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Trinitron television tube

Novel wow and flutter meter

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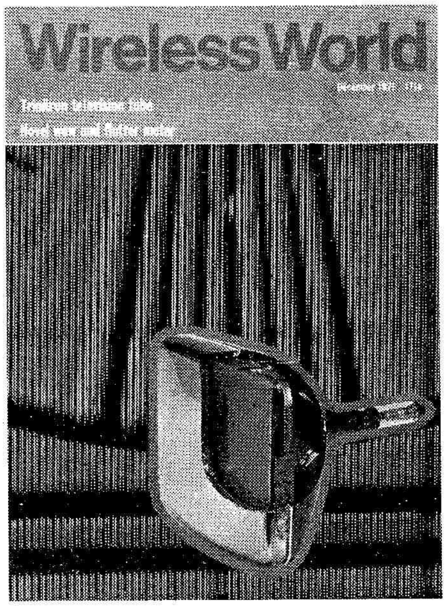

Our cover picture introduces the article describing the Trinitron colour television tube in this issue. It shows a 13-inch tube, cut away to reveal the aperture grille and superimposed on an enlarged section of the tube's vertically striped phosphor screen, which is displaying part of a test pattern.

IN OUR NEXT ISSUE

The current series of articles by W. T. Cocking on a **dual-trace oscilloscope unit** concludes with constructional details for the instrument.

Four-channel stereo will be discussed in detail and several systems described.

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World Communications

In last month's issue (p.547) we reported on the signing by 54 nations of an agreement in which they pledged themselves to co-operate in developing telecommunications satellites. In the report we quoted from Arthur Clarke's speech on that historic occasion in which he referred to the agreement as "the first draft of the articles of federation of the United States of Earth". Communication being a prerequisite to peaceful happy relationships — whether between families, friends or nations — few will disagree with the sentiments he expressed. The opportunity for world-wide communications which satellites afford is unbounded, but does our legislative ability match our technological skill?

Speaking earlier in the year at a meeting of the American Bar Association in London, Robert Sarnoff, chairman of RCA, said "Of all the great enterprises that further civilized progress, communications is the most advanced in technology and the most retarded in law. No encompassing legal framework exists today to permit full utilization by the nations of the world of the benefits of modern communications technology . . . We in communications have plenty of rules and regulations, both national and regional . . . Their collective effect has frequently been to impede progress rather than further it." He went on to point out that by its very nature our technology demands a global environment "it cannot function effectively if narrow national perspectives continue to dominate . . . We require a whole new body of law — domestic and global, terrestrial and space — to give direction and cohesion to our technological progress."

Almost as soon as wireless telegraphy proved itself to be a practical means of communication the need for rules and regulations became apparent. It was as early as 1904 that the first British Wireless Telegraphy Act went on the statute book. As ranges of transmission increased from tens to hundreds of miles it became clear that national regulations were not enough, and so in 1906 an international conference was held in Berlin to lay down regulations governing radio transmissions. The International *Telegraph* Union (then about 40 years old) was given the added task of keeping the radio peace and its name was subsequently changed to the International Telecommunication Union. World radio regulatory conferences have been held by the I.T.U. (now an official organ of the United Nations) every few years since. At these conferences block allocations of frequencies to specific services — broadcasting, maritime, aeronautical etc — are made for the three regions (the Americas, Europe & Africa, and Asia & Australasia) but it is left to the operators of the services within these regions to utilize the frequencies. It is then that the problems of nationalism and the struggle between the 'haves' and the 'have nots' arise.

With the wider use of satellites for radio services the nationalist outlook must be abandoned. In June this year a world conference for the allocation of frequencies for space communication was held in Geneva and attended by some 700 delegates from 100 countries. The regulations will come into force in 1973 but it yet remains for the whole question of the usage of the allocated frequencies by the nations of the world to be settled. No longer can the sharing of the available frequencies be left to groups of users in isolation from the rest of the world. The Broadcasting Unions, for instance, of Europe, Eastern Europe, Africa, Asia, etc, have with varying degrees of success handled the broadcasting assignments in the past but surely a truly international allocation organization is now needed. Is there one of sufficient stature to undertake this task? We have the I.T.U. and its specialist organizations — the International Frequency Registration Board and the International Radio Consultative Committee (C.C.I.R.) — but neither of these as at present constituted has the necessary plenipotentiary powers. Radio communications must not be allowed to continue as a pawn of power.

Novel Wow and Flutter Meter

Checking performance of the author's turntable design

by R. Ockleshaw

This article shows how to check rumble, wow and flutter of the author's turntable design as well as describing a wow and flutter meter using a phase-locked loop. Designed for use with an oscilloscope, it costs around £5 to build. The turntable design was described in the October issue and the pickup arm design in the November issue.

When considering turntable performance three factors are involved – wow, flutter and rumble. Acceptable levels of these effects must always be below the level at which they cannot be perceived i.e. they must always be below the threshold of perception. Now these thresholds of perception apparently vary according to many factors. For instance, the threshold of hearing is shifted upwards after the ears have been exposed for some time to a loud sound. Thus rumble may be heard prior to a loud recorded passage and not after. Much experimental work has apparently been done to establish these thresholds. Figures quoted by Slot* were used as the basis for the required specification of the turntable project. He gives the requirement for peak-to-peak wow and flutter as ranging from 0.6% (for symphonic music) to 1% (for band music). Rumble need not be better than 38dB below the output at a recorded velocity of 1cm/sec r.m.s.

Commercially available units often quote specifications that are seemingly far better than those quoted above. It is usual not to give peak-to-peak deviation but r.m.s. values. This is legitimate only if the wow and flutter exhibits a sinusoidal variation, which incidentally is nearly always not the case. Because they are 2.8 times smaller than peak-to-peak, r.m.s. values look better.

Many are the devious ways manufacturers use to express rumble, often quite meaningless – hardly surprising as rumble is a much more difficult design problem than wow, being affected by both pickup arm and cartridge design. For instance, rumble may be reduced by as much as 10 to 12dB by judicious use of resonance phenomena of the pickup arm.† However, as both rumble and wow are affected by quality of manufacture, it is hardly surprising that there are wide variations in performance quality.

* G. Slot 'Audio Quality' 1964. (Philips paperback, distributed under the Iliffe Books imprint of Butterworths.)

†J. Walton, 'Turntable rumble and pickup arm design' *Wireless World*, vol. 68 1962 pp. 435-7.

Measuring rumble

Rumble is always present to some extent, even on a record, but to be expressed in sensible terms it must be related to a known level of sound. Under the same conditions of turntable speed, amplifier power and settings, loudspeaker efficiency, etc, the level of reproduced sound is proportional to recorded velocity, so it is reasonable to use this as the basis of measurement, and is expressed in terms relative to a fixed recorded velocity. What recorded velocity it is doesn't matter as long as it is quoted.

From a manufacturer's point of view it is advantageous to use a high recorded velocity. As the level of rumble is fixed it results in seemingly better figures, which are always good for business. For example, assume that the output voltage of a velocity-proportional pickup is directly proportional to recorded velocity, then a reference level of 10cm/sec r.m.s. results in an output ten times greater than a reference level of 1cm/sec r.m.s. This is different by a factor of ten, or 20dB. If the rumble level was −20dB with reference to 1cm/sec r.m.s. it may be considered advantageous to quote −40dB with respect to 10cm/sec r.m.s. and to forget to quote 10cm/sec.

Various test records are available with tracks of known recorded velocity; some have special blank tracks as well as standard recorded velocities to assist in rumble measurements. An a.c. millivoltmeter or an oscilloscope is used to measure the pickup output under no modulation and under modulation at a known recorded velocity. Rumble is then

$$-20 \log (v_m/v_0)$$

where v_m is the output from the modulated groove and v_0 the output from the unmodulated groove. In practice the accuracy of this method depends on the rumble being small compared with the reference output, because the modulated groove contains rumble as well. So measured rumble is

$$-20\log[(v_m+v_0)/v_0]$$

As rumble is essentially of low frequency any amplifier in the measuring chain should have a flat response. The alternative is to use a standard of low frequency (100Hz) which is within rumble range. As long as this can be related to a known level with reference to a fixed recorded velocity, the results will be meaningful.

A weighted rumble figure of −36dB relative to output at a recorded velocity of 1cm/sec r.m.s. was recorded for the turntable described. As a comparison two other units were tested. One, a modestly priced single-play automatic had a rumble level so high that accurate measurements were difficult. Most of the noise originated in the unit's motor and was related to the mains frequency, being therefore discrete in nature. The other unit tested was a well-known relatively expensive 'transcription' unit. A surprisingly high rumble level of −20dB relative to 1cm/sec was recorded. All these tests used the same cartridge, but the pickup arm was that which was normally fitted to the unit.

Wow and flutter meter

The basis of measurement is to measure the peak-to-peak deviation of a recorded 3-kHz tone. It is generally expressed as a percentage; a 30-Hz deviation from 3kHz – 15Hz either side – is a peak-to-peak deviation of 1%. The frequency modulated tone is converted into a variable-amplitude signal suitable for display on an oscilloscope or moving-coil meter. By proper choice of bandwidths, or time constants, either composite measurements of wow and flutter can be made or individual components determined.

The instrument described uses a phase-locked loop discriminator, which avoids bulky coils and their subsequent alignment. Recently integrated-circuit phase locked loops have been introduced making a very simple design possible.

A phase-locked loop compares a locally generated signal with a reference. Any phase/frequency error is transformed into a changing d.c. level which controls the frequency of the local generator, bringing it back into phase. For the purpose of this instrument it is so arranged that a large error signal causes only a small deviation in the locally generated signal, the total deviation being within the range to be investigated. A range of 5% of the centre frequency is adequate to measure accurately peak-to-peak deviations around 0.1%. If a suitable loop response time is chosen the error signal can be examined for cyclic variations with an oscilloscope.

The circuit is shown in block schematic form in Fig. 1. The output from the stylus, a fixed 3-kHz tone, is first amplified to a level that will fire the Schmitt-trigger squarer (Fig. 1). For the amplifier one can use an existing amplifier system tapping off at a suitable point along the amplifier chain. The square-wave output is fed to the phase/frequency comparator where it is compared with the output of the voltage-controlled multivibrator. With suitable filtering, the phase/frequency comparator produces an output voltage which controls the multivibrator frequency. Variation of the reference alters the error voltage to produce a change in multivibrator frequency to match the reference variation. The output observed on an oscilloscope will be a net d.c. level modulated by a cyclic variation whose amplitude describes directly any deviation of the reference.

The full circuit is shown in Fig. 2 and uses three i.cs. The first is a t.t.l. Schmitt trigger that generates square waves from the reference input provided its input is above the switching threshold, typically 1.7V. Both this threshold and switching hysteresis are internally temperature-compensated. The second i.c. is more complex, containing two digital phase detectors and a charge pump circuit which converts pulse inputs to a direct voltage level. Both phase detectors have common inputs but have different modes of operation for different applications. Both are essentially sequential digital circuits, the two input signals sequence the circuit in the proper way only when locked together. Only one detector is used in the circuit — that which gives a locked condition when the negative transitions of the variable input and reference input are equal in frequency and phase.

The charge pump accepts the phase detector outputs and converts them to fixed-amplitude positive and negative pulses. An active filter converts these pulses into a direct voltage proportional to phase error. Because of the large frequency range within which this device operates, and because of the necessity to choose the time or rate at which the circuit responds to phase errors, external components are needed to provide the filtering action — *Tr*, *R* and *C* in Fig. 3.

The third i.c. is a dual voltage-controlled multivibrator with only one section used. Frequency control is accomplished through the use of internal voltage-variable current sources which control the slew rate of a single capacitor. A voltage range of +1.0 to +5.0V can produce a ratio variation in frequency of over 3:1.

To ease setting up a variable resistor is used in series with the single frequency-determining capacitor. For a fixed input voltage this alters the multivibrator frequency. This control is necessary because of the restricted frequency range over which the multivibrator operates (5%).

At 3kHz the instrument gives a sensitivity of 300mV per 1% — a 0.1% pk-pk variation will give an output of 30mV —

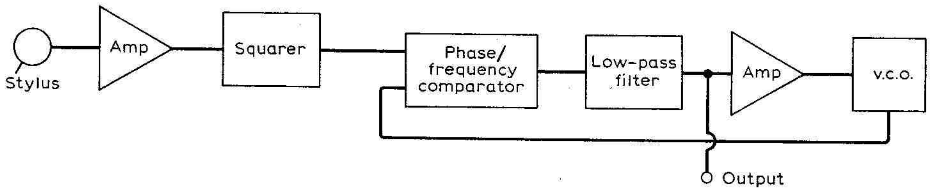


Fig. 1. In this design wow and flutter frequency modulations are converted to a changing d.c. level with a phase-locked loop and then displayed on an oscilloscope.

