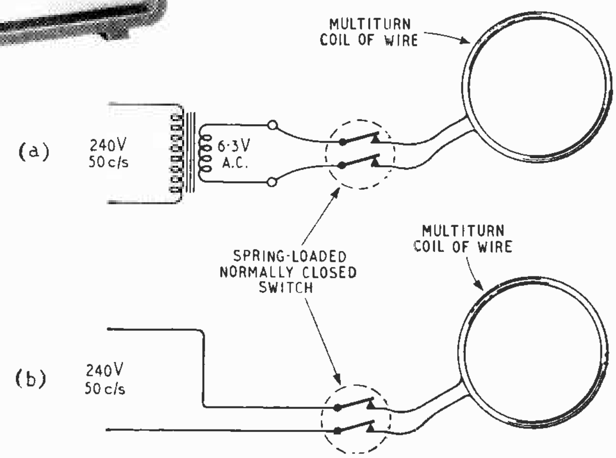


Fig. 7. (left) Commercial colour bar pattern generator for British PAL system: M.E.L. Equipment P.M. 5507, combining keyed- and unkeyed-rainbow patterns with crosshatch/bar facilities.

Fig. 8. (below) Two basic types of degaussing coil arrangements: (a) low-voltage transformer driven; (b) high-voltage mains-driven.



the problem of TV colour pattern generator, you should consult a publication by Telefunken AG, 1 Berlin 10, Ernst-Reuter-Platz 7, called "Selected Papers II; PAL, a Variant of the N.T.S.C. Colour Television System" which is in English and is a special edition of *Telefunken Zeitung*, June 1966. Paper No. 9 in this collection, entitled "Colour TV Pattern Generators" by W. Bruch and R. Schirmer, gives considerable details of the problems and circuitry to solve them.

DEGAUSSING COILS

Colour TV receivers will normally be fitted with an automatic degaussing arrangement, but the degaussing effects of this are confined largely to the colour display tube. If any part of the chassis should become accidentally magnetized, it will be necessary to degauss (demagnetize) the affected area with a special hand-held degaussing coil. This has become standard procedure before adjusting colour convergence, the degaussing coil being slowly moved about round the front and sides of the set and then gradually withdrawn several feet away from the receiver before being switched off.

Essentially a degaussing coil is just a multiple-turn coil of wire fed with 50 c/s a.c. from the mains. Experience has shown that the coil must be capable of producing a field of between 500 and 3,000 ampere-turns. Fig. 8 shows suitable arrangements, one fed from a low voltage transformer for safety and the other direct from the mains. Each version incorporates a spring-loaded, normally open, double-pole switch in the flexible lead to the coil, so that the coil cannot be accidentally left on for long periods and give rise to dangerous overheating.

The low-voltage degaussing coil of Fig. 8(a) uses 28 turns of 14 s.w.g. wire on an 18in diameter coil, fed from a 6.3 V transformer capable of supplying some 30 A. The mains-voltage version of Fig. 8(b) by contrast uses 850 turns of 21 s.w.g. wire on a 12in diameter former.

In the case of degaussing coils connected directly to the mains, for obvious safety reasons special care must be taken to use high grade insulated wire as a precaution against breakdown between adjacent turns, and to ensure adequate insulation of the coil as a whole by layers of insulating tape overall.

INSTRUMENT PRIORITIES

All instruments used for black-and-white receiver work are understandably suitable also for colour sets. But colour receiver work brings a need for specialized colour instruments, for which the practical order of priority would seem to be: (a) degaussing coil; (b) crosshatch/dot pattern generator; (c) colour bar generator; and (d) wide-band oscilloscope.

In all this, however, it should not be forgotten that, except for the degaussing coil, you can do without the other instruments provided you use test patterns available from the transmitters. And so, to paraphrase what we said at the beginning of the article, we can expect some good colour TV engineers in the future to say "Just give me an Avo . . . and a degaussing coil . . . and I can fix any colour TV set."

COLOUR SERIES AS A BOOK

A book by T. D. Towers based on the "Colour Receiver Techniques" series is to be Published by Iliffe Books Ltd. (Dorset House, Stamford Street, London, S.E.1.) and is expected to be available in the Spring of 1968.

LETTERS TO THE EDITOR

The Editor does not necessarily endorse the opinions expressed by his correspondents

Semi-stabilized D.C. Supply

MR. SHORT'S semi-stabilized d.c. supply (October issue p. 482) makes effective use of a constant-current source in the reference section, extracting good performance from a minimum of components. Following the well-known electronics adage " If it works, modify it," may I offer ways of " souping up " the circuit still further?

Just as resistor R_4 in the original senses that load current and boosts the Zener diode voltage to offset the natural fall in output, so we may sense the changes in supply voltage and inject a suitable correcting signal. The resistor R_7, shown dotted in Fig. 1, should achieve this. As the supply voltage increases R_7 contributes a larger proportion of the current to R_1 leaving less to flow in R_2 and R_3, and opposing the original change. The appropriate value is best found on test but is likely to be some hundreds of kilohms. It should also serve to eliminate ripple in the same way since in effect $R_3 + R_2$, R_1, R_5 and the slope resistance of D_1 form a balanced bridge leaving Tr1 with no ripple to detect. One wonders if C_1 could then be left out? The test procedure would then involve adjusting R_7 for minimum ripple which setting should also give maximum stability factor.

Alternatively a transistor can be added as in Fig. 2 converting the reference section into a " Ring-of-two Reference " (July, '67). Now even the Zener diode current is substantially independent of supply voltage ensuring that the current in R_2 is very stable. If R_3 were replaced by two forward-biased silicon diodes they would then compensate for the temperature drifts in Tr2 and Tr3.

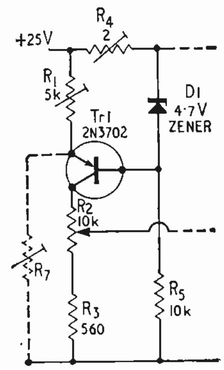


Fig. 1

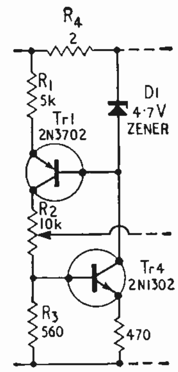


Fig. 2

As usual in such musings, attempted improvements edge the circuit further and further away from its original intentions in the direction of that mythical beast of the circuit designer, the perfect regulator.

PETER WILLIAMS

Paisley, Renfrew

Noise Figure Measurement

I WAS interested to read the comments by Messrs. Bale and Quigley in the September issue about the article by Mr. Matthews in the August number. Messrs B. and Q. are, of course, quite right in their suggestion that the method of measurement appears to be based on a fallacy.

Mr. Matthews calls his attenuated reference input signal N_i, and regards it as being equivalent to the " cold terminated noise " of a calibrated noise source; but this is unlikely to be true in fact. The precise method of determining the reference signal level is not at all clear—which is very unfortunate, because the validity of the measurement depends upon it. Indeed, it would seem at first thought that, as the " cold terminated noise " is really the thermal noise of the source resistance and amplifier input resistance in parallel, the actual signal level must be zero.

However, it is necessary to take into account one fact that has, hitherto, been ignored in the argument; namely, the value of the source resistance. Noise figure is meaningful only on the assumption that the input signal is derived from a specified source resistance. We can argue that the noise figure of an amplifier is the ratio of its noise power output to the noise power output of an ideal amplifier having the same gain and bandwidth characteristics. An ideal amplifier's noise output, P_t, would be given by the product of its gain and the thermal noise from the parallel combination of its input resistance, R_{in}, and the source resistance, R_s. The real amplifier's noise output is, of course, the sum of the output, P_t, due to thermal noise and P_{int}, the output due to internally generated noise.

So the noise figure $F = 10 \log \dfrac{P_t + P_{int}}{P_t}$

Presumably, Mr. Matthews' amplifier is of the conventional voltage sensitive type, so that P_t becomes a direct function of the r.m.s. input voltage due to thermal noise, given by the standard formula:

$$e^2 = 4kTB.\frac{R_s R_{in}}{R_s + R_{in}}$$

We can, therefore, establish a finite level for N_i by a variation on Mr. Matthews' method, in which the output impedance of the attenuator in Fig. 1 of his article is very much lower than the specified source resistance—say $R_s/10$. The thermal noise content of the input signal would then be proportionately low, so that it could be ignored, and a procedure for setting up the reference level would be as follows:—

(1) Connect to the input terminals of the amplifier a resistor of value R_s, equal to the specified source resistance; and, with no signal applied, measure the output power. This power, P_n, is equal to $P_t + P_{int}$.

(2) Remove the resistor, and connect the amplifier's input terminal to the output attenuator of the signal source. If the output impedance of this attenuator is

very low, the noise content of the amplifier's output power will then be equal to P_{int}.

(3) Adjust the signal level to bring the total output power back to the value, P_n, obtained in (1). As the noise power output is equal to P_{int}, the sinewave output power must, then, be equal to P_t, and the r.m.s. sinewave input voltage must, therefore, be equal to the thermal noise voltage from $R_sR_{in}/(R_s + R_{in})$.

With the reference signal level set up in this manner, it can indeed be regarded as N_i, and the remainder of the measurement procedure is then theoretically valid. The method is, however, applicable only to amplifiers in which the change in source impedance does not influence the internal noise generated in the first stage.

St. Albans, Herts. J. F. GOLDING

I SHOULD like to support the September criticism of Messrs. Bale and Quigley of the article in your August issue by Mr. Matthews on the measurement of noise figure. The experimental results obtained by Matthews are sufficiently interesting that a very brief summary of the situation may be helpful to others puzzled like myself by the article. It is of course possible to measure noise figures with a sinusoidal signal generator, but not in the manner proposed by Matthews.

If an amplifier of any input impedance is fed from a sinusoidal signal source with constant output resistance R_s, open circuit sinusoidal voltage of r.m.s. value v, and open circuit mean square noise voltage $4kTR_s$ per unit bandwidth, then the effective input signal to noise ratio is $\frac{v^2}{4kTR_sB}$. Here B is the effective noise bandwidth of the amplifier and output power recording device, k is Boltzmann's constant and T is the absolute temperature of the source. If the amplifier output power is P with the sinusoidal generator at v and N with no sinusoidal input (R_s remaining constant of course), then the output signal-to-noise ratio is $(P/N-1)$. The noise factor is therefore

$$F = \frac{v^2}{4kTR_sB} \cdot \frac{1}{(P/N-1)}$$

This ratio is usually expressed in dB and then called the noise figure but it will be sufficient here to leave it in this form.

Although the noise factor can be calculated from the above formula, the procedure may be inconvenient since B has to be measured by a separate experiment. It is for this reason that a ' white ' signal source, such as a saturated diode, is to be preferred to a sinusoidal source. The effective open circuit mean square voltage with a diode source in shunt with the resistance R_s is $2IeR_s^2B$, where I is the diode current and e the electronic charge. The noise factor then becomes

$$F = \frac{eIR_s}{2kT} \cdot \frac{1}{(P/N-1)}$$

a well known and convenient result. As with a sinusoidal generator, narrow- or broad-band noise figures may be obtained depending upon B, but for the diode case the actual value of B does not enter the calculation.