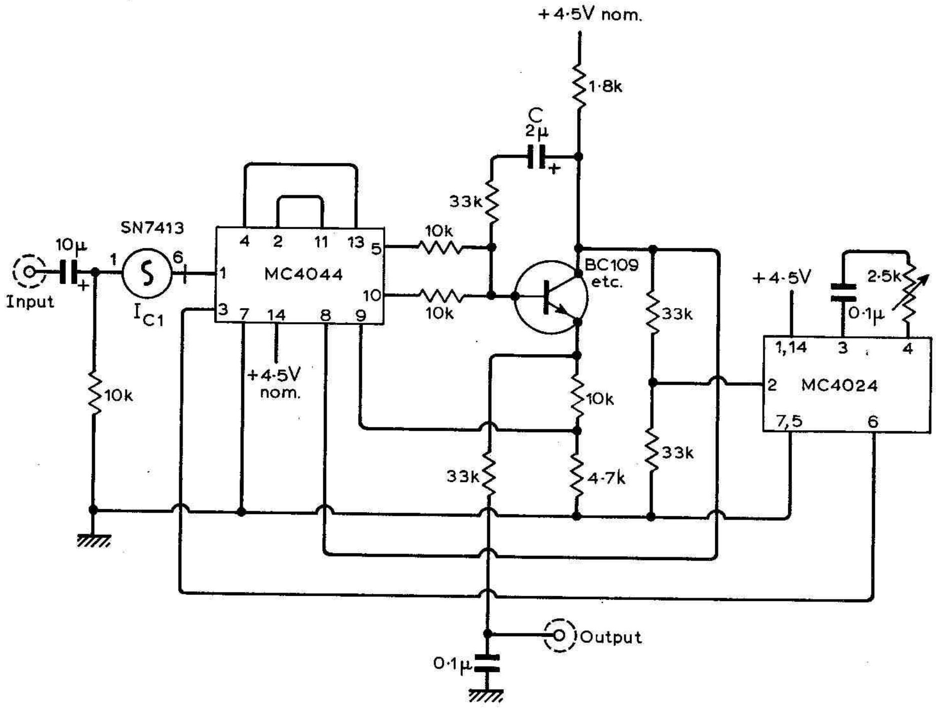
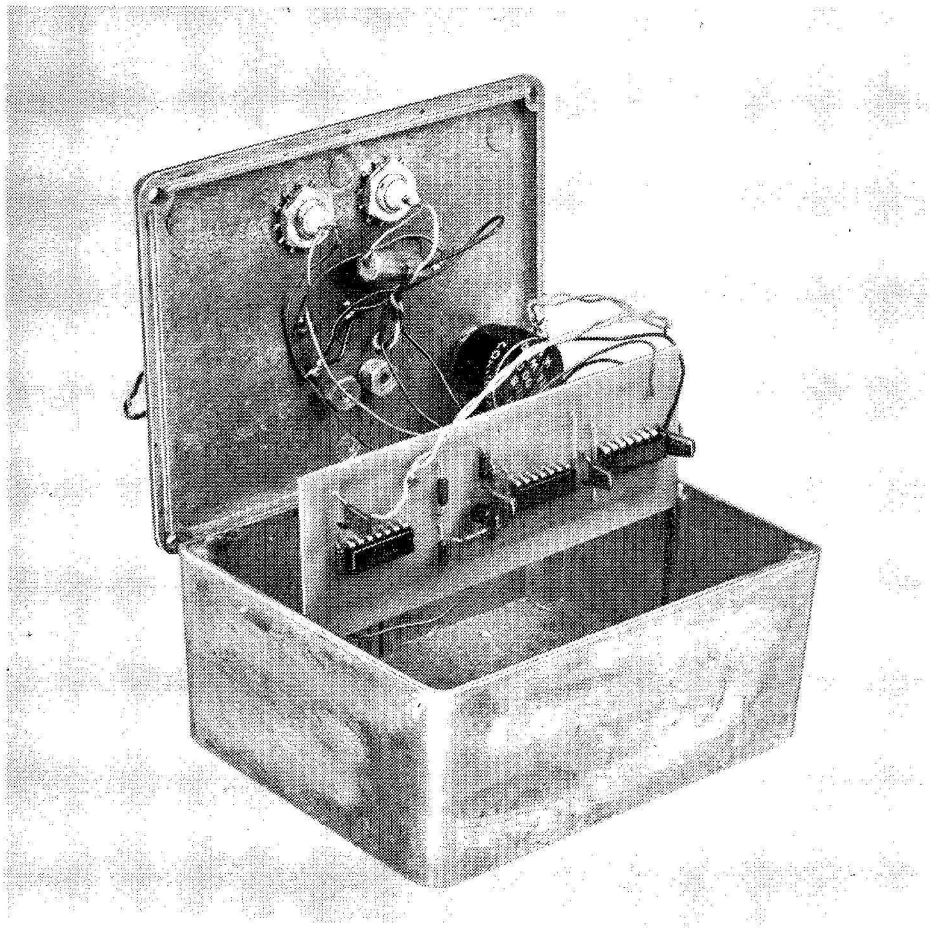


Fig. 2. Complete circuit uses three i.cs—a Schmitt trigger squaring circuit, followed by a phase detector and v.c.o. Pins 7 and 14 of IC_1 are connected to 0V and +4.5V lines respectively.



easily measured on an oscilloscope. The instrument should, however, be calibrated against an oscillator.

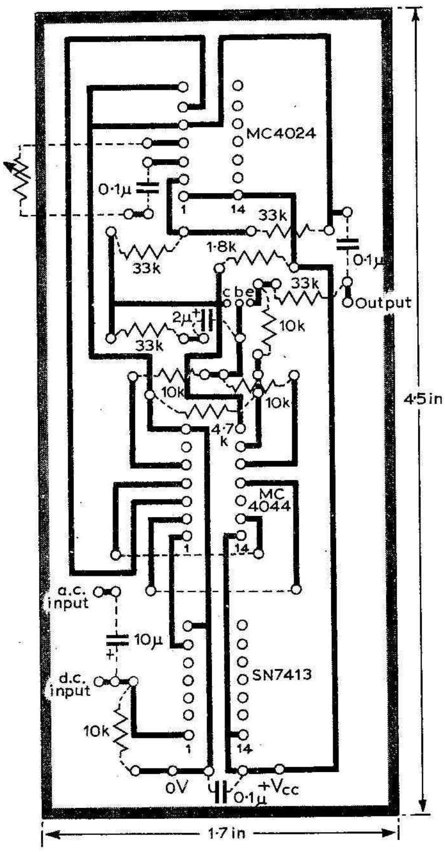
Calibration

Inject a 3kHz tone from a signal generator into the instrument. A level of at least 4V peak-to-peak is required. The output is connected to an oscilloscope with its deflection factor set at 1V/cm. The oscilloscope will indicate a level of either 0V or about +1.7V depending on whether the internal multivibrator is set at a higher or lower frequency than the oscillator. Rotate the variable resistor until a change of state occurs. With a little care the variable resistor can be adjusted until the oscilloscope beam is about half way between the total deflection. If the frequency of the external oscillator is now varied around 3kHz the beam should follow frequency variation, the transition between 0V and +1.7V occurring over a range of about 150Hz. An accurate calibration can then follow by plotting output voltage against frequency.

In use, the external oscillator is replaced by a tone derived from a test record and amplified to a sufficient level. The variable resistor may need adjusting to alter the frequency of the internal multivibrator if the turntable is not running exactly at the correct speed. The total amplitude of the deviation of the oscilloscope beam is then a measure of the peak-to-peak cyclic variation of turntable speed. Divide this figure by 2.8 to give 'r.m.s.' variation.

If the instrument is used for checking tape recorders the spare section of the dual multivibrator can be used as a 3-kHz oscillator with an appropriate capacitor. The output of this can then be recorded on the tape to be played back into the instrument to measure the flutter of the recorder. In this application, reduce C (Fig. 2) to $0.1\mu F$.

Using the instrument on the turntable described, a peak-to-peak deviation of 0.5% was measured at 3kHz.



Printed circuit design used in the prototype. Circuit and battery can be housed in a die-cast box (e.g. STC type 46R CS00.043). Parts for the meter, turntable and pickup arm are available from Longdendale Technological Products, Hadfield, Hyde, Cheshire.

Analysing faults in the turntable

Rumble should be random. Any cyclic tendencies indicate imperfections on the moving surfaces. For instance, if the thrust ball in the turntable assembly is not central it will not rotate on a single point contact, but describe a circular motion on the thrust bearing pad. This will obviously increase rumble and it may appear cyclic. Again if the main bearing is badly made the turntable may precess around the main bearing spindle with obvious results. If the pickup-arm board touches any part of the plinth coupling between the motor and pickup will be increased, showing as a strong component at 100Hz. (If a turntable using either a ball or needle roller race as a thrust bearing is tested rumble may be strongly cyclic. This is characteristic and not a fault unless the race is worn.)

Wow and flutter can generally be seen as well as heard, provided of course, the moving parts can be seen. Check for turntable wobble and pulley concentricity. A tight or damaged main bearing may cause sticking and show up as large, fast transient deviations on the oscilloscope. This can be checked by removing the belt and carefully rotating the turntable by hand. The author has not had any trouble with slipping belts, which is not to say it cannot occur. Ensure that the belt is kept clean and free from grease by washing occasionally in detergent. Much more likely to occur is flutter caused by the side of the belt scuffing the pulley groove wall. Although some scuffing is bound to occur the resilience of the rubber belt filters out any adverse effects to a certain extent. When testing always pay particular attention to the record. The following notes emphasize the point.

Record defects

In practice by far the largest contribution to wow and flutter can come from the disc itself. Often it is impossible to decide on the exact source but it is mainly due to physical defects caused by sloppy manufacturing processes. Calculations can show that the average disc contributes more to wow and flutter than probably the poorest reasonable quality reproducing equipment available. Only two of the more serious defects are discussed — eccentricity and pinch warp.

Eccentricity

This is possibly the least annoying of the two and may in some cases be overcome by a little care and patience on individual discs. It is caused by the spindle hole not being in the exact centre of the groove spiral. The specification concerning eccentricity allows a tolerance of 0.010in (NAB). However it is not uncommon for this to reach 0.040in (see for example letter in *Hi-fi News* Sept 1971 p.1669). Now the central hole is given to be 0.285 ±0.0025in. If a manufacturer were to make the spindle on a record player 0.285in clearly some records wouldn't fit. Even 0.2825in would provide difficulty on some. Again reducing the spindle size to 0.280in would provide difficulties, especially on removal as the flexibility of the record causes it to pinch the spindle. For this reason 0.275in is generally chosen. These tolerances add so it would be quite reasonable to suppose that an average record could quite easily be 0.050in eccentric. To calculate the effect of eccentricity on a groove of constant recorded frequency is straightforward.

The times taken to travel round ABC and CDA are equal and clearly CDA has a longer path length than ABC, so to a

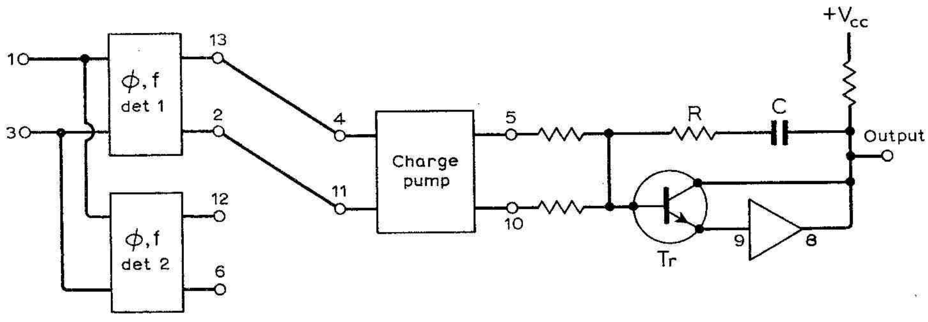
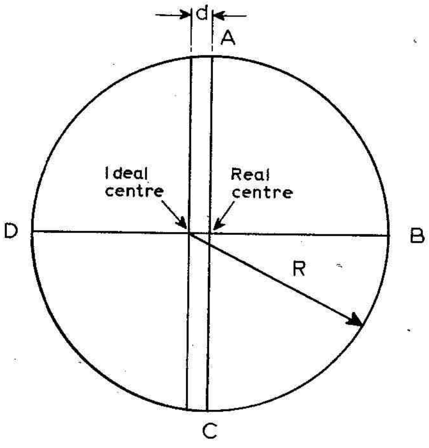


Fig. 3. The charge pump contained in the phase-detector i.c. converts the pulsed detector output to a direct voltage level, which is filtered using an active filter designed around an internal amplifier.



first approximation (as d is small with respect to R), ABC + $2d \approx$ CDA. Thus deviation is

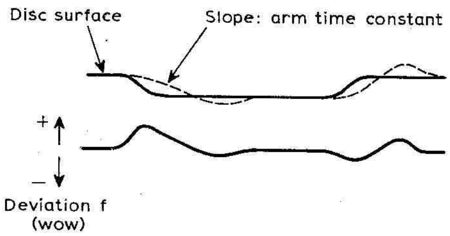
$$\frac{2d}{ABC + CDA} = \frac{2d}{2\pi R} = \frac{d}{\pi R}$$

Inserting some practical values say $d=$ 0.025in and $R=$3in, the peak-to-peak deviation works out to be 0.0026 or 0.26%. Taking an extreme case, $d=$ 0.050in and $R=$2.5in, the peak-to-peak deviation amounts to 0.64%. Note that the deviation gets worse as R decreases. One of the best-known cures for this effect is to open out the disc centre hole and attempt to place the record on the turntable concentrically.

Pinch warp

Pinch warp can cause some very disturbing effects. Its cause is, apparently, removal of the vinyl disc from the press while too hot, and thus in a semi-plastic state. The material cannot support its own weight and a permanent set results.

Modern cartridge design has gone a long way toward curing one of the more obvious effects of this kind of warp — the stylus being thrown out of the groove by the violent movement. The stylus is mounted on a cantilever which has a comparatively soft suspension. Everyone who has used a modern magnetic cartridge must have observed the way the cartridge 'sinks' to a working point after the stylus has made contact with the groove. Unfortunately this soft suspension which so effectively keeps the stylus 'glued' to



the groove results in an annoying source of wow.

The pinch is usually over a small section of the record — usually the time constant of the pickup arm movement is too long to allow the stylus to follow the groove without some movement of the cantilever — see above. As the cantilever is normally very short (10mm) with respect to the length of the pickup arm, the stylus exhibits a considerable fore and aft movement as it follows the groove.

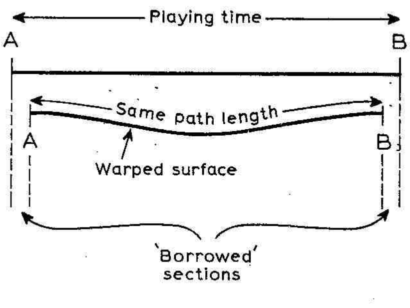
The effects of pinch warp then depend not only on the magnitude of the warp but also on the cartridge and in particular the time constant — related to inertia — of the pick-up arm.

It is not easy to assess the effect of pinch warp in quantitative terms because of the infinite variety of possible shapes and sizes of warps. Again one must assume a time constant (i.e. resonant frequency) for the pickup arm. Perhaps the best method is to measure the variation in distance from the bottom of the cartridge to the record surface as the warp is played. As can be imagined this is not at all easy as one has to measure the distance over which the variation occurs at the same time.

I have a fairly old Decca test record where the peak-to-peak deviation caused by this effect is in excess of 2% when used with a modern magnetic cartridge, and indeed the noise generated by the cantilever suspension as it moves to keep track can be heard too!

The above considers the effect of a pinch warp when it is too fast to be followed by the pick-up arm and thus the stylus cantilever moves, but wow can also be caused by pinch warp which is easily followed by the arm.

If it is assumed that the warped part of the record achieves its shape without any stretching of the material within that section but is accommodated by material from the rest of the disc, a situation akin to eccentricity results i.e. differences in path length, *viz.*



Here calculations can be based on considering the percentage increase in path length related to the depth of warp and length over which warp occurs. Figures in the region of 0.2% can be expected for drops of 0.070in over a distance of 1in.

In practice it cannot be stated that stretching does not occur, in which case this effect is reduced. Naturally, eccentricity, pinch warp and stretching occur together and act in combination. To an untrained ear eccentricity is hardly noticeable as the variation is so slow and only then probably on the innermost grooves but it does come as a surprise when it is observed on a wow meter. Pinch warp wow can usually be heard in most circumstances.

Conclusions

Compared to commercially available equipment, the performance figures obtained for the project appear to give some scope for improvement. However, reputable manufacturers use special records for their tests which are very expensive and not generally available. These will be flatter and have such refinements as adjustable centres. They enable much more accurate measurements to be made. The figures given are those likely to be obtained with generally available test records and are necessary to enable performance to be assessed by constructors. In the near future I hope to report more accurate performance figures which will be more representative of the unit's performance.

Additions & Corrections

'Electrostatic headphone design' (November). In Fig. 11 the 680kΩ and 82kΩ resistors should be in series (the 82kΩ on the supply side) and decoupled at their junction. The lower EF86 should have a 120kΩ anode resistor. In Fig. 13 the earphone e.h.t. series resistor can be 10MΩ for convenience. *Construction note:* The author is preparing a short practical-hint sheet to assist readers making up the headphone units. It will include simple instructions for obtaining the recommended resistivity of about $10^9\,\Omega/\square$. The sheet will be sent to anyone on receipt of an s.a.e.

'Digital audio delay system' (October 'New Products'). This equipment is being marketed in this country by F. W. O. Bauch Ltd, 49 Theobald Street, Boreham Wood, Herts.

The **Reslosound ribbon microphone** featured on last month's front cover was the MR1, not UD4 as stated.

News of the Month

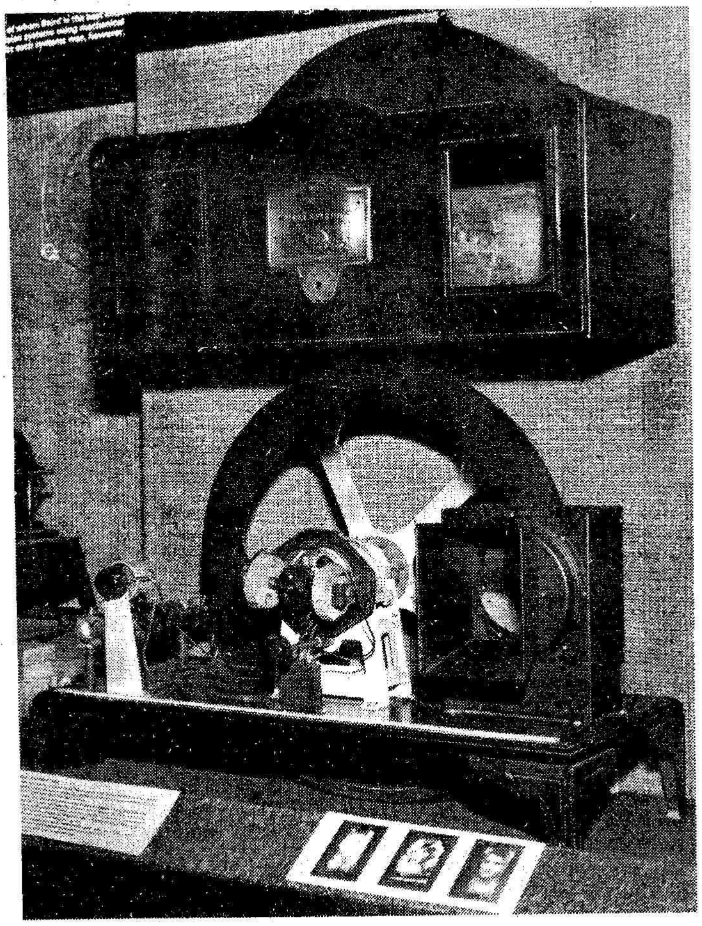
Stereo broadcasting to be extended in 1972

We have heard from the B.B.C. that the work to extend stereo broadcasting to Radio 2 and Radio 4 will be carried out in three phases.

Phase one is already in progress and is concerned with providing stereo programme origination facilities for Radio 2 and Radio 4. Control equipment in London has to be modified and the number of gramophone turntables, tape machines and outside broadcast units equipped for stereo is being increased throughout the U.K. It is expected that it will be possible to originate the majority of programmes on Radio 2 and some programmes on Radio 4 in stereo by the end of 1972.

Phase two consists of providing stereo transmitters for Radio 2 and Radio 4 at those sites already transmitting Radio 3 in stereo. This will involve setting up several s.h.f. links using p.c.m. These links have been developed by the B.B.C. and each one will carry ten audio circuits. Each stereo programme will use two circuits and stereo coding will be carried out at the main transmitters. The use of p.c.m. will provide listeners with improved quality because a wider audio bandwidth and improved signal-to-noise ratio will be achieved. It should be possible to transmit Radio 2 and Radio 4 in stereo in the London area and in the midlands by the end of 1972 and in the north of England during 1973. The transmitters at Rowridge (central southern England) and Belmont (Lincolnshire) are to be modified to handle the three stereo programmes during this phase.

Phase three will start in 1974 and it is expected that the three programmes in stereo will be available from Kirk o'Shotts (Lanarkshire), Pontop Pike (Durham), Sandale (Cumberland), and Wenvoe (Glamorgan).



The Minister of Post and Telecommunications officially opened the new telecommunications gallery of nearly 10,000 sq.ft at the Science Museum, South Kensington, on October 26th. The gallery is divided into two; one portraying the development of telegraph and telephone systems (radio being incidental) and the other portraying radar, communication satellites, radio and television (including Baird's Televisor, shown here, and his original transmission equipment).

Skylarks pin-point X-ray source

In 1970 the position of the celestial X-ray source GX3+1 near the centre of our galaxy was established to within two minutes of arc by equipment designed by the Massachusetts Institute of Technology and flown in a NASA sounding rocket. This has enabled astronomers to calculate opportunities for pin pointing GX3+1 more accurately by a method involving observations of the source at the moment of eclipse by the moon so that it can be identified with a visible object. When the moon eclipses a source for which the position in the sky is roughly known, the exact position at which the X-ray emission is cut off is the same as the accurately known position of the leading edge of the moon. In an experiment on September 27th by Dr. D. A. Pounds a team at the University of Leicester took a 'bearing' which shows that the X-ray source GX3+1 was in a 'box' 120 seconds of arc long and one quarter of a second of arc wide, an area within which about 30 visible stars may be seen. Measuring equipment was carried on a Skylark rocket launched from Woomera by a British Aircraft Corporation team.

On October 24th a second Skylark was launched in a 'window' only one minute wide carrying an experiment devised by Professor A. P. Willmore, of the Mullard Space Science Laboratory of University College, London, which provided a 'cross-bearing', reducing the area to be searched by a factor of 60. If astronomical observation reveals a star in this area it is likely to be the source of the X-ray emission GX3+1. Taken together the experiments have reduced the error box by a factor of 1000.

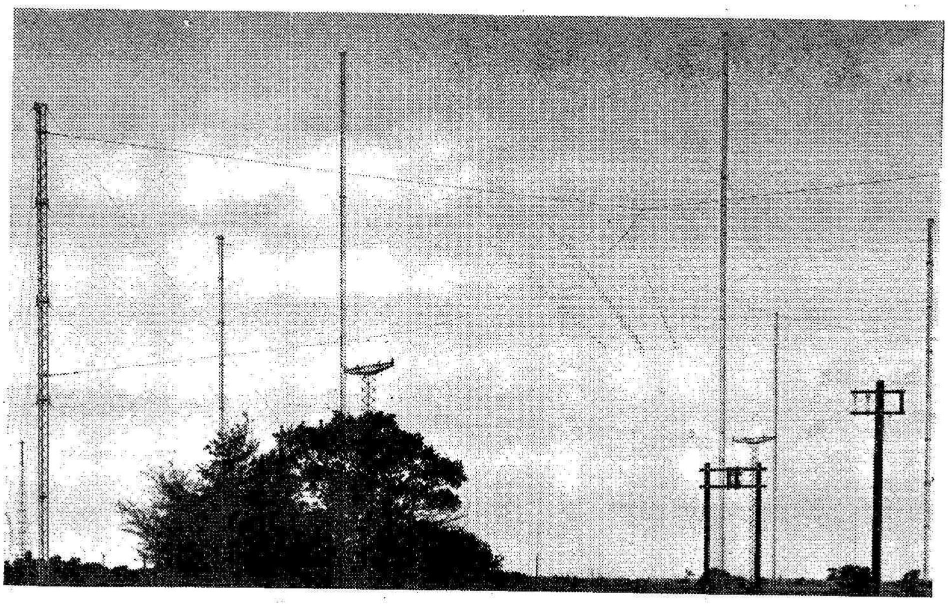
The experiments took advantage of the only two occasions this year on which the X-ray emission was eclipsed by the moon, as seen from Woomera, but each experiment required a different technique, the one taking place during daylight and the other at night. Both experiments, which involved very sophisticated techniques, were financed by the Science Research Council and launched in the Council's National Rocket Programme.