Since Matthews' experimental results show reasonable agreement with those obtained by a standard method, and this is the important and puzzling point, it is interesting to look for the conditions for this agreement. Let v_1 and v_2 be Matthews' two sinusoidal source voltages (corresponding to his two source attenuator settings) which give amplifier power outputs in the ratio, say, 2. Then

$$F = \frac{v_1^2}{4kTR_sB} \cdot \frac{1}{(P/N-1)} = \frac{v2^2}{4kTR_sB} \cdot \frac{1}{(2P/N-1)}$$

If these equations are rearranged, and Matthews' required result that F should be simply given by $(v_2/v_1)^2$ is substituted, then we obtain the necessary result that

$$v_1^2 = 4kTR_sB(1 - 2/F)^{-1}.$$

Only fortuitously could v_1 have this value initially since F is unknown. Further, if F is less than, or equal to, 2 (i.e. 3 dB noise figure) then under no condition can the source attenuator change which doubles the output power be equal to the noise figure.

Finally, it may be pointed out that a noise figure can, under favourable conditions, be measured without using an external signal generator at all, (the source resistance is used as a generator.) Output power measurements are made with the amplifier input in turn shorted, open circuited and loaded with R_s. From these measurements, and a knowledge of the amplifier input resistance, the noise figure can be calculated. Derivation of the necessary formulae can be found in the GE Transistor Manual 7th Ed. P. 504.

E. MATHIESON

University of Leicester

MAY we trespass upon your space once again, to state firmly that Mr. Matthews is wrong?

(1) The excess noise output of any noise generator is *relative* to that from a matched termination at room temperature. If the instrument is direct-reading, as in the case of the Magnetic AB, or the Marconi noise diode instrument, some temperature is assumed, usually 290°K, and corrections applied to the indicated noise figure to allow for variations in room temperature. At least one maker supplies hot and cold loads for calibration purposes, but the secondary standard is *still* the room-temperature noise from the termination. (Mr. Matthews' N_i.)

(2) Our quarrel with Mr. Matthews is therefore two-fold:—

(a) His original analysis, although correct in itself, does not deal with what he actually *did*. Our original letter dealt at considerable length with this point, and we do not intend to repeat it. Suffice it to say that N_i was replaced by an initial signal generator setting (which we called S_1), which had a curious quality of being negligible for purposes of analysis, but significant for measurement purposes, and connected to the noise level by the meaningless phrase: " at the lower limit of normal operation." We went through all this in full. Mr. Matthews has not yet answered this criticism.

(b) He states that it is only necessary to measure a ratio to know the noise figure. We state that this is not so. Some standard is required, even if it is only a well-matched load at room temperature. In the case Mr. Matthews originally dealt with, he proposed to attempt to measure the ratio S/N-out to S/N-in. He did not in fact do this, as we have already shown, but even if he did not manage this, he at least showed that a standard *is* required in his own analysis, which is quite correct for the case of NO initial input signal. Having got rid of S/N-out by the doubling procedure he is left with S/N-in. In fact N-in is the required standard! However, Mr. Matthews did not use it!

F. V. BALE and M. J. QUIGLEY

Radio & Space Research Stn.,
Slough, Bucks.

Ring-of-two Reference Circuit

I WAS interested to see Mr. P. Williams' elegant voltage reference circuit in the July issue, and especially his statement that he had experienced no difficulty with the circuit failing to start on switch-on. The circuit is, of course, a non-saturating complementary bistable, and the start-up performance is strongly affected by circuit strays, the gain of the transistors at low current, and the leakage of the Zeners at low reverse voltages.

Some time ago I designed a battery-operated instrument for field use (shown at this year's R.E.C.M.F. Exhibition), embodying a circuit similar to that of Mr. Williams, but with one Zener diode replaced by a resistor. Looking at the circuit again for the purpose of this letter, I made it up with such components as happened to be at hand (Fig. 1) and noted a fall of 2 mV as the supply was reduced from 18 V to 9 V.

This is not quite as good as the performance of Mr. Williams' circuit, but, where adequate, saves a Zener diode. Where better performance is required the circuit

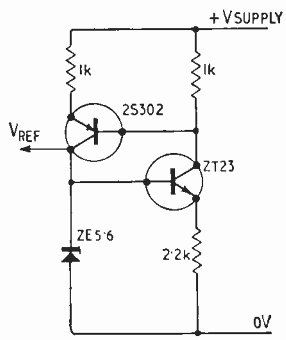


Fig. 1

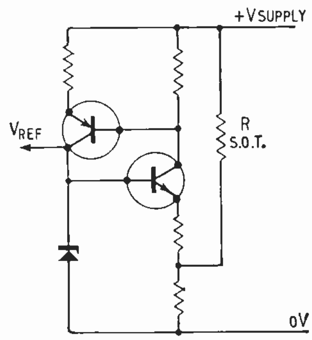


Fig. 2

of Fig. 2 is worth considering. Using the components of Fig. 1 and with R = 12k, the output was constant at 5.809 V to within 100 μV for a supply in the range 9-18 V.

Hatfield Instruments Ltd., Plymouth, Devon — D. I. H. MAY

Manx Radio

I NOTE with some degree of interest the statement made by J. F. Craine of Ramsey, Isle of Man, concerning Manx Radio (October issue, page 508).

I regularly listen to the transmissions from Manx Radio on 232 metres, and having written to this station for verification of my reception reports, I find that the following words are printed clearly on the front of the card. "The only local radio station and the only licenced commercial radio station in Great Britain". That being so, it follows that the Isle of Man must likewise be considered to be a part of Great Britain, which is, after all, just another name for the United Kingdom.

Glasgow, E.1. — IAIN T. PATERSON

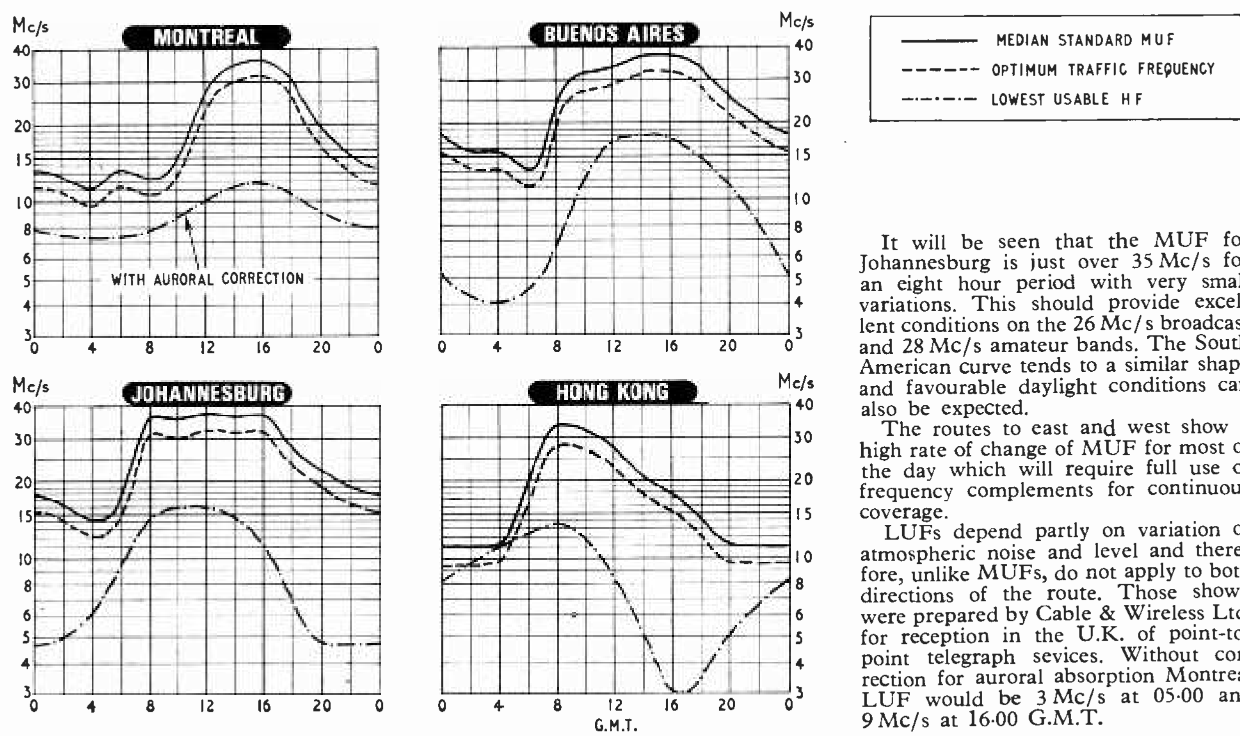
To what base uses . . .

I WONDER how many of your readers will reflect that the subjects* of your October cover picture hardly justify the electronic expertise that is being lavished on them?

Maidstone, Kent — J. KEITH CARTER

*So far as we were concerned the cameras were the "subjects"! ED.

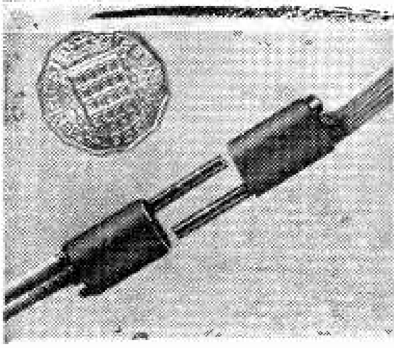
H. F. PREDICTIONS—NOVEMBER



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

The routes to 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 variation of atmospheric noise and 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 sevices. Without correction for auroral absorption Montreal LUF would be 3 Mc/s at 05·00 and 9 Mc/s at 16·00 G.M.T.



Depicted here are typical examples of a range of Waterproof Connectors of unique design enabling electrical circuits to be connected or disconnected even when under water. The range caters for electrical loads of 440 volts a.c. 175 amps. down to the signal current levels associated with instrumentation and similar arrangements.

The basic design incorporates a patented principle referred to as "Watermate". Both plug and socket are moulded of a specially compounded neoprene rubber with unusually high insulation resistance and non-wetting surface. As mating occurs water, salt deposits, sand and other foreign matter are wiped from the sockets and ejected from a duct in the socket to form a leak-proof seal. The wiping action assures a dry connection at the moment of contact resulting in a leakage resistance of not less than 100 megohms WHEN MATED UNDER WATER.
They are pressure balanced and will not block up under high pressures. There are no glands or threads to seize up in water and the method of moulding to the associated neoprene jacketed cable provides an extremely robust and simple connector for both Military and Civil applications.
For full details of these Connectors and a new Underwater Reed Switch Assembly, please write or telephone to the Technical Sales Department..

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WW—130 FOR FURTHER DETAILS

WORLD OF AMATEUR RADIO

New R.S.G.B. Headquarters

AFTER a search that began more than ten years ago, the Radio Society of Great Britain is shortly to move into new premises at 35 Doughty Street, Holborn, London, W.C.1. Acquired by the Society's wholly owned subsidiary—Lambda Investment Company Ltd.—for £32,500, the property comprises about 2,600 square feet of accommodation compared with the 1,200 square feet at present available.