The latest experiment, devised and built (under the direction of Professor R. L. F. Boyd, F.R.S.) at UCL's Mullard Space Science Laboratory, Holmbury St. Mary, was launched in a spin-stabilized Skylark rocket. A 1,000 square centimetre area X-ray counter giving a field of view 20° by

6° (the 20° axis being parallel to the Milky Way and the payload) was spun at three revolutions per second, thereby sweeping across GX3+1 three times per second. The counter could not be directed at the X-ray source continually throughout the flight until occultation, as was the case with the daytime experiment in the stabilized Skylark SL1002 on September 27th, since the occultation took place at a time when neither sun- nor moon-stabilized Skylarks could be used. The S.R.C's Royal Greenwich Observatory at Herstmonceux made the calculations required for the timing of these two experiments. GX3+1 is one of some 40 X-ray stars which have been discovered by rockets in the comparatively new science of X-ray astronomy. Sounding Rockets such as Skylark are considered to be the only practical means of carrying out rapid and relatively inexpensive studies of this type, particularly when infrequent opportunities occur, as they do in seeking the source of X-rays from deep space.

Stabilization of Skylark payloads using Marconi Space and Defence Systems attitude control units make it possible to direct the pay load with great accuracy.

Ongar radio station formally re-opened



After 50 years' service, the Post Office radio station at Ongar, Essex, has again been re-equipped at a cost of £750,000. Careful planning has ensured that the station's services — telephone, telegraph and facsimile transmissions to more than 25 administrations in eastern Europe, the Middle East, Africa, and South-East Asia — have not been disrupted during the re-equipment programme.

Mr. Keith Hannant, Director of Post Office International and Maritime Telecommunications, formally re-opened Ongar radio station on October 15th.

The new equipment consists of 23 self-tuning, 30kW, high-frequency radio transmitters which now operate alongside seven of the older transmitters.

The station has 34 directional aerial arrays. Aerials for telephone and telegraph services are usually two-tier rhombics on 150-ft masts. The upper tier gives the low-angle radiation essential for frequencies below 13MHz, while the lower tier covers the higher frequencies. Log-periodic aerials, with their characteristic wide horizontal angles and high back-to-front ratios, are used for facsimile transmission because this is often made to several countries simultaneously.

Optical traffic speed indicator

A road traffic speed measurement system is being developed by Marconi Radar Systems and the Great Baddow Research Laboratories within GEC-Marconi Electronics, under contract to the Director of Telecommunications, Home Office. The system employs an optical method of measurement, originally devised to measure the speed of steel strip as it passed through a rolling mill.

The device uses narrow reflecting strips to produce an image of the vehicle or target as a succession of separated, vertical strips, focused on a photodiode. The optical effect is almost exactly the same as if the target were being viewed through a grating which was placed against it.

The output voltage from the photodiode is proportional to the amount of light falling upon it from all of the slits in the 'virtual' grating. If the object moves, then the images also move across the photodiode.

Any irregularities in the optical image — bright spots or shadows — will move across the slits of the 'virtual' grating, and will produce a fluctuation of the light falling on the photodiode. This fluctuation will have a frequency which is directly related to the speed at which the object is moving. The photodiode output voltage will therefore vary periodically at this same frequency.

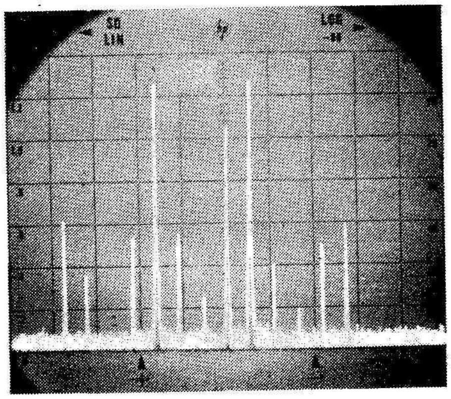
The frequency of the fluctuating voltage is measured and converted to a speed reading, and presented to the operator on a digital display. Liquid crystal displays are being considered since they provide a high contrast display at any level of incident light.

Multiplex operation of television transmitters

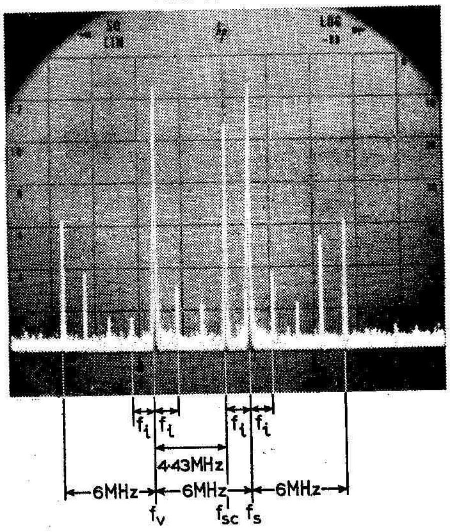
Normally u.h.f. television stations have two transmitters, one for vision and one for sound, each with its own klystron power amplifier stage. A standby is provided for each of these in case of breakdowns. For some broadcasting applications there may be an argument for multiplex operation, using a single klystron for amplifying both vision and sound, to reduce capital and running costs — since a 7-8ft high vapour-cooled tube delivering some tens of kilowatts is a very expensive component. What has hindered multiplex operation so far has been the fact that non-linearity in the klystron output/input power characteristic gives rise to intermodulation and cross modulation products between the vision, colour subcarrier and sound signals. If the klystron is operated on a part of its power characteristic giving adequate efficiency these i.m. and c.m. products are higher than permitted by C.C.I.R. recommendations (i.m.p. level should be at least 51dB below peak sync level). This sort of situation is shown in the upper spectrogram which displays the vision (f_v), subcarrier (f_{sc}) and sound (f_s) frequencies — the tallest 'spikes' — with, surrounding them, i.m. products which are somewhat greater than the required 51dB down (10dB divisions on the X axis of the graticule).

Electromechanical Enterprise, the Hungarian transmitter manufacturers, have developed a technique which minimises this problem by applying correction to the waveform of the klystron input signal. In effect it makes the klystron output/input power characteristic more linear, enabling the tube to operate more efficiently within the C.C.I.R. requirements. This organization has been collaborating with E.M.I.-Varian Ltd, manufacturers of klystrons, in a series of tests at the British firm's Hayes, Middlesex, factory, using an EMI-Varian high-gain klystron of the integral cavity type. These tests have shown that multiplex operation using the single tube will readily allow 25kW peak sync with i.m. and c.m. products well within the C.C.I.R. specifications. A typical test on Channel 28 frequency (f_v=527.25MHz), with a klystron gain of 52dB and d.c. power input of 180kW, gave 26.4kW peak sync and an efficiency of 17.6%. In general, multiplex operation is possible at power levels from 10 to 25kW with efficiencies of 15 to 17.5%. (Without correction the tube can operate in multiplex at only 8% efficiency.) The lower

Without correction



With correction



f_i = 1·57MHz (intermod. product)

spectrogram shows the effect of introducing the correction unit on the i.m. products, relative to the upper spectrogram. In each case the outer 'spikes' of energy are cut off by the transmitter's 8-MHz pass band characteristic.

In the tests the correction process, which is based on the non-linear characteristic of a diode, has been applied to signal frequencies in the i.f. range: f_v=38.9MHz, f_{sc}=32.9 to 38.9MHz, f_s=32.9MHz, as would occur in a transposer station. The B.B.C. and I.T.A. are unlikely to use the technique but other broadcasting organizations may do so. Indeed, Hungary's first u.h.f. television station, in Budapest, is using corrected multiplex transmissions of this kind in regular service.

The 1972 edition of the *Wireless World* Diary is now available. The diary, which shows a week at-an-opening, contains 60 pages of technical and general information.

Copies may be obtained from stationers and booksellers price 48p or direct from The Trade Counter, Dorset House, Stamford Street, London S.E.1, price 51p including p & p.

Garrard receive American award

Garrard Engineering, of Swindon, received, in New York, the American 'Maker of the Microphone' award. The award is presented annually in memory of Emile Berliner, who made important contributions during the last century to the development of the microphone, and who also invented the disc record and the gramophone.

The award, for an outstanding contribution to the world of sound in developing a zero-tracking error pickup arm for disc record reproduction, was received on behalf of Garrard by Mr. G. T. Thomson-Gordon, Garrard's General Manager of Manufacturing. The first Garrard unit to incorporate zero-tracking — the Zero-100 — has already topped £1M in export sales.

Automatic film focusing

Hand focusing of the image on a cinema screen will soon be a thing of the past if an idea of a private inventor goes into production. The invention has been taken up by N.R.D.C. and developed into a practical system by the Sira Institute.

It is not enough for a skilled projectionist to focus on the titles at the beginning of a film and hope that focus will stay sharp until the end. The picture may go out of focus at any time for a number of reasons; these include variation in the thickness of the photographic emulsion, film distortion, expansion of components in the projector, and inaccurate positioning of the lenses as they are interchanged. David Fenner, the inventor, found a way of automatically detecting picture focus. His method uses the fact that the variations in the intensity of light along a line of the picture are more gradual in an out-of-focus picture than in a focused one.

He makes use of the natural scanning operation that takes place every time the film is pulled down to change from one frame of the picture to the next. Normally a shutter blade in the projector cuts off light from the screen while the film is being pulled down. In the new device a filter is fitted to the shutter blade so as to transmit the invisible near-infra-red part of the light. This causes an image, not seen by the audience, to travel over the screen and past a photo-electric detector which converts the light variation into electronic signals.

In practice two detectors are used, placed effectively in front of and behind the screen, and the circuitry is arranged so that when the picture is in focus on the screen the signals from the two detectors are equal. If the focus of the projected beam is not exactly at the screen the balance of the circuit is upset, and an error signal is generated to automatically refocus the projector. The only projector modifications needed are the fitting of the optical filter in the shutter blade and attachment of a motor to the focus control, if this is not available already.

N.R.D.C. is sponsoring further development at Sira Institute, Chislehurst. A working system has been constructed.

Data only satellite

Marconi's Radio and Space Division are to undertake a feasibility study for the European Space Technology Centre at Noordwijk, Holland. This calls for a detailed examination of a system which would use a geostationary satellite linked to large numbers of small, low-cost ground stations, and would be devoted exclusively to data distribution and transmission.

Oh, nought or zero?

The C.E.I. Joint Committee on Metrication has recently been discussing how metric dimensions and tolerances can be referred to colloquially. When discussing a synonym for a millimetre three possibilities were suggested — millimetre, milli and mil — the latter, although convenient, could easily be confused with the American 'mil' meaning one-thousandth of an inch. Moving down the scale micron or micrometre appear to be the alternatives although micrometre could conceivably be confused with the micrometer measuring instrument.

Decimal fractions of a millimetre also pose problems, for instance 0.1mm could be called, point one, one-tenth or one hundred microns.

The RS/C.E.I. Joint Committee on Metrication Secretariat (Institution of Production Engineers, 10 Chesterfield St., London W1X 8DE) would welcome constructive comments from readers.

All O.K. with Prospero

Prospero (X3), Britain's first technology satellite, is now in orbit and transmitting data successfully from all the experiments on board. First results, now being analysed by Marconi engineers, indicate that the power supplies, data handling systems and all of the experiments carried by the satellite have performed well, and that the new types of construction employed have proved successful on their first entry into the space environment. In addition, the spacecraft has responded to commands from the ground to replay the information recorded so far. The main purpose of the satellite is to prove a wide variety of new and advanced techniques which will be needed for the communication and navigation satellites of the future.

F.E.T. Tester

Measures mutual conductance, zero-bias drain current and gate cut-off voltage in junction f.e.ts

by D.E.O'N. Waddington, M.I.E.R.E.

As more f.e.ts are used and as more cheap ones become available, an f.e.t. tester becomes more of a necessity. A recent survey[1] of American transistor testers shows that very few f.e.t. testers exist and that what there are, are very expensive. While, to the author's knowledge, no similar survey has been carried out in this country, it is known that f.e.t. testers are rare.

The method of test adopted for f.e.ts will depend upon several considerations, not the least of which is the frequency with which the tester will be used. If f.e.ts are to be tested only very occasionally, the methods employing an ohm-meter should be used. For more frequent testing, the convenience of a dedicated tester is very attractive. The possibility of designing a tester for checking all types of field-effect devices was considered but it was found that there were too many variants in the m.o.s.f.e.t. area. Thus the present tester is confined to conventional depletion mode junction f.e.ts.

Ohm-meter tests

Tests that can be made with an ohm-meter are illustrated in Fig. 1. In Fig. 1(b), the f.e.t. is treated as a diode with two connections to one of its electrodes (either end of the channel) and is tested by checking that the diode conducts when it is forward biased and has a high resistance when it is reverse biased. This checks that the junction is intact and also, in the case of an unmarked f.e.t., can help to identify the gate electrode and also to determine whether the f.e.t. is p- or n-channel. However, as normal junction f.e.ts appear symmetrical at z.f., this test cannot distinguish between the source and the drain. In Fig. 1(c) the f.e.t. is treated as a simple resistor and the resistance between the source and drain with the gate connected to the source is measured. The channel resistance thus measured is R_{DSon}. This measurement can also give an indication of the transconductance as $g_m \approx 1/R_{DSSon}$. In all these ohm-meter tests care should be taken that the ratings of the f.e.t. under test are not exceeded. It is usually safe to use a standard 20,000Ω/volt multimeter on the normal ohms range, as under these conditions the maximum terminal voltage is 1.5V and the current about 600μA.

Although not strictly speaking an ohm-meter test, the method of measuring V_P

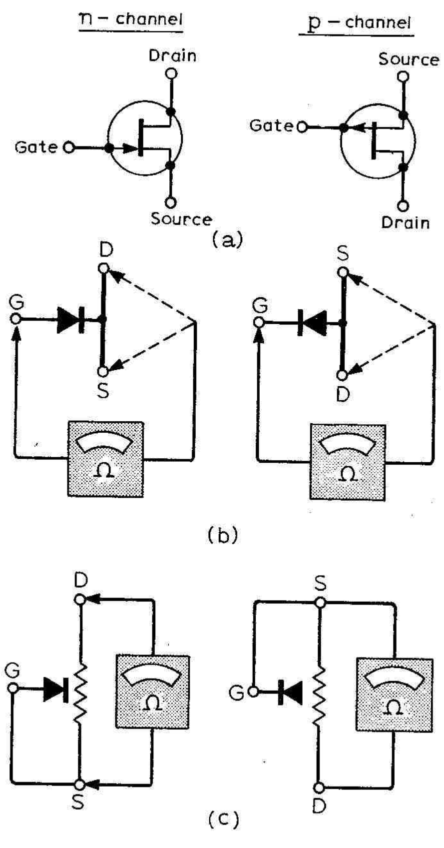


Fig.1. (a) Symbols for n-channel and p-channel junction f.e.ts. (b) Equivalent test circuit for checking the gate-channel diode, (Note: with most ohm-meters the red or 'positive' lead has a negative potential; thus a diode conducts with the red lead connected to the cathode terminal). (c) Equivalent test circuit for checking channel resistance, R_{DSon}.

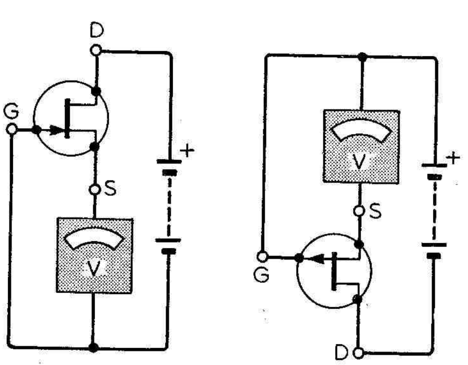


Fig.2. Measurement of V_P. The supply for this test is not critical.

illustrated in Fig. 2 comes into this category. The method consists of measuring the source-gate voltage with the supply connected between the gate and the drain. Ideally this measurement should be carried out with a voltmeter having a very high resistance so that the drain current approaches zero. However, with a standard 20,000Ω/V voltmeter, the current, assuming that V_P gives full-scale deflection, will be only 50μA. This will reduce with meter deflection.

While the ohm-meter tests can show whether the f.e.t. is usable, they give very little practical information. For example, it would be very difficult to select a pair of f.e.ts for matched g_m using an ohm-meter. This brings us to the question of what parameters should be measured. Apart from breakdown voltages, the three most important parameters are most probably, g_m (mutual conductance), I_{DSS} (zero bias drain current), and V_P (gate cut-off voltage). The g_m can be measured by either static or dynamic methods, and although the dynamic method possibly gives a more meaningful result, for most purposes a static method is quite adequate. Both I_{DSS} and V_P are essentially static parameters and are best measured as such. Thus, in order to keep the tester simple it was decided to make static measurements only.

Most test-books on f.e.ts tell us that the following relationship holds: $g_{m0} = 2I_{DSS}/V_P$. This formula assumes a perfect square law characteristic but, despite the fact that few f.e.ts are perfect, is accurate enough for practical purposes. Initially it did not appear to be possible to solve this equation by a simple electrical circuit as there are three unknowns, and while it is possible to measure two of them directly the third, g_{m0}, would need to be calculated. However, if a component in the test circuit could be set to be proportional to one of the unknowns, the measurement problem could be simplified considerably. The test circuit shown Fig. 3 can be analysed as follows:

Let $R_L \gg R_G V_P$

Then $V_1 = I_{DSS} R_L$

$$I_m = \frac{V_1}{R_G V_P} = \frac{I_{DSS} R_L}{R_G R_L}$$

$$g_m = \frac{2I_{DSS}}{V_P}\left(K\frac{R_L}{R_G}\right) = KI_m.$$

Thus, if I_{DSS} is measured using a circuit which has in it a resistor which is proportional to V_P the meter reading will be proportional to g_m. The proportionality will be dependent only upon the choice of values for R_L and R_G. Having obtained a method of evaluating the equation, the only problem that remains is to set the resistor so that it is proportional to V_P. This can be done quite simply as shown in Fig. 4. The tapping on the potential divider R is adjusted until the drain current is just reduced to zero. As the gate of the f.e.t. draws no current, this adjustment can be arranged such that the resistance between the points A and B is proportional to V_P, i.e. $R_G V_P$. This resistor can now be switched into the measuring circuit so as to permit the measurement of g_m. In practice, a further small resistor, having a value equal to the meter resistance, is included in the biasing chain between the point A and 0V so that the value of $R_G V_P$ is correct when the g_m measurement is made.

I_{DSS}

The measurement of I_{DSS} is illustrated in Fig. 5. The f.e.t. under test has its source and gate connected together and the drain current is measured directly using a conventional milliameter circuit. The switch, S_{2a}, is used to select the milliameter range. The lowest range is 5mA f.s.d. while the highest is 100mA f.s.d. In order to prevent damage by overheating to the f.e.t., a resistor R_x is connected in series with the supply to limit the maximum power available for dissipation in the f.e.t. under test to about 500mW. Although this will, of neces-

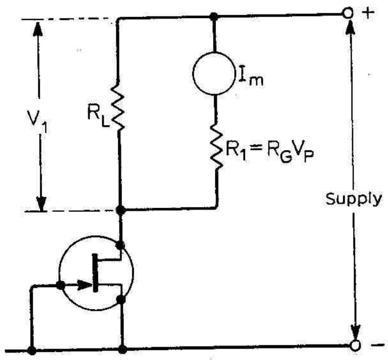


Fig.3. Circuit for measuring g_m.

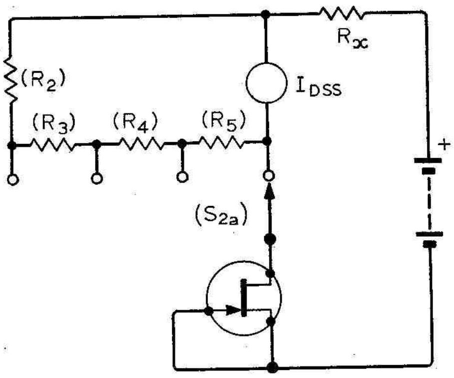


Fig.5. Measurement of I_{DSS}. Resistance R_x is chosen so that the maximum power which can be dissipated in the f.e.t. is 500mW.

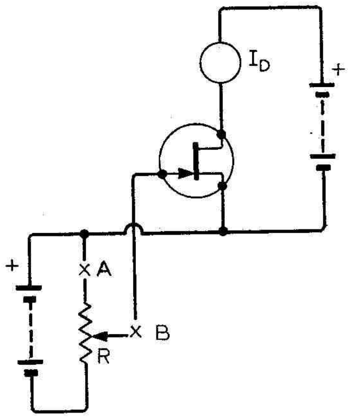


Fig.4. The value of R is adjusted until I_D is zero. The resistance AB is then proportional to V_P.

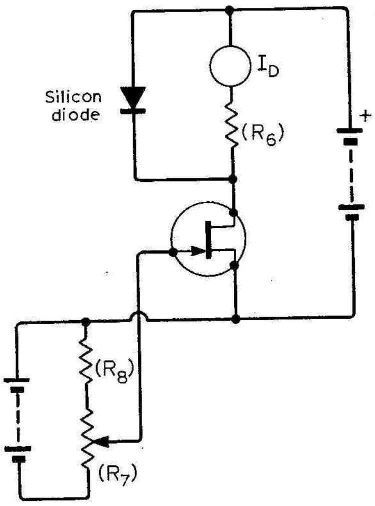


Fig.6. Circuit for measuring V_P. Resistance R_6 is chosen so that the voltage drop across it and the meter is approx. 600mV. Potentiometer R_7 is calibrated in volts.

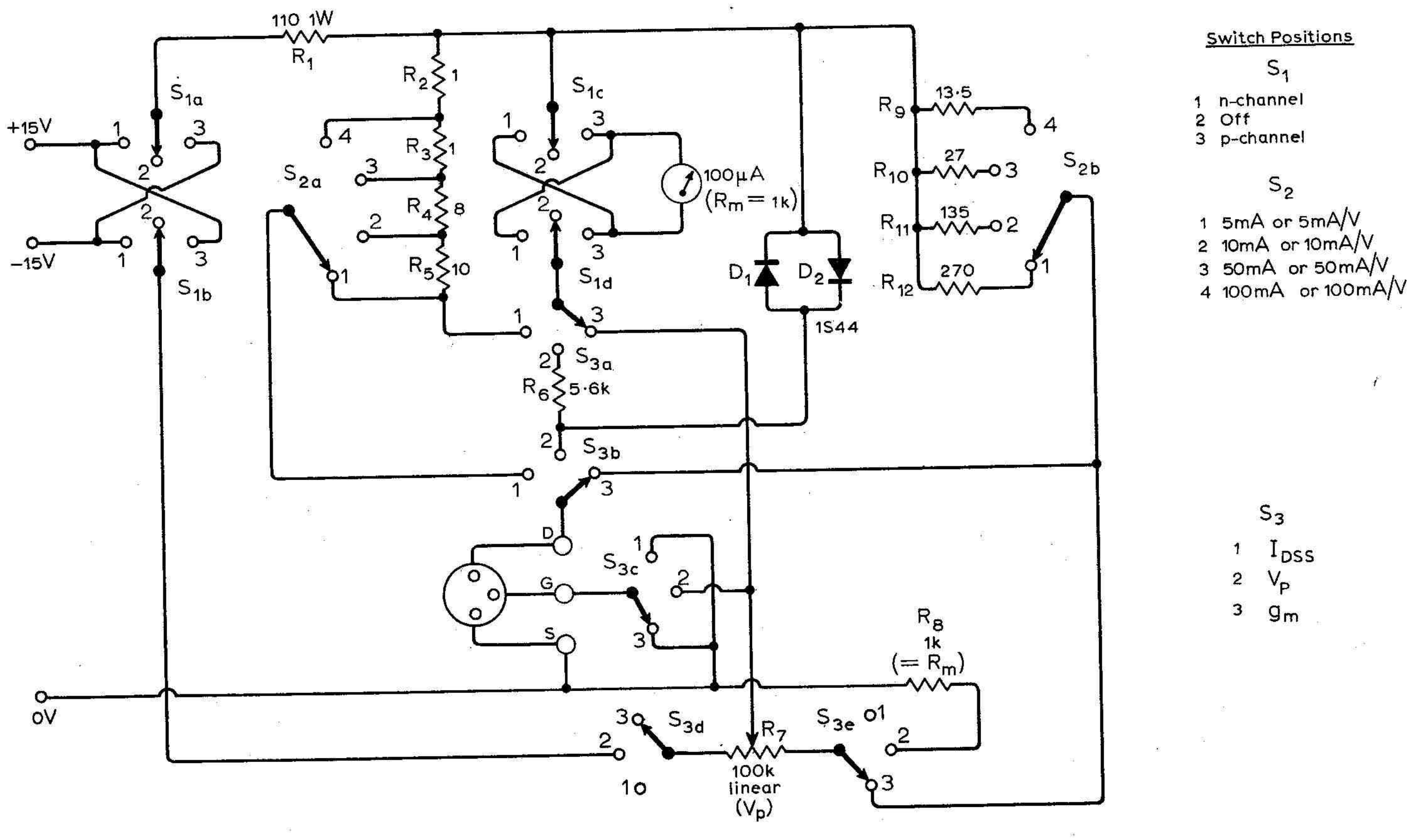


Fig.7. Circuit of the complete tester. (The values of the resistors connected to S_{2a} are not precise but should give negligible error.)

sity cause the voltage at which the test is carried out to vary, the protection was considered worth the sacrifice. However, if desired, the value of this resistor could be changed or a switch to short the resistor momentarily could be included. The implications of this change, however, should be clearly understood and taken into account.