In the 54 years since the society was founded by the late Rene Klein on July 5th, 1913, it has known only four official addresses; the first being 107 Hatton Gardens, W.C.1, rented to the Wireless Society of London, as it was then called, by Mr. A. W. Gamage, of Holborn. For four years during the Second World War it was at 16 Ashridge Gardens, Palmers Green, London, N.13, and since 1943 at its present address, 28 Little Russell Street, W.C.1.

Financially the new project (estimated at £40,000, including alterations to the building, installation of heating and decorations) will be met partly from contributions to Headquarters Fund (£2,620 up to last August) and partly from the issue of £20,000 6% Redeemable Debenture Stock for subscription by members in units of £25. Full details and a form of application to purchase stock have been sent to members.

Top Band Operation

AS from July 20th, portions of the 1800-2000 kc/s band became available to radio amateurs in various areas of the United States of America. The only segment prohibited to amateurs is 1825-1875 kc/s used by Loran stations.

In the United Kingdom and eight other European countries, administrations may allocate up to 200 kc/s to their amateur service within the band 1715-2000 kc/s, but steps must be taken to prevent harmful interference to stations in the fixed and mobile services and the mean power of amateur stations must not exceed 10 watts. U.K. amateurs may operate between 1800 and 2000 kc/s, but must take care to avoid interference with U.K. coast stations.

During recent months several transatlantic contacts have taken place between amateurs on Top Band, including one between H. A. Aspinall, G3RXH, of Skipton, Yorks, using a 100-ft vertical aerial, and Stewart Perry, W1BB—doyen of Top Band DX enthusiasts—of Winthrop, Mass.

Tristan da Cunha.—Alan Hemming, who has just returned to the lonely island of Tristan da Cunha in the South Atlantic after a period of leave in the United Kingdom, combines the duties of Postmaster with those of commercial radio operator. Additionally he operates, when time permits, an amateur radio station under the call sign ZD9BE. A recently acquired Swan 350 transceiver and 3-element tri-band array will soon be in use. As a further sideline Alan Hemming also provides a regular broadcasting service for the 250 inhabitants of the island, including record request programmes. Before taking up his first appointment in Tristan Mr. Hemming operated from Wales as GW3SWQ.

Emerald Isle Tour.—Proof of what can be done in the way of consistent operation on the amateur 2-metre band was provided recently by T. P. Douglas, G3BA, of Sutton Coldfield, and B. H. Meaden, G3BHT, of Liverpool, who during the course of a 10-days tour of Ireland by car made 812 contacts on telegraphy and 150 contacts on single sideband telephony. Operation was confined to 4½ hours per day on telegraphy and to 25 minutes on telephony. The call EI2AXP was used when operating in Eire.

Balloon with 144-Mc/s Transponder.—Karl Meinzer, DJ4ZC, who was responsible for constructing the I.A.R.U. Region I OSCAR (now waiting to be launched in the United States) has lent a 144-Mc/s transponder to Albert Chisholm, W5UJF, of Alamogarde, New Mexico, who is preparing it for a balloon flight from Holloman Air Force Base near his home during the next few weeks. The instrument is similar to that installed in OSCAR (Orbiting Satellite Carrying Amateur Radio) and the purpose of the flight is to give radio amateurs experience in tracking and communicating via airborne transponders in preparation for future OSCAR flights. The launch will be made in the early evening and the flight is expected to last 12 hours. About six hours of the flight time will be spent at the maximum flight altitude of between 100,000 and 130,000 feet. The input passband is centred on 144·1 Mc/s and the output on 145·9 Mc/s. The U.K. OSCAR co-ordinator is W. H. Allen (G2UJ), 24 Arundel Road, Tunbridge Wells, Kent.

F.C.C. Licence Decisions.—The United States Federal Communications Commission has dropped the idea of a First Class Amateur licence and is to reinstate the Advanced Class with a new 50-question technical examination with a Morse code speed of 13 words per minute. Current Advance Class licence holders are to regain their status. Effective November, 1968, small segments of the lower portions of the 80, 40, 20 and 15 metre bands, as well as the segment 50-50.1 Mc/s are to become available only to holders of the Extra or Advanced Class licence. Proposals for a special callsign identification system have been dropped, the term for Novices has been increased to two years but permission, which Novices now have, to use telephony on 2 metres is to be withdrawn in 1968.

Basle Exhibition.—Radio amateurs will operate two stations at the third International Exhibition of Industrial Electronics (INEL) being held in Basle during the period November 14th-18th. The stations will operate on frequencies in the 3.5 and 144 Mc/s bands and will use the call HB9XAA. A special QSL card will be sent to confirm contacts. Further information can be obtained from Fritz Muelheim (HB9AAF), Im Lohgraben 13, 4104, Oberwil (BL).

Amateur TV Group for West London.—It is announced by the British Amateur Television Club that it is proposed to form a group in the West London area with a view to planning and running club exhibitions and demonstrations. Those interested are invited to contact R. Tibbutt, 11 Revel Road, Wooburn Green, High Wycombe, Bucks.

Beacon News.—The beacon station 9H1MB on Malta is now operational 24 hours a day on 70.1 Mc/s, the beacon station ZB2VHF on Gibraltar is operational on 70.26 Mc/s and the beacon ZD7WR on St. Helena on 28.992 Mc/s. Reception reports on signals from any of these stations will be welcomed by the R.S.G.B. Scientific Studies Committee, c/o 28 Little Russell Street, London, W.C.1.

4U1ITU Kept Busy.—During the first six months of 1967 the various operators of 4U1ITU, the amateur radio station located in the I.T.U. building at Geneva, completed more than 10,000 two-way contacts. W. A. Sinclair, GM3KLA, of Lerwick, Shetland Islands, and P. J. Smyth, EI9J, of Cavan, Ireland, recently became the first amateurs to contact 4U1ITU on six bands.

Amateur Radio in Nigeria.—Despite the state of war that now exists in Nigeria, amateur radio operation is still allowed although amateurs resident in the Northern Region have been required to register with the police and to send photostats of their licence and transmitter details to the authorities.

JOHN CLARRICOATS, G6CL

Solid-state Scanning and Tuning

Two of the many technologies covered at the WESCON show

By AUBREY HARRIS

WHEREAS in television picture tubes scanning is accomplished by deflecting an electron beam, either by magnetic or electrostatic means, over the surface of photo-sensitive material, in solid-state imaging it is performed by sampling, in an ordered fashion, individual elements of a mosaic of photo-elements. At the recent WESCON show in San Francisco G. P. Weekler and R. H. Dyck, of Fairchild, described an array of 10^4 photo-transistors and 10^4 m.o.s.f.e.ts in a $\frac{1}{2}$in $\times$ $\frac{1}{2}$in area. The photo-transistors are spaced on 0.005-in centres in the 100×100 element array. The elements in the array are scanned in much the same way as a magnetic core memory is addressed, that is, by coincidence of x and y co-ordinate voltage pulses (Fig. 1). An AND gate is formed by an m.o.s.f.e.t. at each element. The gates are enabled by first applying a negative voltage to one row and then by feeding a pulse voltage sequentially to the columns; when all columns in one row have been sampled, the adjacent row is treated in the same manner. The video output is obtained from a load resistor connected to a " bus line " joined to one side of each photo-transistor.

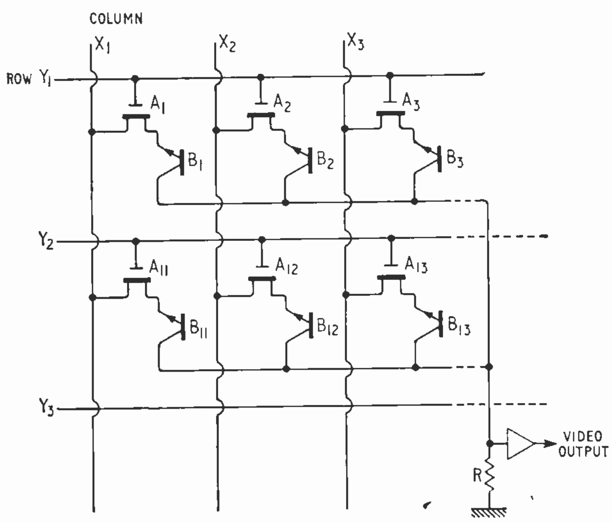


Fig. 1. Schematic arrangement of Fairchild solid-state imaging array. Each photo-element point consists of an m.o.s.f.e.t. (A) and a photo-transistor (B).

The scan voltages are derived from counters or shift registers constructed with integrated circuits. Eventually totally integrated scanning generators will be used.

Sources of noise in the output signal are due to the load thermal noise, sensor shot noise, amplifier noise and correlated noise due to high level switching. The first three sources are treated by normal techniques, but the correlated noise, which is coupled to the output by parasitic capacitances of the integrated structure, is handled in a different way. Theoretically, it is possible to isolate the noise due to sampling from the wanted signal; " sampling theory " tells us that the maximum information frequency is one half of the sampling rate, that is, it occupies a lower portion of the frequency spectrum. The video signal then can be separated from the sampling noise by suitable filtering methods.

Dr. P. K. Weimer *et al* (RCA Laboratories) gave details of a 180×180 (32,400) element sensor which had been incorporated into an experimental camera; the overall size of the camera including its batteries and a small u.h.f. transmitter is of similar size to a 35 mm photographic camera. The power input to the camera is 220 mA at 14 V d.c. Each element in the array consists of a diode in series with a photo-conductive element.

The self-scanned sensor consists of four separate thin-film one-inch square substrates: the array, a vertical and a horizontal shift register (scan generators) and a column of 180 video coupling f.e.ts. In fabrication the substrates are assembled together, epoxied at their edges, and conductive strips evaporated across the joins where required. Fig. 2 shows the assembled circuit arrangement. Each of the 180 output points of the horizontal scanning generator is joined to one column of diode anodes, the 180 output points of the vertical scanning generator connect to the 180 f.e.t. gates, and the f.e.t. drains are connected to the appropriate columns of photo-conductors. Video output is derived from the common connection of the transistor source terminals suitably loaded.

Each scan is initiated by applying a start pulse to the appropriate shift register which is timed by external clock pulses. The scanning generators produce a series of positive gating pulses moving sequentially along the ouput terminals, from H_1 to H_{180}. At any particular instant, the video output signal is related to the element which at that time has its diode anode positive and its corresponding transistor gate also positive.

One feature of solid state scanning which may have far-reaching effects is that the utilization time between successive horizontal (line) synchronizing pulses is virtually 100% compared to some 85% with conventional electron beam type scanning. This is because no time is required for flyback or retrace of the electron beam at the end of the scan lines and frames. In other words, the time usually lost during the " blanking " periods can be used for active picture output. This, of course, requires the use of similar solid state scanning in both pick-up and display devices.

The photo-conductive material (CdS+CdSe) used in the array has a spectral response peaking in the region 5,600-5,800Å and extends from below 4,000 Å to a sharp sensitivity drop at about 6,300 Å. Lag characteristics and sensitivity are theoretically similar to existing vidicons, although continued development is expected to improve all these parameters.

Similar work, with a 100×128 matrix, using photo-transistors and f.e.ts has been carried out by R. A.