V_P

The measurement of this parameter is effectively taken care of in the g_m measuring circuit. All that is necessary is to calibrate the gate bias control in voltage so that V_P can be read directly. In practice the meter needs protection as, when the gate is shorted to the source, the drain current will be equal to I_{DSS} and could damage the meter if it were set to the sensitive range necessary to detect zero drain current. The protection is accomplished by connecting a diode across the meter as shown in Fig. 6. In order to increase the effectiveness of the protection, a resistor is connected in series with the meter so that, with the current required for full-scale deflection flowing through the meter, the voltage across the diode is just sufficient to turn it on, i.e. 600mV.

The circuit of the complete tester is shown in Fig. 7. The physical layout of the tester is not at all critical. In order to accommodate both n- and p-channel devices, a polarity reversing switch S_1 has been included and the protection diode for V_P measurement has been duplicated. A suitable front panel layout for the tester is shown in Fig. 8.

As the calibration of the instrument depends for its accuracy on the power supplies, it was considered worth while to stabilize both supply rails reasonably accurately. The circuit for a suitable voltage stabilizer is shown in Fig. 9. A first glance at the circuit would suggest that it is over-complicated, but it should be borne in mind that the supply must be protected against possible short-circuit damage, a very present hazard in any tester of this type. The protection circuit for the positive line works as follows: If the transistor and diode Tr_2 and D_2 respectively are ignored, the circuit will be seen to be a conventional series stabilizer, Tr_4 being the series pass transistor and Tr_1 the comparator/amplifier. Under the normal operating conditions the base-emitter junction of Tr_2 is reverse biased so that Tr_2 is cut off and can indeed be ignored as far as operation of the regulator is concerned. As the reverse voltage applied to the base-emitter junction of Tr_2 is about 8V the diode D_2 is included in the circuit. If the output is shorted to earth, the emitter-base junction of Tr_2 becomes forward biased and Tr_2 bottoms. This turns off both Tr_3 and Tr_4 completely. Removal of the short-circuit restores the status quo. The protection of the negative supply works in a similar fashion. A word of warning to those who would like to use this protection method elsewhere. If the supply is worked into a capacitive load, there is the possibility that the output voltage will rise slowly and 'stick' at about 6V with Tr_2 just turned on. The method of preventing this is shown in Fig. 10. The capacitor C_5 holds the base of

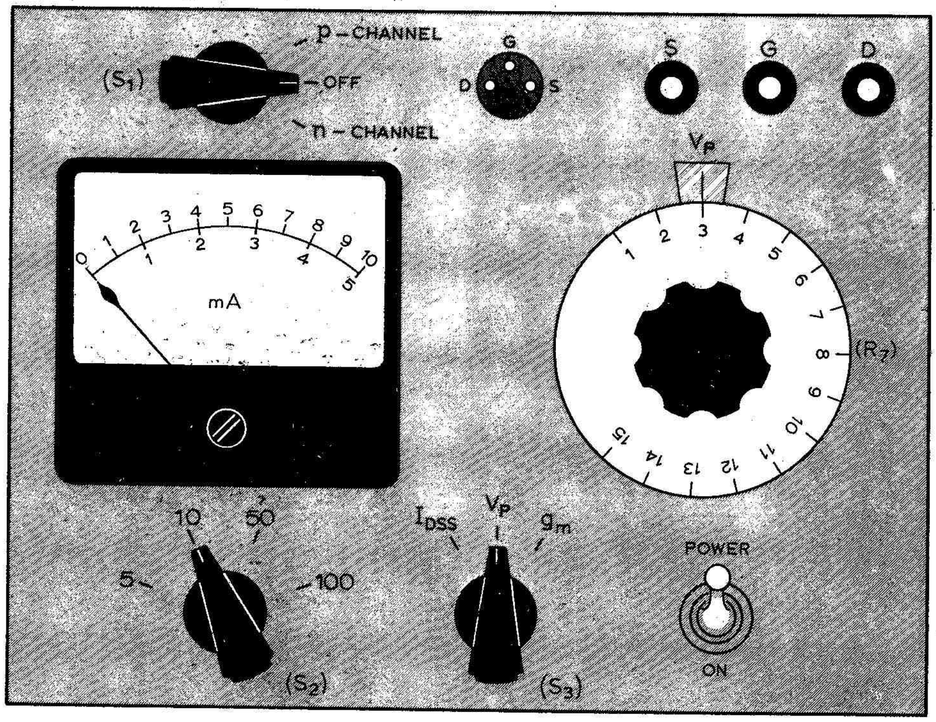
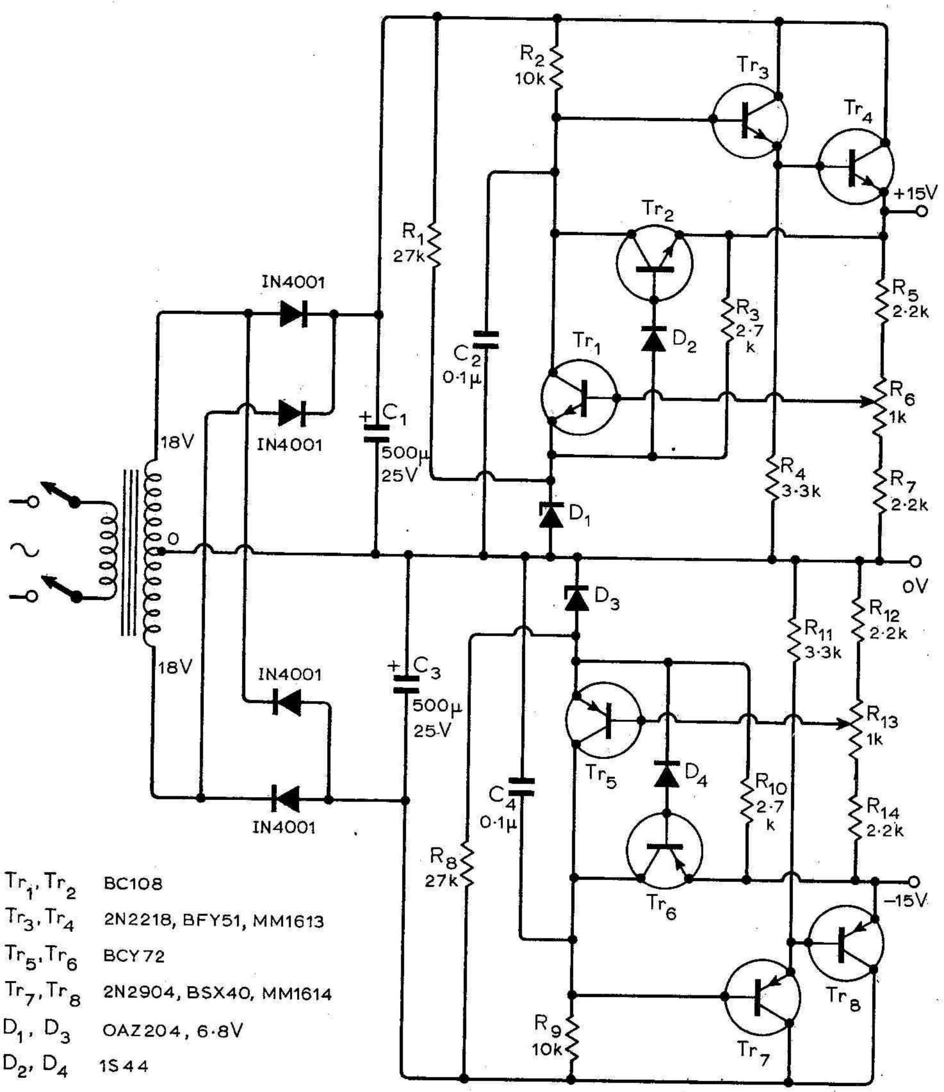


Fig.8. Layout of front panel of the prototype instrument.



Tr_1, Tr_2	BC108
Tr_3, Tr_4	2N2218, BFY51, MM1613
Tr_5, Tr_6	BCY72
Tr_7, Tr_8	2N2904, BSX40, MM1614
D_1, D_3	OAZ204, 6·8V
D_2, D_4	1S44

Fig.9. Power supply circuit incorporating protection against possible short-circuit damage.

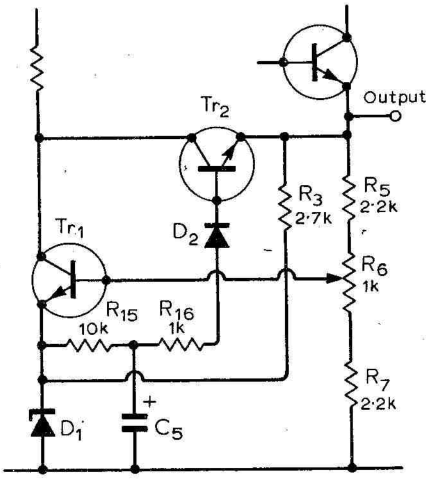


Fig.10. Modified protection circuit. R_{16} is included to limit the base current if the output is short circuited.

Tr_2 off so that the output voltage can rise to its full value. The charging time constant C_5R_{15} need not be very long but it must be longer than the rise time of the power supply output.

Measurement accuracy

$\mathbf{I_{DSS}}$. The accuracy of the I_{DSS} reading will depend upon the quality of the meter used and the accuracy of the meter shunt resistors. The latter can be either wire-wound, metal film or metal-oxide. (8Ω = 8.2Ω in parallel with 330Ω). Care must be taken that the meter resistance is made up to exactly 1000Ω.

$\mathbf{V_P}$. The V_P dial will need to be calibrated in voltage so that V_P can be read directly. The method is as follows;

1. Measure the value of the V_P potentiometer ($R_p = R_7+R_8$) and calculate the voltage to which the supply lines must be set.

$$V_s = \frac{R_p+1000}{101500} \times 15$$

This gives the correct value for the supply voltage for best accuracy. However, if precision measurement is not needed, this calculation can be omitted and the nominal value of 15V used.

2. Set the positive rail voltage to V_s by adjusting R_6.
3. Set the negative rail voltage to V_s by adjusting R_{13}.
4. Set S_1 to 'n channel', S_3 to 'V_p' and monitor the voltage between the gate and source terminals using a high resistance voltmeter. (The position of S_2 is unimportant.) As the maximum source resistance 'seen' by the voltmeter will be 25kΩ, the resistance of the meter used for this calibration should preferably be at least 2.5MΩ. This will reduce the additional inaccuracy to 1%.
5. Rotate the V_P dial to set the voltage read by the meter to each of the required calibration points in turn. e.g. 0.5V, 1V, 1.5V . . . 15V and mark each point.

$\mathbf{g_{mo}}$. The accuracy of this measurement will depend upon three factors, namely: the accuracy with which steps 1, 2 and 3 of the V_P calibration have been carried out, the accuracy of the meter shunt resistors selected by S_{2b} and, last but not least, the accuracy with which the operator has set the V_P potentiometer. The meter shunt resistors can readily be obtained with a ±1% tolerance (13.5Ω = 2×27Ω in parallel). With a practical instrument the overall measurement accuracy will probably be of the order of ±5%.

Operating procedure

The method of operating the instrument is as follows:

1. Switch on the power.
2. Connect the f.e.t. to the tester.
3. Set the function switch (S_3) to I_{DSS}.
4. Set the meter range selector (S_2) to 100mA.
5. Set the polarity selector (S_1) to 'p' or 'n' channel as appropriate.
6. If necessary adjust the meter range selector and read I_{DSS} directly from the meter.
7. Set the function switch to V_P.
8. Adjust the V_P dial so that the meter just reads zero and read V_P directly from the dial.
9. Set the function switch to g_m.
10. If necessary adjust the meter range selector and read g_{m0} directly in mA/V.

Reference

1. IC and Semiconductor Testers. *Electronic Design* 22, October 25, 1970, p. 91 et seq.

Constructional Projects

Most issues of the journal, and particularly those containing constructional articles, soon go out of stock. New readers, and those who may have missed an issue during the past year, may like to know that sets of pages of the following articles are available. They cost 12½p per article. Requests, with remittance, should be sent to the Trade Counter, Dorset House, Stamford Street, London, S.E.1.

February '71
New approach to Class B amplifier design *by Peter Blomley*
Stereo decoder using sampling *by D. E. O'N. Waddington*
March '71
Wien-bridge audio oscillator *by A. J. Ewins*
New approach to class B amplifier design (conclusion) *by Peter Blomley*
May '71
Miles-per-gallon meter *by S. C. Hambly*
F.M. stereo tuner — 2 *by L. Nelson-Jones*
Memory for Karnaugh map display *by Brian Crank*
June '71
200-W Linear amplifier *by G. R. Jessop*

Announcements

The first **Dial-a-Program** cable system in the United States has been ordered from Rediffusion by the Health Sciences Communications Center, Case Western Reserve University, Cleveland, Ohio. Initially 12 of the 36 channels will be put into use when the equipment is delivered in February 1972.

Pye Telecommunications Ltd has been awarded a contract by the Home Office Directorate of Telecommunications, worth over £500,000, for the supply of **radio link** equipment and v.h.f. receivers for the police and fire services.

Thorn Electrical Industries Ltd have purchased Etabl. G.L. Carpentier S.A., of Kuurne, Belgium, manufacturers of **radio and television receivers** marketed under the CARAD brand name.

Redifon Telecommunications Ltd is a new company formed within the Redifon Group. It incorporates the existing Communications and Marine Divisions of Redifon Ltd. The company has received an order worth almost £¼M for the supply of radio communications equipment to nineteen airports in Nigeria.

Prowest Electronics Ltd has been taken over by the recently formed company known as Broadcast Systems Ltd. The majority shareholding in Prowest was previously held by Westward Television and Grampian Television.

Rank Bush Murphy Ltd. have acquired from Hurrell and Johnson Ltd the whole of the capital of **Baron Instruments Ltd,** manufacturers of marine electronic equipment.

Contracts worth approximately £50,000 are being placed by the Post Office with Eddystone Radio for the supply of high stability radio receivers for use with British medium-range **coastal radio** stations.

EMI Electronics has received a contract worth almost £200,000 to re-equip a **Belgian television studio** for colour broadcasting.

Marconi Communications Systems have received an order worth £¾M from **Czechoslovak Television** for outside broadcast units fitted with Marconi's Mark VIII automatic colour camera.

International Marine Radio Company Ltd, of Croydon, Surrey, have been awarded a further contract by Esso International Services Inc. worth £150,000. IMRC are to supply and install a complete range of communication equipment and navigation aids for nine tankers.

Dual Decca **radar installations** for nineteen new tankers (and replacements for five existing tankers) have been ordered by Esso. The value of the order approaches £300,000.

Marconi International Marine Co. Ltd, has received an order to supply main and reserve **communications equipment,** v.h.f. radiotelephone and an automatic direction-finder to each of three new tankers on order in Japan.

Scientific Electro Systems (Essex) Ltd, 113/115 The Broadway, Leigh-on-Sea, Essex, have been appointed **sole U.K. agents** for two companies; Microwave Cavity Laboratories, a division of K.M.S. Industries Inc., of Illinois, U.S.A., and the French company, Audiola.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Television fire hazards

The startling fact cited by "Vector" in his contribution in the August issue "colour sets were 40 times more likely to cause fires than black-and-white models" prompts us to briefly describe work in this field which is being undertaken by sub-committee 12B (safety) of the International Electrotechnical Commission. Publication 65, drafted as long ago as 1952 by this sub-committee and regularly up-dated since, entitled "Safety requirements for mains operated electronic and related equipment for domestic and similar general use", is already wellknown. It covers virtually all the safety aspects of, for example, a domestic television receiver, and is in principle equally as applicable to colour television receivers as to black and white models.

During the meeting of sub-committee 12B held in Brussels in June, 1971, the question of fire hazards was raised at a number of points during the discussion of draft modifications to Publication 65. Fire and shock hazards were considered in relation to printed wiring boards, for example.

The practice of fitting an on/off switch on the secondary side only of the mains transformer was also discussed and the different practices in a number of countries were described. It was remarked that in the British standards this situation had been overcome by prescribing a mains switch which isolates the apparatus from the mains in the off position, but according to the present wording in Publication 65 the condition in which safety capacitors and capacitors between the main poles remain under voltage stress is permitted, and in the opinion of many of the delegates this was unacceptable. It was pointed out however that a very large number of eliminators (of the type which could be used for mains operation of battery receivers) were on the market without a switch. Another view was that the mains plug could be considered as the available isolating device. In some ways this was an improvement on the situation where a single-pole main switch was fitted which remained under voltage stress.

Conscious of the danger in this respect the meeting finally resolved that apparatus having capacitors connected between the mains poles and the chassis or accessible metal parts, and apparatus having a power consumption exceeding 10VA should be provided with a mains switch which disconnects all parts of the apparatus from all poles of the mains, but not necessarily fuses, interference suppression coils and capacitors between the mains poles. Both the German and Netherlands delegations asked for further consideration of the matter.

The committee also identified a fault condition consisting of a short-circuit across insulation consisting of varnish, enamel or textile material, with certain exceptions.

We hope that the foregoing will demonstrate to your readers how the I.E.C. is continuing to look into the basic practical aspects ensuring safety of television receivers.

C. J. STANFORD,
General Secretary
International Electrotechnical Com.,
Geneva.

Electro-optical gearbox

Mr Dinsdale's article in the August issue describes digital speed control work on lines similar to that developed at the National Engineering Laboratory[1] in the period 1951-1961 and later applied to provide a "perfect" electronic gearbox[2] against which the actual performance of mechanical gears could be compared.

In dealing with practical applications we found that the arrangement shown by Mr Dinsdale in his Fig. 1 had the drawback that when M and N were realistically large numbers, the information from the two shafts became available at too infrequent intervals. For this reason we evolved the arrangement shown in Fig. 1 in which we multiply digitally by 'm' and divide by 'n' and thus obtain a test pulse for each pulse from the grating on the tested gear shaft. In a servo application this constant sensitivity of measuring error simplified the design of the control circuits.

Finally, in 1962[2] we set out, as in Fig. 2, a block diagram for a gear hobbing machine without gears, very similar in principle to that in Mr Dinsdale's Fig. 1, in which only one batching counter was needed (as the worm wheel drive was equivalent to a single tooth gear wheel and thus used a batch count of 1).

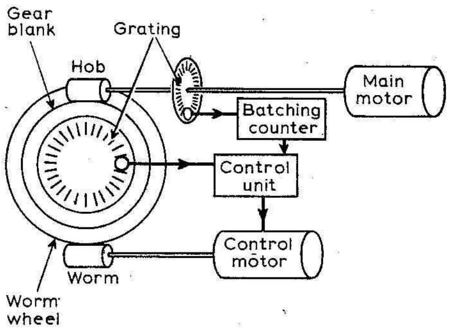


Fig. 2. Gear hobbing machine without a gearbox.

The principal electronic problem in a servo control of the dynamic position of one shaft relative to another lies in dealing with transient conditions. In an arrangement using grating, there may well be an electrical 360° phase error for an angular error of 18 seconds of arc. We found it

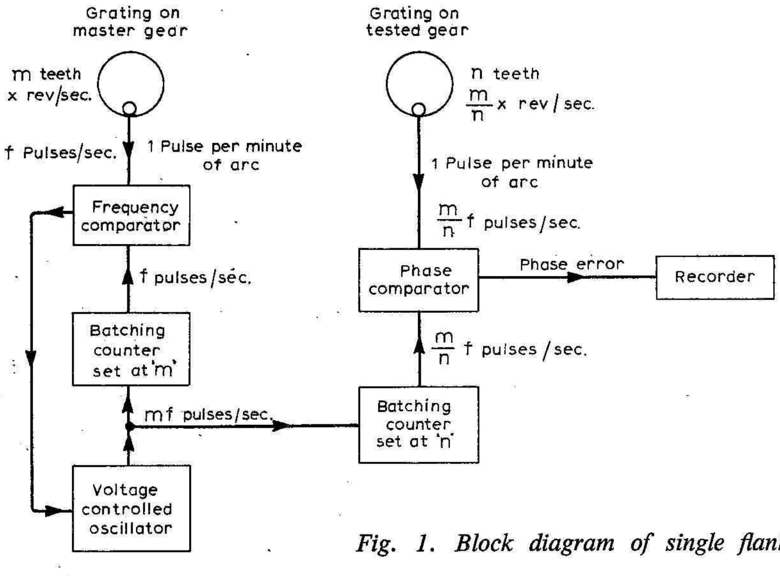


Fig. 1. Block diagram of single flank tester.

useful to have a phase comparator[3] with a range of 3600 degrees, whose output remained at its minimum if the controlled signal continued to lag in phase (if its frequency was slightly less than the reference) and whose output remained at a maximum if it continued to gain in phase.

Mr Dinsdale's article would have been more interesting if it had given details of the more up-to-date circuit techniques he will be using today, to implement ideas pioneered using gas-filled counting tubes and then transistors.

W. H. P. LESLIE,
National Engineering Laboratory,
East Kilbride.

[1] See for example: Leslie, W. H. P., 'Precision control of shaft speed', *Electrical Energy*, September 1956, pp2-5
[2] Leslie, W. H. P., 'Widening the applications of diffraction gratings for measurement and control', Machine Tool Design & Research, Oct. 1962, pp 393-411
[3] Leslie, W. H. P., and Nairn, D., 'A fast counter for adding or subtracting randomly related pulse trains', *Electronic Engineering*, April 1962, pp 227-233

The author replies:
I was interested to read Mr Leslie's comments, as I am very familiar with the work carried out by N.E.L. on this subject.

I agree that the basic principle of operation follows closely the work carried out some 10 to 15 years ago and patented by N.E.L., Cranfield and others, but the system now operating at Cranfield possesses a number of refinements and additional features which were not touched on by this earlier work.

The system in operation at Cranfield is currently being applied to gear grinding, and differs from the application to a gear hobbing machine (Mr Leslie's Fig. 2) in that the worm/wormwheel drive has been eliminated, and the master shaft operates at a speed of about 2000 r.p.m. (significantly faster than would be used for gear hobbing). Results to date show that the degree of control is better than 2 arc seconds, and gears have been ground at Cranfield with a maximum tooth-tooth spacing error of less than 30 micro-inches on a 3-inch diameter gear; this is a considerably higher accuracy than can be produced by a conventional grinding machine using a normal gearbox.

At these higher speeds, certain servo problems are greatly accentuated, and I must admit that the actual system in use is considerably more complex than Fig. 1 of my article suggests. In the interests of commercial security, I was obliged to omit certain important details which are the subject of patent applications.

I am also well aware of the problem of servo control under transient conditions, especially when accelerating from rest to 2000 r.p.m. in a few seconds; in fact the Cranfield phase comparator has a range of 360,000 electrical degrees together with additional circuitry to prevent the system from losing pulses in the presence of violent transients.

I would be pleased to demonstrate the system at Cranfield to interested readers of *Wireless World* (by appointment only), but I must reiterate that commercial security prevents the disclosure of full system details.

J. DINSDALE.

Morse outmoded?

Having read the item under the above heading in "World of Amateur Radio" in the August issue I should like to ask Dr John Irwin (K6SE/5) if he would be so strongly for phone and against c.w. if he had to learn Japanese to get worldwide QSOs. International fellowship and understanding begins with no advantages neither privileges. This is the opinion of the Spanish and Latin American people who will continue to work c.w. as the best way to understand foreign languages . . . or perhaps in the opinion of Dr Irwin we must learn Russian.

Fortunately c.w. will never disappear; on the contrary many countries (Spain included) are newly promoting c.w. through national associations and private clubs. The return to QRP rigs also contributes to c.w. appreciation.

JUAN ALIAGA ARQUÉ,
Barcelona.

F.M. tuner bandwidths

L. Nelson-Jones, in his reply to K. Clayson (July issue) about f.m. tuner bandwidths, exposes a problem which I believe to be the subject of much woolly thinking. If this system were to be examined with a slowly sweeping input frequency, the response curves would indeed be as he indicates, the effective bandwidth being increased by the limiter; but then if only a slowly changing input frequency had to be dealt with a bandwidth equal to the peak-to-peak deviation would in any case be sufficient.

A normal f.m. signal, however, requires a larger bandwidth because it contains many sidebands extending beyond the ± 75 kHz region. So long as the signal passes through a linear system, we are equally entitled to think of it either in simple terms as a single sinewave of varying frequency or as a sum of carrier and sidebands. When it encounters a limiter, however, the sideband picture at once leads us into very deep water. The mind boggles at the prospect of analysing the response of a highly nonlinear system to an input which contains many frequencies, and we are forced back to the simple picture. I believe that the need for more than 150 kHz bandwidth can be explained in terms of this model by considering the phase/frequency response of the i.f. amplifier; which is, of course, closely related to the amplitude/frequency response. It then appears that the limiter will be of no value in correcting for an inadequate amplifier bandwidth.

Anyone who wishes to apply a rigorous mathematical analysis is welcome to do so, but perhaps it would be better for someone with the right facilities to test the matter experimentally. Before starting, though, we should question anew just what bandwidth an f.m. system does require, and what effects an inadequate bandwidth is likely to produce, particularly with a stereo signal.

RICHARD G. MELLISH,
Heriot-Watt University,
Currie,
Midlothian.