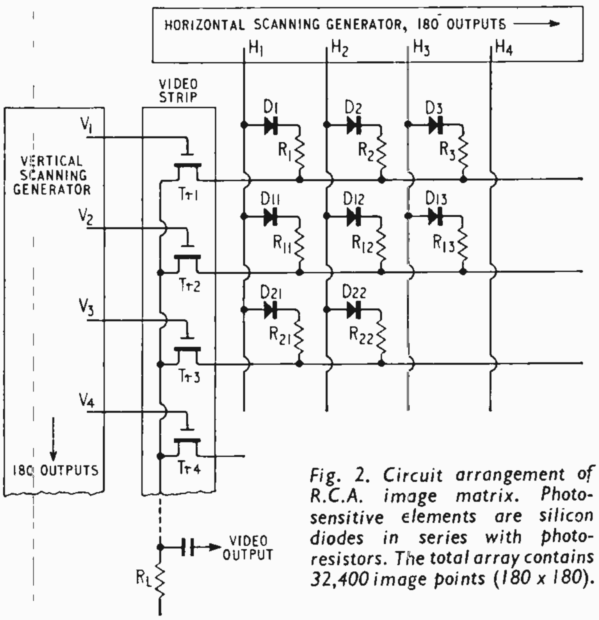


Fig. 2. Circuit arrangement of R.C.A. image matrix. Photo-sensitive elements are silicon diodes in series with photo-resistors. The total array contains 32,400 image points (180 x 180).

Anders *et al* (Westinghouse) on a 60 frame-per-second system. Five to seven shades of grey were found to be possible with "normal room lighting." Usable images were obtained with levels down to 1 foot candle at the sensitive surface. With a lower frame repetition rate (6 frames-per-second), the illumination could be dropped to 0.1 foot candle. It is hoped that in the next year or so a complete 200-line, 60-frame camera could be packaged in the volume of a 2 to 3 inch cube.

Although the emphasis in most of the work described seemed to be on micro-miniaturization the mosaics can be made virtually any size. This means that for particular applications, for example pattern recognition, the image mosaic could be used "in-contact" with the object and thus avoid the need for intermediate lens imaging. Some of the other advantages quoted for this type of image sensor are that no vacuum tubes, high voltages, magnetic fields nor filament supply is required, and smaller, lighter pick-up devices having greater compatibility with other integrated circuit devices will be possible.

ELECTRONIC TUNING

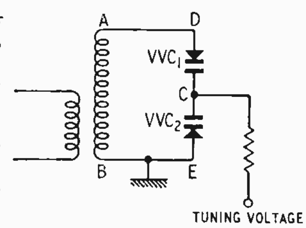
In military and aeronautical applications of electronic equipment there is an ever present desire for size and weight reduction. Invariably this is coupled with requirements for greater robustness and immunity from the effects of vibration and shock. The mechanically variable tuning capacitor is often found wanting in these respects. Voltage variable capacitors (varactors, varactor diodes or varicaps) have been developed to overcome many of these problems. These two-terminal p-n junctions act like a slightly charged capacitor due to the "p" and "n" type semiconductor material effectively forming conductive plates with the depletion layer providing a dielectric. When a reverse bias voltage is applied to the terminals the depletion layer increases in size separating the "plates" and thereby reducing the capacity.

Among the features considered desirable by E. A. Janning (Avco Electronics) in his paper "Application of electronic tuning to tactical communications equipments" were primarily a large junction capacitance and also a high reverse breakdown voltage. These two features enable a high capacitance ratio to be obtained and allow large frequency ranges to be covered in tuned circuits. Typical characteristics of a 500 pF device at -8V are, capacitance change ratio, 5.1: 1; max. reverse voltage, 150 volts; and Q=250 at 10 MHz.

There is a non-linear relationship between frequency and capacitance in a resonant circuit, $f \propto \frac{1}{\sqrt{C}}$ and the capacitance of a varactor varies proportionately as $1/V^n$ (where V is the reverse voltage across the diode and n is the exponent of the junction). For an abrupt (i.e., not graded) p-n junction the exponent is approximately 0·5. Thus frequency varies as V. This non-linearity can produce intermodulation, cross modulation and harmonic generation problems in r.f. tuners. These effects can be minimized by the use of two techniques; one, by ensuring that the a.c. signal excursion across the tuned circuit is low compared to the d.c. bias. The other is to connect two varactors in series opposition across the inductance to be tuned (Fig. 3). With this arrangement, the d.c. signal (tuning voltage) is applied to both, varying the capacitance of both, but the effect of the a.c. (detuning signal voltage) is to increase the capacitance of one diode while decreasing that of the other. This helps to reduce the detuning effect as compared with the use of a single varactor.

As an example of a piece of equipment which has been designed using these devices, a 74,000 channel receiver (1 kHz per channel) working in the range 2-76 MHz was quoted. The frequency stability is $\pm$ 30 Hz. From the above data it can be seen that extremely high precision may be obtained. Furthermore, remote- and servo-controlled tuning is simplified obviating the need for bulky motors driving mechanically variable capacitors. Also it is possible to provide frequency variable circuits in remote parts of equipment in an easy manner; the "tuning knob" is replaced by a conductor supplying a variable voltage.

Fig. 3. Back-to-back connection of voltage variable capacitors to reduce detuning by signal voltage. Tuning voltage is applied across C—D and C—E varying the capacitances of VVC_1 and VVC_2 in the same sense. The detuning (signal) voltage A—B appears in opposite phase to each of the varactors.



In another paper, P. M. Norris and P. Heidenreich (Motorola) described the "Epicap," a voltage variable capacitor which has a tuning ratio of over 20 : 1. This was developed for a.m. broadcast receivers. The Epicap has a *hyperabrupt* p-n junction with a voltage exponent of 2. Thus capacitance varies inversely as the square of the applied voltage ($C = \frac{K}{V^2}$). In a tuned circuit, therefore, the resonant frequency varies directly as the tuning voltage. This linear relationship facilitates aerial and oscillator circuit design as tracking problems are minimal.

In an evaluation test comparing ganged-mechanical capacitance tuning with v.v.c. tuning, a pair of Epicaps were matched to within 2% at three different voltages in their bias range. Although some slight loss of selectivity and S/N ratio was noted, optimizing the design of the aerial and oscillator coils was proposed as a solution to this. It seems virtually certain that practical, compact, high-quality, solid-state tuning will be with us within the next few years.

NOVEMBER MEETINGS

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

LONDON

1st. I.E.E.—" State space methods in dynamical systems analysis " by Dr. A. G. J. MacFarlane at 5.30 at Savoy Pl., W.C.2.

1st. I.E.R.E.—" Deflection circuits for colour and monochrome television receivers " by K. E. Martin and B. E. Attwood at 6.0 at the London School of Hygiene and Tropical Medicine, Keppel St., W.C.1.

1st. B.K.S.T.S.—" Colour temperature " by R. Knight, at 7.30 at the Royal Overseas League, Park Pl., St. James's St., S.W.1.

2nd. I.E.E.—Appleton lecture " The position of fundamental scientific research in the United Kingdom " by Sir Harry Melville at 5.30 at Savoy Pl., W.C.2.

6th. I.E.E. Grads.—" Thyristor control " by F. F. Mazda at 6.30 at I.E.E., Savoy Pl., W.C.2.

7th. I.E.E. Grads.—" Microelectronics " by P. Cooke at 6.30 at West Ham College of Technology, Romford Rd., E.15.

8th. R.S.G.B.—" Colour television " by G. Roe at 6.30 at the I.E.E., Savoy Pl., W.C.2.

9th. R.T.S.—" Q-file—a unique electronic system for the control of stage and studio lighting " by R. E. Jones and A. Isaacs at 7.0 at I.T.A., 70 Brompton Rd., S.W.3.

13th. I.E.E. & I.P.P.S.—Colloquium on " Electron probe instrumentation " at 10 a.m. at Savoy Pl., W.C.2.

14th. I.E.E.—Colloquium on " Design of high-frequency transistors with special reference to high power " at 2.0 at Savoy Pl., W.C.2.

14th. I.E.E. Grads.—" Satellite communications " by D. Wilkinson at 6.30 at Woolwich Polytechnic, S.E.18.

15th. I.E.E. & I.E.R.E.—Colloquium on " Techniques of connecting computer peripheral equipment " at 10 a.m. at Savoy Pl., W.C.2.

16th. I.E.E.—Discussion on " Are component specifications being improved? " at 5.30 at Savoy Pl., W.C.2.

17th. I.E.E.—" Hall effect transducers " by Dr. E. Cohen at 5.30 at Savoy Pl., W.C.2.

17th. I.E.E.—" Josephson junctions " by L. Solymar at 5.30 at Savoy Pl., W.C.2.

22nd. I.E.E.—" Solid state electronics " by Dr. J. Evans at 5.30 at Savoy Pl., W.C.2.

22nd. S.E.R.T.—" PAL delay lines " by R. W. Gibson at 7.0 at the London School of Hygiene and Tropical Medicine, Keppel St., W.C.1.

23rd. I.E.E. Grads.—" Radio astronomy " by Prof. J. G. Davies at 6.30 at I.E.E., Savoy Pl., W.C.2.

24th. I.E.E.—Colloquium on " Integrated circuits and logical design " at 2.30 at Savoy Pl., W.C.2.

24th. Royal Institution.—" Michael Faraday and the ether: a study in heresy " by Prof. L. Pearce Williams at 9.0 at 21 Albemarle St., W.1.

27th. I.E.E.—" Computers and adaptive radar " by Dr. C. S. E. Phillips at 5.30 at Savoy Pl., W.C.2.

29th. I.E.E.—" Contacts in telephony—a search for the ideal " by D. J. Williams, L. J. Allen and Dr. T. A. Davies at 5.30 at Savoy Pl., W.C.2.

29th. I.E.R.E.—" Generation, propagation and applications of microwave acoustics " by Professor K. W. H. Stevens at 6.0 at 8-9 Bedford Sq., W.C.1.

29th. B.K.S.T.S.—" Audio aspects of magnetic tape performance " by G. Balmain at 7.30 at the Royal Overseas League, Park Pl., St. James's St., S.W.1.

BASINGSTOKE

23rd. I.E.R.E.—" Electronics in the printing industry " by F. C. Holland at 7.30 at the Technical College.

BEDFORD

13th. I.E.E. & R.Ae. Soc.—" Electricity and electronics in aircraft " by Sir Robert Cockburn at 7.45 at Bridge Hotel.

BELFAST

15th. R.T.S.—" Colour television: a practical approach " by B. Rogers at 7.0 at Queen's University Lecture Hall.

BIRMINGHAM

2nd. I.E.E.—" Micro-electronics " by Dr. G. D. Sims at 6.15 at the University of Aston.

8th. S.E.R.T.—" Close range radar " by M. J. Withers at 7.0 at the Electrical Engineering Dept., the University.

22nd. R.T.S.—" The strange journey from retina to brain " by Dr. R. W. G. Hunt at 7.0 at the Medical Institute.

27th. I.E.E.—" Electronics and the printing industry " by J. V. Ashworth at 6.0 at M.E.B., Summer Lane.

BOURNEMOUTH

28th. I.E.R.E.—" Impact of electronics in meteorology " by C. E. Goodison at 7.0 at the College of Technology.

BRIGHTON

7th. I.E.R.E.—" Piezo-electric properties of thin films " by Dr. M. G. Cornwall at 6.30 at the College of Technology.

BRISTOL

22nd. I.E.R.E. & I.E.E.—" M.O.S. transistors " by G. G. Bloodworth at 7.0 at the University.

CAMBRIDGE

9th. I.E.R.E. & I.E.E.—" The engineering principles and applications of microwave filters " by G. Craven at 8.0 at the University Engineering Labs, Trumpington St.

23rd. I.E.E.—" The future of solid-state devices in the microwave field " by Dr. J. E. Carroll at 8.0 at the University Engineering Labs., Trumpington St.

CARDIFF

8th. I.E.R.E.—" Data logging, display and alarm techniques " by B. M. Lees at 6.30 at the Welsh College of Advanced Technology.

8th. R.T.S.—" Multi-standard colour television " by Bernard Marsden at 7.30 at the Angel Hotel.

17th. S.E.R.T.—" Electronics in photography " by C. W. Hooper at 7.30 at Llandaff Technical College, Western Ave.

29th. R.T.S.—" A four-tube colour camera " by I. J. P. James at 7.30 at the Angel Hotel.

COVENTRY

20th. I.E.R.E.—" Transistorised mobile transmitters " by A. J. Rees at 7.15 at the Lanchester College of Technology.

EDINBURGH

14th.—I.E.R.E.—" Stereophonic reproduction of sound " by J. Moir at 6.0 at the Dept. of Natural Philosophy at the University.

EVESHAM

28th. I.E.R.E.—" The educational policy of the C.E.I." by Prof. E. Williams at 7.0 at the B.B.C. Club.

FARNBOROUGH

2nd. I.E.R.E.—" Radio telemetry " by P. R. Barkway at 7.0 at the Technical College.

GATESHEAD

1st. S.E.R.T.—" Battery television and electronic devices " by R. Simmons and L. Newton at 7.0 at the Five Bridges Hotel.

GLASGOW

10th. S.E.R.T.—" Technical training for the electronic industry " by G. M. Rendall at 7.30 at the Y.M.C.A., 100 Bothwell St., C.2.

13th. I.E.R.E.—" Stereophonic reproduction of sound " by J. Moir at 6.0 at the University of Strathclyde.

HANLEY

21st. I.E.E.—Faraday lecture " Electronics in medicine " by Dr. D. W. Hill at 7.30 at Victoria Hall.

HENLOW

21st. I.E.E.—" Blind landing of aircraft " by G. Harrison at 8.0 at the Officer Cadet Training Unit.

HORNCHURCH

22nd. I.E.R.E.—" The use of network techniques in electronics project planning " by L. T. Hammon at 6.30 at the College of Further Education, 42 Ardleigh Green Rd.

LEEDS

1st. I.E.R.E.—" Integrated circuit applications " by J. A. Cayzer at 7.0 at the Dept. of Electrical Engineering, the University.

LEICESTER

8th. R.T.S.—Forum on colour servicing at 7.15 at the Vaughan College, St. Nicholas St.

23rd. I.E.R.E. & Brit. Computer Soc.—" Hybrid computers " by Dr. N. W. Bellamy at 6.30 at the University.

LIVERPOOL

15th. I.E.R.E.—" Some applications of electronics in oceanography " by A. M. East at 7.0 at the Regional College of Technology, Byrom St.

MAIDENHEAD

14th. S.E.R.T.—" Military mobile communications equipment " by Major Meadows at 7.0 at East Berks College, Boyn Hill Ave.

MANCHESTER

13th. Soc. Instrument Tech. & I.P.P.S.—" Lasers and their application to measurement " by Prof. O. S. Heavens at 6.45 at the Literary and Philosophical Society, 36 George St.

16th. I.E.R.E.—" Gas lasers " by H. Foster at 7.15 at Renold Bldg., College of Science and Technology, Altrincham St.

NEWCASTLE-UPON-TYNE
8th. I.E.R.E.—"Tape controlled recording automatic checkout equipment" by A. H. Parker at 6.0 at the Inst. of Mining and Mechanical Engrs., Neville Hall, Westgate Rd.

NOTTINGHAM
7th. R.T.S.—"Colour in general and the PAL system in particular" by I. Nicholson at 7.45 at the Co-op Educational Centre, Broad St.

PLYMOUTH
1st. R.T.S.—"Television-sound techniques" by Glyn Alkin at 7.30 at the Studios of Westward Television Ltd.

14th. I.E.R.E. & R.T.S.—"Translating and transcoding colour TV systems with common scanning standards" by S. M. Edwardson at 7.30 at the College of Technology.

READING
23rd. I.E.R.E.—"Computer programming" by M. E. Flavel at 7.30 at the J. J. Thomson Physical Lab., the University.

SHEFFIELD
8th. Soc. Instrument Tech.—"Lasers and their applications" by H. Foster at 7.0 at the Industries Exhibition Centre, Carver St.

STONE
13th. I.E.R.E., I.E.E. & I.P.O.E.E.—"Storage systems for telephone switching" by J. R. Pollard at 7.0 at the G.P.O. Central Training School, Yarnfield.

SWINDON
8th. I.E.R.E. & I.E.E.—"Microelectronics" by Dr. S. Forte at 6.15 at the College.

WOLVERHAMPTON
1st. I.E.R.E.—"Thyristors and their use in industrial control" by D. E. Cattermole at 7.15 at the College of Technology, Wulfruna St.

Photoplot Radar at Teesport

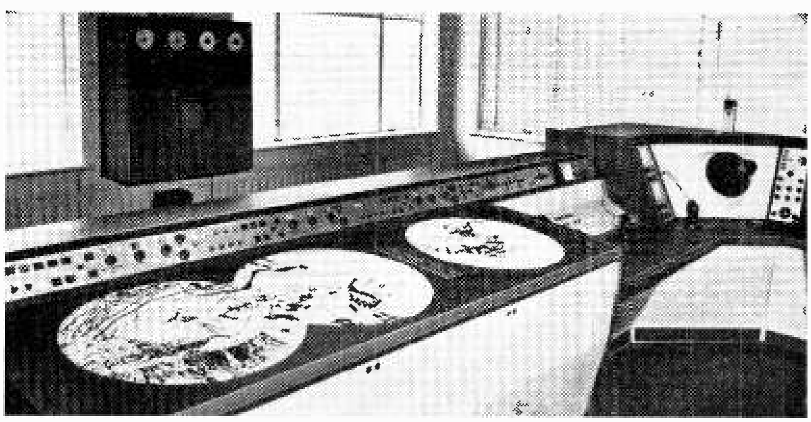
THE official inauguration of the new Surveillance Radar at Teesport Harbour took place on August 22. The main contractors for the installation, which is worth over £100,000 and is certainly the most advanced in the U.K. and possibly in the world, were Kelvin Hughes. The Teesport Harbour surveillance radar is shore based and surveys the seaward approach to the estuary, the estuary itself and the dock areas. In principle it is no different from other port installations, but technically it has great distinction. It is the first to incorporate the Kelvin Hughes Photoplot display system and two radar scanners coupled by a Ferranti microwave link. The control and display centre is at the Harbour Master's Office at Lackenby Dock with a local scanner. The remote scanner is at South Gare, nearly three miles away at the mouth of the estuary. Both scanners are horizontally polarized, end-fed, slotted waveguide arrays mounted on 100ft towers, and peak powers of 40 kW are used at a frequency of 9,000 MHz. The parabolas for the microwave link are mounted on the same towers just below the radar scanners. The microwave system is the Ferranti 14,000 HR, specially developed for this installation. The main link is a broad-band transmission of radar data from the remote scanner at South Gare to the Control Centre with additional channels carrying scanner bearing and synchronizing data, monitoring information and an engineering speech link. In the opposite direction narrow-band facilities provide the return engineering speech link and remote control of the South Gare fog-horn, lighthouse and m.f./d.f. beacon from the Control Centre.

The microwave link operates in the 7,000 MHz band with a power of 1 W. Solid state devices are used throughout with the exception of the transmitter output stages which use kylstrons. The Control Centre is equipped with a large console housing three Kelvin Hughes Photoplot displays, a conventional c.r.t. display, the v.h.f. radio telephone and other equipment.

The Photoplot display is unique in that it is a large photographically projected display on a flat surface of sufficient brilliance for viewing in ordinary ambient light. No viewing hoods or light adaptation are necessary and, if required, several people can observe the display simultaneously. A small high-definition c.r.t. carrying the radar picture is photographed on 16 mm film which then passes through a rapid processing unit which develops, fixes and dries the film in six seconds. The film is then optically projected on to the viewing surface. As well as providing flat, large-screen, daylight viewing, the Photoplot system has other advantages. It can be easily integrated with navigational chart transparencies and it provides a permanent photograph record of events. This, coupled with tape playback of speech traffic, gives all the information which may be required in any subsequent investigation.

On the display console a pair of Photoplot displays cover the main channel of surveillance on a scale of 1/9,000. The third Photoplot display covers a proposed anchorage area and an area of Tees Bay covering the approach to Hartlepools presented on scales of 1/9,000 and 1/18,000, respectively. Separate from the Photoplots is a conventional 16 inch direct viewing display which can be used for general surveillance and during periods of low traffic when the expense of running the Photoplot display system may not be justified. When the two overlapping Photoplot displays are both selected to the 1/9,000 scale they assume an integrated presentation and both displays operate in synchronism in the film processing cycle.

The normal frame repetition times for the Photoplots are 15 seconds, 1.5 minutes or 3 minutes and any of these times may be selected to suit the particular navigational situation under examination. A subsidiary switch, however, enables a 7.5 second repetition rate to be achieved for close-quarter situations and for talking ships in.

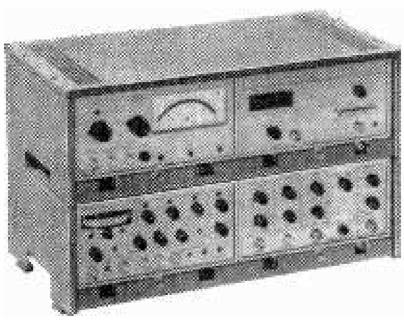


The control room of the harbour radar system showing the Photoplot display.

NEW PRODUCTS

Universal Anemometer

FROM Disa (Dansk Industri Syndicat A/S) Denmark, there is now available Type 55 DOO universal anemometer. One of the main features of this instrument is the wide range of measurements which can be carried out via individual plug-in modules. These parameters include velocity profile, shock wave, water flow, flow resistance, aerodynamic noise temperature turbulence, and diffusion. Almost all the currently known probes may be used with this anemometer; hot wire probes, including tungsten or platinum-iridium; different types of wedge-shaped, tapered and flat hot-film probes; film probes on quartz fibre, and thermistors. The individual modules are available separately. The basic instrument 55DO1 functions as a constant temperature anemometer, but it is switchable for constant-current operation. The bridge ratios are about 1:1 and 1:20. The latter ratio (ratio of resistance values for the two half-sections of the bridge) is the simpler of the two modes of operation, essentially because the independent variable bridge arm, employed for adjusting the probe operating temperature, is incorporated within the instrument. Probe resistance range at the 1:20 ratio is 0 to 61 Ω, adjustable with built-in four decade resistor. At the 1:1 bridge ratio the range is 0 to several hundred ohms. The overall frequency range of the system at the 1:20 ratio is d.c. to 150 kc/s and at 1:1 ratio it is d.c. to 400 kc/s. Other modules are the auxiliary unit 55D25 (amplifier, filter, zero suppression, square wave generator); r.m.s. voltmeter 55D35; and digital d.c. voltmeter 55D30. Distributed in the U.K. through the Disa branch office at 116 College Road, Harrow, Middlesex.

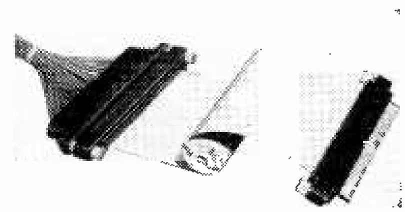


WW 301 for further details

CONNECTOR SYSTEM

A ROUND wire to flat conductor wiring system has been introduced by Advanced Circuits International for use in test equipment racks, computers, instrumentation banks, data processing equipment, and machinery where movement of the chassis and occasional disconnection is required. The central feature is a coiled flexible length of flat conductor cable with connectors at each end. They incorporate a special receptacle block designed to hold leads having terminals locked into precision cavities. One end of this expansile system is connected to the equipment rack and the other to the movable chassis. As the chassis is withdrawn, the coil of flat cable unwinds, and vice versa. Any risk of jamming or pinching of cables is overcome, and there is no possibility of interference with the chassis. Problems of misalignment or sagging are eliminated, say the makers. Laboratory tests, it is stated, have shown that there is no practical fatigue limit to the material. One important advantage claimed is that when a rack-mounted drawer in a cabinet is withdrawn all electrical connectors remain undisturbed, eliminating the need for complicated jumpers. This is said to assure normal operation of other selected circuitry in the rack, a major point of value in servicing the equipment. The product is a complete self-contained assembly eliminating hours of detailed work in the preparation of connectors, soldering and terminating. Alternative types have from 15 to 36 conductors. They can be installed in double or triple layers, if required. The Thomas and Betts Co. Inc., 123 Newgate Street, London, E.C.1.

WW 303 for further details



Atomic Frequency Standard

AS a primary frequency standard, the Rohde and Schwarz atomic frequency standard XSR has been developed for use in accurate standard frequency systems, and for special applications in the field of single-sideband and multiplex techniques. The stable atomic resonance of rubidium 87 constantly readjusts a precision crystal oscillator, thus compensating for crystal ageing. Long-term error for this standard is less than $\pm 5 \times 10^{-11}$ after a year of continuous operation. Short-term error measured over one second is 1×10^{-11} p.p.m. Frequencies of 5 Mc/s, 1 Mc/s and 100 kc/s are produced at 1 V r.m.s., the output impedance being 50Ω. At the bandwidth of 500 c/s the signal to noise ratio of the 5 Mc/s frequency is better than 100 dB. Should the a.c. voltage fall short of its nominal value by 15%, then a battery takes over. Rohde and Schwarz, 8000 München 8, Mühldorfstrasse 15, Germany.

WW 302 for further details

Precision Trimmers

THE dielectric body of the Type MSN miniature precision trimmers is a silicate glass, containing lead oxide. Manufactured by Steatite Insulating Ltd., Hayley House, Hayley Road, Birmingham 16, these trimmers are available for chassis, printed circuit and panel mounting. The tube of the dielectric body is 4 mm o.d. and the air gap between the piston and the inner dielectric is less than 0.0002 in. There are few capacitance values each ranging from 0.4 pF and extending, respectively, to 4, 6.3, 10, 16 and 25 pF. The Q factors exceed 500 at 20 Mc/s with a capacitance resolution of better than 0.01 pF. Working voltage is 500 V, and the operating temperature range is −55 to +125°C.

WW 304 for further details

Silvered Mica Capacitors

DIP-COATED silvered mica capacitors D10 and D20 by Dubilier are available to DEF-5132-H5 classification. The D10 type has a capacitance range of 10 to 1,000 pF at 350 V d.c. peak, and the D20 has a range of 100 to 4,700 pF at 350 V d.c. peak, and 200 to 2,200 pF at 750 V d.c. peak. Temperature range for both types +55°C to +125°C and the temperature coefficient is −10 to +50 p.p.m./°C over the range +20°C to +125°C. Dubilier Condenser Co. (1925) Ltd., Ducon Works, Victoria Road, North Acton, London, W.3.

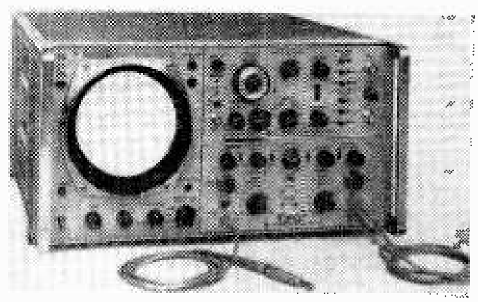
WW 305 for further details

R. F. SHIELDING

SHIELDS for the suppression of radio interference are available in a variety of forms from Knitmesh Ltd., Clements House, Station Approach, South Croydon, Surrey, CR2 OYY. Knitmesh material is a knitted mesh, which is produced from materials available in filament form. One or more filaments are interlocked in a loop structure made in a tubular shape from $\frac{1}{8}$in to 6in diameter. Shapes available include gaskets for hinged lids, bonding collars, spindle glands and r.f. shielding mounted on silicon rubber tubing.

WW 306 for further details

1Gc/s SAMPLING SCOPE



FOR the investigation of fast waveforms, a new sampling oscilloscope is offered by Hewlett-Packard which will operate at frequencies up to 1 Gc/s. The basic oscilloscope mainframe may be either Model 140A or the variable persistence/storage Model 141A. Either of these becomes a sampling instrument by using the plug-in 1410A vertical amplifier, and 1425A delayed sweep generator. In addition to delayed sweep the latter plug-in has automatic triggering, to provide a bright base line in the absence of a signal, and to lock-in when the signal is connected. Calibrated sweeps as fast as ten picoseconds per centimetre may be selected for high time-resolution. A push-button on the front panel returns the sweep momentarily to times one magnification, to permit the observer to check the source and identity of the expanded trace on the screen. Single scans may be initiated, to help make clearer photos, or to store traces of signals which are drifting or changing. Delayed sweep is of particular value in examining the details of pulse trains. A bright dot may be placed by the observer anywhere on a complex waveform; that portion of the trace may then be expanded for detailed examination at the touch of a switch. The delayed sweep feature enables the observer to trigger the scope sweep on the chosen single pulse of a train, after the delay period. This results in jitter-free presentation with improved measuring ability and accuracy.

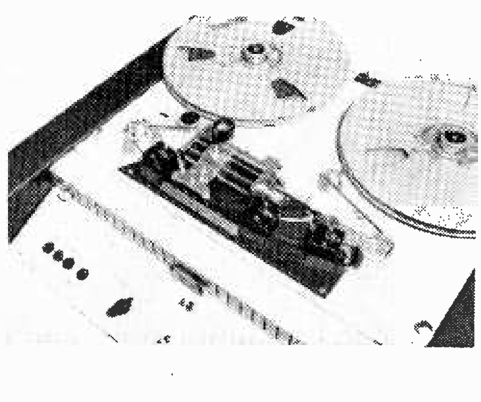
The vertical amplifiers have built-in delay lines. With these, automatic triggering to 1 Gc/s may be initiated from either of the two inputs, with complete display of the leading edge of the observed signal. The sensitivity of this amplifier is 1 mV/cm at 1 Gc/s. Hewlett Packard Ltd., 224 Bath Road, Slough, Bucks.

WW 308 for further details

Correlation Recorder

A NEW recorder/reproducer recently introduced by Leevers-Rich Equipment Ltd., designed particularly to provide accurate facilities for auto-correlation work, offers continuously variable time shift intervals ranging from 2.5 sec down to 40 ms. The equipment is available for twin channel operation using $\frac{1}{4}$in tape or for four-channel operation using $\frac{1}{2}$in tape and accommodates reels of up to $10\frac{1}{2}$in diameter. Loop attachments may be fitted for repetitive examination of signals. The tape transport embodies a special headblock system with micrometer adjustment to provide head traverse and movement of the head may be effected either manually or by means of a small driving motor. The head traverse is bidirectional, offering both advance and delay facilities and has a resetting accuracy of 0.0005in in a total traverse of 2.5in. Two six-speed ranges are available with this model covering $\frac{15}{16}$ to 30 i.p.s. or $1\frac{7}{8}$ to 60 i.p.s., and a range of electronic modular amplifiers can be supplied to cover direct mode or frequency modulated mode operation. A footage indicator with push button reset facility provides accurate location of any particular period of information. The complete equipment is housed in a trolley console. Leevers-Rich Equipment Ltd., 319, Trinity Road, Wandsworth. London, S.W.18.

WW 307 for further details



Microwave Radiation Monitor

FOR the protection of personnel working in proximity to high-power microwave sources a radiation monitor is available from Aveley Electric Ltd., South Ockenden, Essex. Known as the Narda Microline B86B3 Electromagnetic Radiation Monitor (manufactured in the U.S.A.), it provides detection of microwave power density over the frequency range of 0.45 to 12.4 Gc/s. Throughout this band, the instrument responds to all planes of polarization: linear, left/right hand circular, random, pulsed or continuous wave. This response is achieved by presenting a seven-inch diameter aerial aperture to the radiation. All incident energy is then integrated, and the total field strength read on an output meter. Measurement of radiation of difficult frequencies with varied polarization from several sources simultaneously is easily carried out. Calibration charts are provided which permit accurate quantitative measurements to be made of c.w. or pulsed power density. This instrument contains a thermistor bridge assembly, batteries and output meter.

WW 309 for further details

S.S.B. Transceiver

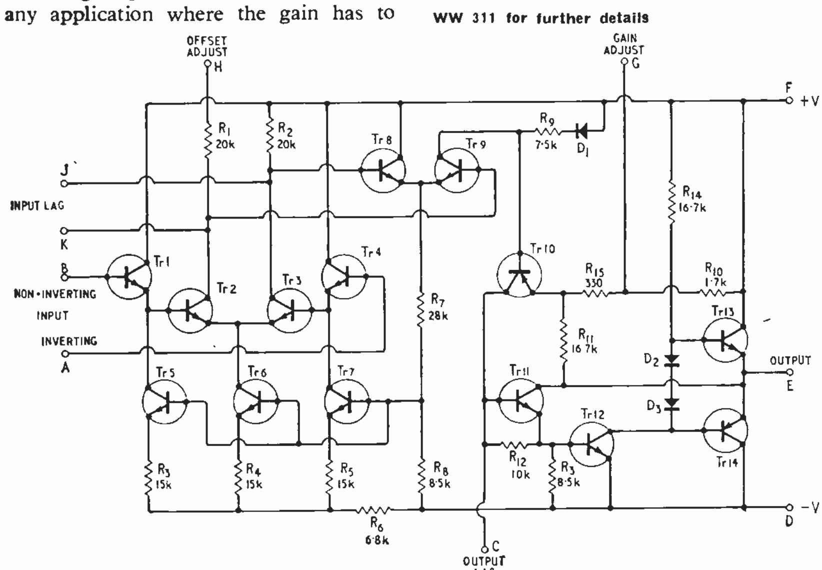
IN the receiver section of the Heathkit SB-101 s.s.b. transceiver (10 to 80 m), the sensitivity is less than 1 μV for 15 dB signal-plus-noise to noise ratio for s.s.b. operation. Carrier wave selectivity (with optional c.w. filter installed) is 400 c/s minimum at 6 dB down and 2 kc/s maximum at 60 dB down. The output impedance is unbalanced for 8 or 600 Ω speaker and high impedance headphones. The power output is 2 W with less than 10 % distortion. Image and i.f. rejection is better than 50 dB. In the transmitter section the d.c. power input for s.s.b. is 180 W p.e.p. continuous voice; for c.w. it is 170 W. The r.f. power output is 100 W from 80 to 15 metres, and 80 W on 10 metres. Harmonic radiations are 45 dB below rated output. Transmit-receive operation on s.s.b. is push to talk or Vox; on c.w. provided by operating Vox from a keyed tone using grid block keying. Carrier suppression is 55 dB down from a single-tone output, and unwanted sideband suppression is 55 dB down from a single-tone output at 1 kc/s reference. The modes of operation are selectable upper or lower sideband (suppressed carrier) and c.w. Visual dial accuracy is within 200 c/s on all bands and dial mechanism backlash is less than 50 c/s. Frequency stability is less than 100 c/s per hour after 20 minutes warm-up from ambient temperature and less than 100 c/s for ± 10 % line voltage variations. Power requirements are 700 to 850 V at 250 mA; 300 V at 150 mA; -115 V at 10 mA; and 12 V at 4.76 A. Daystrom Ltd., Gloucester.

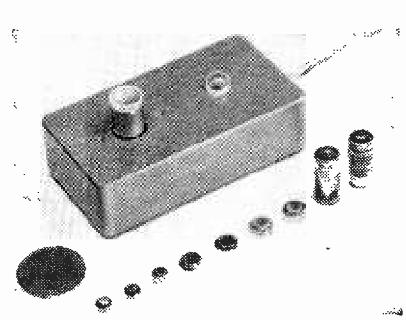
WW 310 for further details

Operational Amplifier

HIGH performance and low cost are claimed for a new silicon monolithic integrated operational amplifier, the MC1433, from Motorola Semiconductor Products Inc., York House, Empire Way, Wembley, Middlesex. This new device has an open loop voltage gain of at least 30,000. It possesses an unusually large output voltage swing typically ± 13 V with a power supply voltage of only ± 15 V. This large output voltage swing means that the considerable voltage gain of this amplifier is usable at higher input levels, and that the usable output signal is larger than with operational amplifiers with more restricted swing. This amplifier is designed to use as a summing amplifier, an integrator, or for any application where the gain has to be controlled by the negative feedback. In addition, it is a suitable amplifier for general systems applications where a high gain, low distortion amplifier is required. Temperature stability is assured by the low temperature drift of only $\pm 8\,\mu$V/°C. The input offset voltage is a maximum of only 7.5 mV at 25°C, and can be adjusted to zero by externally varying the potential on one of the leads. This monolithic operational amplifier is available in both the 10-pin metal can as the MC1433G, and in the $\frac{1}{4} \times 1 \times 4$ in ceramic flat pack as the MC1433F. Both models are designed for operation over the commercial/industrial temperature range of 0 to +75°C.

WW 311 for further details





Miniature Battery Charger

THE miniature battery charger CE15 by Crowborough Electronics will charge a wide range of micro-miniature and sub-miniature cells. It is intended for nickel-cadmium re-chargeable cells, but it will also rejuvenate any of the miniature mercury or silver-oxide cells now in general use. Fully solid-state, and incorporating a double-wound mains transformer for safety, this unit will produce a constant charging current, independent of mains voltage variations, battery voltages or polarity. The unit is available as a 240 V or 110 V model, and has a neon indicator lamp. Crowborough Electronics, 3 Rotherhill Road, Crowborough, Sussex.

WW 312 for further details

FAST RECOVERY SILICON RECTIFIERS

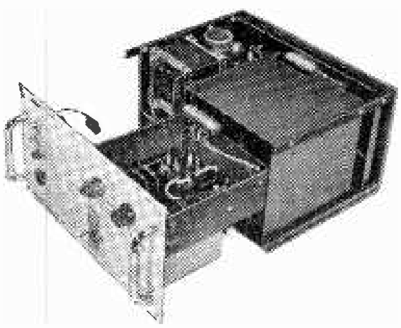
FAST recovery, high current, miniature silicon rectifiers IN4942-IN4948 by the Semteech Corpn. U.S.A. for use with high-frequency power sources are now available in the U.K. from Bourns (Trimpot) Ltd. The fast recovery characteristics of these new units are said to offer the designer new capabilities for advanced design with reduced dimensions, improved performance and higher reliability. Designed for use in critical industrial and military applications, these rectifiers have solid internal construction, allowing full area contact to both rectifier leads, in turn giving the units mechanical strength and extremely low thermal impedance from junction to mounting terminal. Typical reverse recovery times are 100 ns up to 600 V p.i.v. and 250 ns up to 1000 V p.i.v. Average rectified current is 1 A at 55°C without heat sink and 3 A if mounted to MIL-STD 750 (heat sink mounted either side of device). The leakage current is 0.1 mA at rated p.i.v. at 25°C. Dimensions of the rectifier are: diameter 0.125in, length 0.235in. Bourns (Trimpot) Ltd., Hodford House, 17-27 High Street, Hounslow, Middlesex.

WW 313 for further details

E.H.T. UNIT

CONSISTING of a common main chassis with provision for plug-in units for various outputs, the Farnell e.h.t. supply unit provides a selection of voltages from 500 V to 5 kV. The input required is 200 to 240 V 50 c/s. Type E1 sub-unit has an output of 500 V to 1 kV at 10 mA, and Type E2 provides 1 kV to 2.5 kV at 5 mA. Two other plug-in units under development will provide 2.5 to 4 kV at 2 mA and 3.5 to 5 kV at 2 mA respectively. Mains stability (±10% change) is less than 0.05% and load stability (100% change) is less than 0.1%. Farnell Instruments Ltd., Sandbeck Way, Wetherby, Yorks.

WW 314 for further details



PAL Field Sequence Display Unit

IN order to check the correctness of a PAL signal, or the relative phase of two PAL signals, it is necessary to examine the field sync interval in detail. Triggering an oscilloscope at 50 c/s or 25 c/s leads to a superimposition of fields, and clear identification is difficult. The PAL Field Sequence Display Unit by RCA is designed to overcome this problem by supplying a trigger signal of 12.5 c/s derived from a composite video input signal, so that remote signals can be monitored. The trigger signal can be made of random phase by means of a switch, when by depressing a button the phase can be advanced one field at a time. Alternatively, when a selector switch is placed in the automatic position, fields 1, 2, 3, or 4 can be displayed, the unit identifying the fields from the incoming array of bursts. The unit uses only one video, the reference video, to identify the fields. Radio Corporation of America, Broadcast and Communications Product Division, Central and Terminal Avenues, Clark, New Jersey, 07066, U.S.A.

WW 315 for further details

Japanese Test Meters

MULTI-TEST meters available from Household Electrix Ltd., 47 High Street, Kingston upon Thames, Surrey, include four models in the Japanese Sanwa range. The P-1B is a midget tester with a d.c. current range of up to 100 mA, and it measures up to 1000 V on both d.c. and a.c. ranges (1 kΩ/V). Resistance can be measured up to 100 kΩ. The price is £3 2s. The JP-5 is said to be suitable for educational purposes. A fast acting protection fuse incorporated instantly breaks overcurrent to protect the meter movement. D.C. current measurements go up to 500 mA and voltage measurements up to 1000 V on d.c. and a.c. ranges (2 kΩ/V). Resistance measurements on the instrument go up to 1 MΩ. The price is £4 17s 6d. The third meter is the U-50D, described as a circuit tester of 35 μA sensitivity. The protection circuit incorporated safeguards the movement, and the acrylic front admits full light on the mirrored scale dial for easy reading. It measures from 0.1 to 1000 V, at 20 kΩ/V d.c. and from 2.5 to 1000 V at 8 kΩ/V a.c. The current range is 50 μA to 250 mA d.c. Resistance can be measured from 1 Ω to 5 MΩ. The price is £6 10s. Lastly the 360-YTR, which is said to be useful for checking transistor circuits—on the low d.c. voltage ranges—for their high internal resistance. It measures up to 1000 V on a.c. and d.c. (4 kΩ/V), and the current ranges from 100 μA to 250 mA d.c. Resistance is measured from 1 Ω to 20 MΩ. The price is £6 17s 6d.

WW 316 for further details

VARIABLE CAPACITOR BOXES

TWO types of variable capacitor boxes are available from J. J. Lloyd Instruments Ltd., Brook Avenue, Warsash, Southampton, S03 6 HP. The first, the VC1 has a calibrated twin-ganged air-spaced capacitor, with both gangs brought out to separate low-loss terminals, so that by connecting the gangs in parallel, the capacitance indicated on the dial can be doubled. The gangs may also be series connected for very small capacitance readings, indicated on a separate scale. The three ranges are 10 to 65 pF, 20 to 130 pF and 40 to 260 pF. The tolerance at 20°C is ±1% or ±1 pF, whichever is the greater. Maximum working voltage is 500 V d.c. The second capacitor box VC2 has a single air-spaced capacitor used with a single decade of close tolerance silvered mica capacitors to give a wider capacitance range. The range is 20 to 1130 pF; the tolerances and working voltage are the same as for the VCI. Both instruments are calibrated in picofarads and no allowance has to be made for inherent stray capacitance within them.

WW 317 for further details

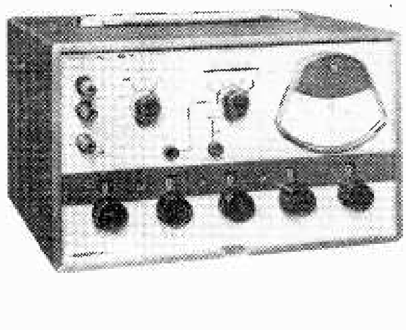
Optical Document Reader

FIRST in a range of optical reader/sorter systems, the P4200A Optical Document Reader from the Data Equipment Division of the Plessey Automation Group is said to be capable of handling 1,200 documents per minute and reading O C R (optical character recognition) "A" font at 2,200 characters per second. Initially, readers with one or three pockets will be offered; multi-pocket reader/sorters will be available later. Documents are held down on to rotating drums for transporting through the mechanism, by means of a vacuum suction system. This vacuum system permits the machines to handle documents which may be in a poor condition, or which may be printed on low quality paper, as well as the more rugged cheque paper. Applications exist for this equipment in all industries with a major information and paper handling problem. One of these equipments is said to easily replace 20 punch card operators. Plessey Automation Group, Soper's Lane, Poole, Dorset.

WW 318 for further details

Differential D.C. Voltmeter

TYPE TF 2606 differential d.c. voltmeter, by Marconi Instruments Ltd., covers the ranges 0 to 11, 0 to 110 and 0 to 1100 V, with an accuracy of 0.05% and a measurement discrimination of 0.0001%; the discrimination is better than 0.1 mV on the 11-V range. It is a manually operated voltage measuring instrument with the full accuracy of a digital voltmeter. It comprises an accurate reference source, a five-decade potentiometer and a sensitive centre-zero electronic voltmeter. Voltages up to 11 V are measured by comparing the unknown directly with the potentiometer output voltage. Above 11 V, a high-impedance attenuator is introduced between the input terminal and the measuring circuit. For many of the more common applications it is claimed to possess advantages over the digital instrument. For example, below 11 V it presents an almost infinite resistance to the unknown source when the potentiometer is set for a zero meter reading. It is very useful, therefore, for measurement of the output e.m.f. of high resistance sources, and for other similar measurements where even the 1 MΩ normally regarded as an acceptable digital voltmeter input resistance can cause errors. Other features of the instrument are provision for standardizing the reference voltage against a built-in standard cell; the ability of the instrument to indicate small changes in voltage without the necessity to adjust the potentiometer setting manually; the provision of an analogue output suitable for driving a chart recorder directly—to obtain an equivalent output from a digital voltmeter it is also necessary to use a digital-to-analogue converter. For applications where it is necessary to adjust the unknown voltage to a particular level, this differential voltmeter performs to considerable advantage. The potentiometer controls are simply set to the required voltage, and the device under test is adjusted to provide zero reading on the TF 2606 panel meter. This facility is of particular value in production line calibration and testing. Marconi Instruments Ltd., St. Albans, Herts.



WW 319 for further details

Instrument Cleaner

SOFT, rather like Plasticine to the touch, Rodico block instrument cleaners are said to be harmless to the skin, and non-corrosive to metal. As the block becomes too dirty for use the outer surface is shaved down until the clean mass shows again. Rodico is said to provide an easy and positive method of rapidly removing dirt and contamination from surface areas such as those found on precision instruments, small gears and gear trains, instrument dials and faces from which the lacquers and inks tend to dissolve when cleaned with solvents or cleaners. It will also remove corrosive finger prints from metal surfaces such as printed circuit boards. Southern Watch & Clock Supplies Ltd., 48-56 High Street, Orpington, Kent.

WW 320 for further details

Self Adjusting Wire Stripper

A SINGLE-HANDED wire stripping tool weighing 7 oz, produced by A.B. Engineering Co. is said to be fully self-adjusting within the range of all standard conductors from 0.015 in to 0.15 in. A dial adjuster is provided to extend the range downwards to 0.003 in to accommodate non-standard cables and coaxials. It is also stated that insulation is stripped from cables without damaging the wire, regardless of core diameter. The price is £8 5s. A.B. Engineering Co., Apem Works, St. Albans Road, Watford, Herts.

WW 321 for further details

Reversible Decade Counter

COUNTING frequencies of up to 1 Mc/s in either direction is possible with the DCM 739 reversible counter from Quarndon Electronics Ltd. Four saturating flip-flops are used to give high reliability and noise immunity and to provide 1-2-4-8 b.c.d. outputs. The count direction is determined by the voltage applied to the control lines. Power requirements are -6 V $\pm 10\%$ at 65 mA and $+6$ V $\pm 10\%$ at 2 mA. Pulse amplitude is from 4 to 5.5 V, pulse width (min) is 300 ns and the rise time (max) is 20 ns. Output voltage levels are 1 (-6 V) and 0 (0 V). Quarndon Electronics Ltd., Slack Lane, Derby.

WW 322 for further details

MILLIVOLT—MILLIAMP CONVERTER

MILLIVOLT (d.c.) outputs from a thermocouple or other millivolt source can be converted to a proportional d.c. mA output through the Airpax MAS 100 converter. The magnetic-transistor amplifier has one magnetic stage and three stages with silicon transistors. This is said to provide stable operation; maximum accuracy change being $\pm 0.10\%$ for a $\pm 10\%$ change in the supply voltage of 115 V, 50-400 c/s. This unit will convert input signal spans from 2 to 50 mV into output current ranges of 1 to 5; 4 to 20; or 10 to 50 mA. Noise and output ripple is 0.2% of maximum full scale output. Airpax Electronics Inc., Seminole Division, P.O. Box 8488, Fort Lauderdale, Florida 33310, U.S.A.

WW 323 for further details

Calibration Resistance Standards

SIX transfer or secondary resistance standards for calibrating test instruments which measure very low currents between 10^{-8} and 10^{-16} A are now available from Morganite Resistors Ltd. of Jarrow. These Morganite standards are made with resistance values of every decade from 10^{8} to 10^{13} Ω. They are based on the Megistor glass-enclosed resistor. Each standard is enclosed in a case 4.25in (10.8 cm) long on which BNC coaxial socket connectors are mounted. The complete set of six standards is supplied in a case for £165. Individual standards can also be supplied at prices ranging from £25 to £35. Morganite Resistors Ltd., Bede Industrial Estate, Jarrow, Co. Durham.

WW 324 for further details

Signal Splitter

A USEFUL device permitting a source to drive signals through three separate paths, and maintain 50 Ω at input and outputs is the Bishop type 080-101 four port splitter/adder. It can also add signals from 50-Ω sources. More generally, any 3, 4 or more sources and loads can be interconnected maintaining 50 Ω at all ports. The specification includes 6% reflection in a 140 ps pulse system (d.c. to over 2 Gc/s equivalent bandwidth); risetime 100 ps continuous input power rating of 1.5 W under all conditions, 4 W terminated; zero phase shift between outputs. The four ports are each BNC types, any one being used as the input. The 080-101 four-port splitter/adder is available from U.K. representatives, Claude Lyons Ltd., Instruments Division, Hoddesdon, Herts.

WW 325 for further details

SOLID STATE INVERTERS

A RANGE of solid state inverters Transipacks) that can be switched to provide outputs of 115 V at 60 c/s or 220/250 V at 50 c/s is available from Industrial Instruments Ltd. The units employ solid state devices throughout and the six models provide power outputs from 100 W to 1.5 kW with a frequency stability of ±1 %. If greater accuracy is required provision is made for an internal tuning fork oscillator or an external locking facility; by this means frequency stabilities of better than ±0.01 % can be achieved. The prime power would normally be derived from 24 V accumulators but suitable accumulator eliminators (Transiregs) are available. International Instruments Ltd., Stanley Road, Kent.

WW 326 for further details

INFORMATION SERVICE FOR PROFESSIONAL READERS

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

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

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

Real and Imaginary

By "Vector"

"Such labour'd nothings, in so strange a style,

Amaze th' unlearn'd,
and make the learned smile"
—Alexander Pope

THE newly-fledged graduate of a learned Society may be very properly proud of the honour which his efforts have brought him. He has acquired a recognized professional status, with the golden goal of full membership on the distant horizon. True, he may feel a pang of injustice at the thought that he is now a junior in the company of members of forty years' standing, some of whom might have a leetle difficulty in passing today's 'O' levels, but this is, after all, an imperfect world.

With acceptance into a Learned Society we become humble acolytes in a high priesthood. Henceforth an impregnable wall of mystique shelters us from the slings and arrows of commercial managers and ranks below. Somewhere, infinitely far above us, we have a President. We may not be able to recall his name off-hand; certainly we will rarely see him at the meetings. But we are sure that if ever the Almighty got into a bit of a tangle with one of His physical laws it would be to our President that He would turn for advice. With such knowledge as that for our shield and buckler we can afford to smile indulgently at the uninformed layman. He is not one of us. He doesn't understand.

In gratitude for such benefits the acolyte casts around for ways to serve the Society. Should he, for instance, contribute a paper? At this thought the less impetuous go and lie down until the fit passes, but the go-getter will set his hand to the plough, impatient to drive that first furrow which may, in due season, lead to the harvest of full membership and, maybe, a place in the hierarchy. It is to such that the following notes are dedicated.

His first act, naturally, will be to filch that copy of The Proceedings which conspicuously adorns his Group Leader's deck, and to thumb through its virgin pages. A quick browse will convince him that the contributors are a crumby lot who can't write for toffee. In his mind's eye he can already see the look of amazed delight on the President's face as he reads our hero's crisp, pithy, factual exposition and in imagination can hear the curt memo being dictated: "Mark young Smangle down as a potential council member."

Do not, I pray you, fall into this pit. For if you do, then assuredly in due course (maybe a year or so) your maiden effort will return like a homing pigeon, but with more of a dull thud; after five such attempts you will be much older but still not have made the grade.

No need for this agony. You can short-circuit it by realizing at the start that those contributors upon whom you poured your calumnies are the clever ones who have really done their homework. They know that in a Learned Society paper a spade must never be described as a spade. If it must be referred to at all it must go down as a ferrous spatulate device with vegetable appendage. Better still, don't call it anything—just plunge straight in with a full physical and chemical analysis and if you can manage to work in a few Fourier Transforms for luck, so much the better. (Good old Fourier! Whatever should we do without him?) In short, if you can contrive to begin your paper with "Let u equal . . ." and continue in the same strain, then you are home and dry. Oh yes—and do remember to put not fewer than 50 words in your title. If you can't think of anything better, one of the lyrics as vocalized by Procol Harum* will do admirably.

You must also be careful to put in a few deliberate mistakes as red herrings for the referees. These (the referees, not the red herrings) are Aged Members whose function in life is to maul the papers and keep young whipper-snappers like you in their place. As these venerable gentlemen were in their prime at the period when Galvani was messing about with frogs' legs, don't disguise your herrings too well. Put in a few calculations in mics and jars, make the errors in this section, and the referees will be so grateful they will record a unanimous vote for the paper.

With these points in mind, plus an assortment of lifts from text books, salted liberally with the stock phrases from the appended examples from papers presented to one society, you may make the grade, and, one never knows, qualify for a premium.

*Or for less with-it readers, the Rolling Stones.

YOU WRITE	YOU MEAN
It can be proved that . . .	I hope it can be proved that . . .
It is generally acknowledged that . . .	I heard someone say that . . .
It can be shown that . . .	You figure it out; I can't be bothered.
It is clear that . . .	It's not clear, but I'm shaming you into taking it for granted.
Did not operate as well as had been predicted . . .	The equipment burst into flames.
After considerable experimentation a solution was found . . .	We fiddled about until it came right.
A typical sample . . .	The only sample which did what we wanted.
If instability results, appropriate remedial action will suggest itself . . .	If instability results you will have to think of something Jack.
It is technically feasible but there are practical problems . . .	It cost ten times as much as we estimated.
Transient tests were carried out . . .	The fuses blew every time we switched on.
The equation was solved numerically . . .	We averaged eight different answers.
This value is a first approximation . . .	This value is flagrant guesswork.
It should be possible to improve the method . . .	Nothing worked.
Various methods have been used to palliate these deleterious factors . . .	We cooked the figures wholesale.
The fundamental principles will now be described in detail . . .	We mugged the following from a textbook.
It is of interest to compare . . .	It isn't, but I'm going to all the same.
There are certain practical difficulties in realising the gain figure . . .	All the transistors burn out simultaneously.
Some reservations must be placed on these figures . . .	These figures are quite useless.
The most promising approach is . . .	We couldn't think of another way to do it.
The author wishes to thank Mr. J. Dewarflask for a number of significant comments . . .	The Group Leader insisted on poking his nose in.