TV sound quality

I read with interest your editorial in the October issue and the letter from R. Sear regarding the poor quality of television receivers and the problems of persuading either manufacturer or retailer to provide extension speaker facilities.

I rent a colour receiver (incoporating the BRC series 3000 chassis) from Radio Rentals, Ruislip, Middlesex. I discussed the problem with this branch of providing an isolated feed of sound and was amazed to find that an official modification exists which brings out a parallel feed from the speaker socket together with an on/off switch for muting the internal speaker in the receiver. I was even more surprised to find that this modification is carried out for less than £3.

J. G. SYMONS,
Uxbridge,
Middx.

Ceramic pickup equalization

I am surprised that Mr. Walton ('Letters', August issue) suggested that I quoted him out of context; since both his books and my article referred to ceramic pickup equalization with low resistance loads the remarks were very much in context.

Referring again to the quotation in question "Now because of the (capacitative) nature of crystal and ceramic pickups it is only necessary to connect them into a sufficiently low electrical resistance for their inbuilt correction for recording characteristics to be almost nullified". This statement is not true in the context of Mr. Walton's book, neither is it true as a bald statement as quoted. A low resistance load (e.g. 20 kΩ as suggested by Mr. Walton in his book) does give so-called 'velocity loading', but it has no effect on the inbuilt correction for recording frequency characteristic. That is why the quotation was included in the examples of myths, since it inferred an effect in pickup performance which simply does not occur.

B. J. C. BURROWS,
Ewelme,
Oxford.

London Audio Fair

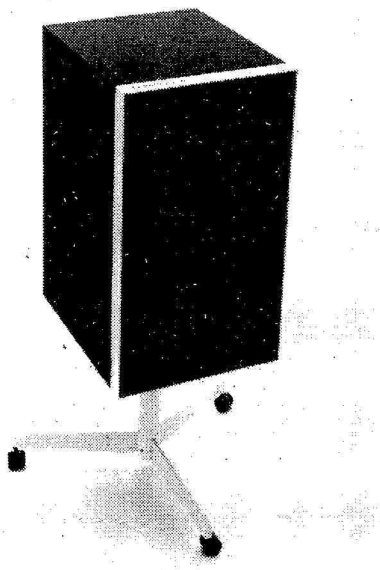
Review of a show attended by more than 70,000

In reporting on last year's Audio Fair we diagnosed an increasing interest in (and awareness of) the standards of good fidelity amongst visitors to the exhibition. A recent publication, *Audio in Transition**, predicts that the present boom will soon pass away leaving a steady growth rate of 20% per annum for the better quality products. (Does this really mean that the horrid systems associated with some 'household names' will vanish? One can only hope so!)

It is regrettable therefore that so many of the British manufacturers of well engineered audio equipment opted out of the Olympia show — although it must be noted that a few held satellite exhibitions in hotels off Kensington High Street — and it is a disappointment whatever the reason for non-attendance. One thing is for certain — it is possible to put on a first rate demonstration if the room is big enough. This was proved by Bang & Olufsen who made the most of the stand construction facilities offered, and created a highly civilized sound proof apartment conducive to relaxed listening. Of course there is a sound level limit for any size of room made of flexible panels, and our conclusion is that proper assessment of equipment is possible under Audio Fair conditions only if the sound level is tailored to room size. (Some loudspeaker demonstrations actually took place in square rooms!)

Once again *Wireless World* sponsored a lecture demonstration on each day. Tristram Cary fascinated many visitors with an audio visual demonstration of basic waveshapes, and showed how voltage controlled oscillators are used in modern synthesizers. Ralph West had assembled an enormous array of historical equipment all of which he miraculously got to work, spicing his discussion of the landmarks in audio with some very amusing asides. Arthur Bailey's discourse on loudspeakers included a demonstration of the new Ferrograph enclosure and the effect of cross-over component value tolerance on colouration. John Linsley Hood used AR3a speakers, a high-quality 70W per channel class B amplifier and a flashing-light meter to show how little signal power is required for average symphonic

*Finnresearch Ltd, 30 Baker Street, London W.1. Price £18.



New-style bass reflex enclosure from Ferrograph.

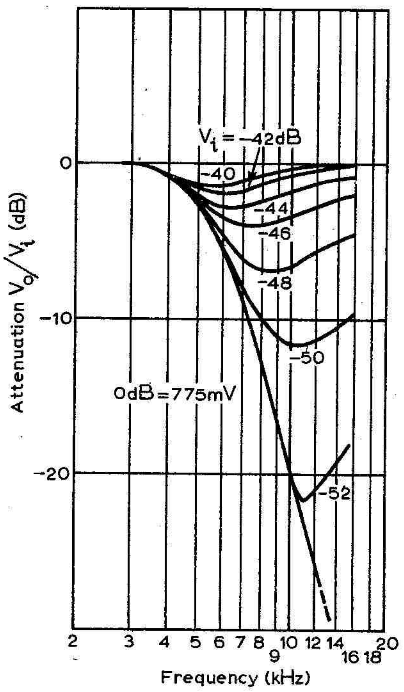


Fig. 1. Typical curves showing effect of playback-only dynamic noise reducing circuit. As input signal falls in level, circuit progressively attenuates tones above about 4kHz.

material and how much is required for piano reproduction. The final lecture demonstration was on horn loudspeakers, for which 'Toneburst' brought a pair of wooden horns based on the concrete design published in *Wireless World* in May 1970. Besides the clarity and frequency range of the system the solid stereo image attracted comment — the speakers were, of necessity, twenty six feet apart.

Noise reduction in cassette machines

To the list of current noise reduction techniques for cassette machines that we have mentioned recently – Dolby B, and systems used by JVC, National, Sanyo, Philips – we must add the Trio/Kenwood 'denoiser' (KF-6011). This is another playback-only system that attenuates high-frequency low-level signals depending on the signal level.

Just before the exhibition, Philips gave a demonstration of their dynamic noise limiter. They also demonstrated their DIN-standard cassette machine, N2510, which will be marketed at the end of 1972. Philips plan to market chromium dioxide tapes then, and their cassettes will have two extra holes so that when a cassette using the new tape is inserted, it automatically changes the bias and alters the equalization time constants from 120 and 3,180 to 70 and 3,180μs.

Returning to noise limiters, Philips admit theirs is not going to make cassette reproduction into 'hi-fi' reproduction. Given this qualification, it will be a welcome innovation for most cassette users, even though material containing low-level passages at high frequencies will be attenuated, the amount depending on level – see Fig.2. (When the h.f. or complete signal is zero there is full noise reduction of 10dB at 6kHz and 20dB at 10kHz.) The argument in all this is that musical instruments when played softly do not have a high harmonic content, and that they mostly have fundamentals below 4.5kHz – the frequency at which the noise circuit starts to take effect. (A point that Philips make is that the Dolby B system is not fully mono/stereo compatible – a stereo cassette processed using the Dolby B processor, is not truly mono

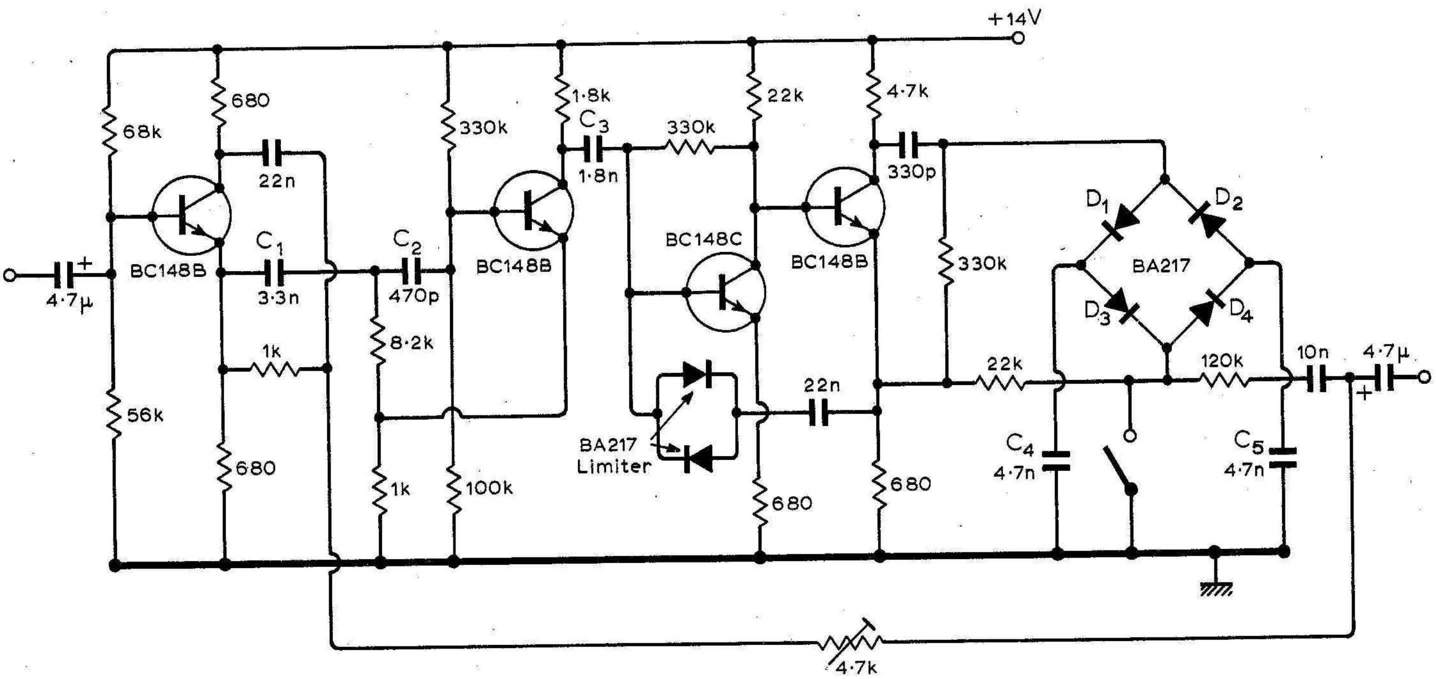


Fig. 2. Complete circuit of Philips dynamic noise reducer. Capacitors C_1, C_2 and C_3 form part of the high-pass filter. Diodes D_1 and D_2 and capacitors C_4 and C_5 form a peak detector providing a control potential to attenuator diodes D_3 and D_4.

compatible because the two channels normally require different processing.) An add-on unit is expected to be available in March or April 1972, costing £12-13. The existing cassette machine N2503 will be produced with the noise limiter, to be called N2506 and costing £4 or £5 extra. Philips are offering their circuit – shown in Fig.3 and in simplified form in Fig.4 – on a royalty-fee basis to manufacturers using the cassette system.

Four-channel systems

The newest thing to the exhibition this year was the 'surround sound' and quadraphonic equipment. It was however clear that many people are confused by the current four-channel situation. And if there's confusion among visitors (nay, even distributors of equipment) what about the public at large? The confusion is not so much about discrete vs matrixed methods, but between what are misleadingly being called 'matrix' and 'phase-shift' methods of decoding and synthesis, and also about exactly how this is done. In the CBS method* for instance it happens that the locus of the stylus in the 'coded' disc groove can assume a helical path under certain conditions – i.e. one rear channel signal only – and this seems to have thrown some people off balance! The puzzled newcomer to four-channel coding systems is best advised to forget what's happening in the disc groove. The point is that the four channels of information can be matrixed into two – with or without phase shifting circuitry – and conveyed by any two-channel medium, cassettes included (one U.S.A. company is already producing coded cassettes) where there is no equivalent to the stylus motion. So if you find circular, elliptical or helical modulations confusing, forget it – it is merely a consequence of the phase relationships between the two channels.

As regards the confusion between 'matrix' and 'phase-shift' systems, methods that combine more than two signals into two channels without multiplexing or increasing bandwidth are matrix systems. The CBS and Sansui methods use 90° phase shift circuits *in addition* to matrixing (more details next issue).

Currently there are many equipments, especially from Japanese makers, which use matrices to reproduce in four-loudspeaker format either coded or conventional two-channel discs (latest on the scene is Zenith in the USA). The trouble, of course, is the lack of a standard at present and not all systems are compatible with one another. For instance a CBS-coded disc played through a Sansui decoder produces a left front signal in the left back speaker! What is needed seems to be a universal decoder designed to reproduce *any* coded information, which, provided the coding system was known e.g. Sansui or CBS (or others for that matter, but at the moment it looks to us as though one or both of these or a new derivative will win), could be switched to the appropriate decoding matrix. We have just heard that Electro-Voice have produced an integrated circuit for decoding which claims to be suitable for all existing matrices, but we do not have details yet.

Of those equipments intended to provide four-speaker sound from conventional two-channel sources (2-2-4 systems), first to be made in the U.K. is the Pye Stereo +2 adapter which puts difference signals in the rear speakers. (The two rear signals are usually in antiphase

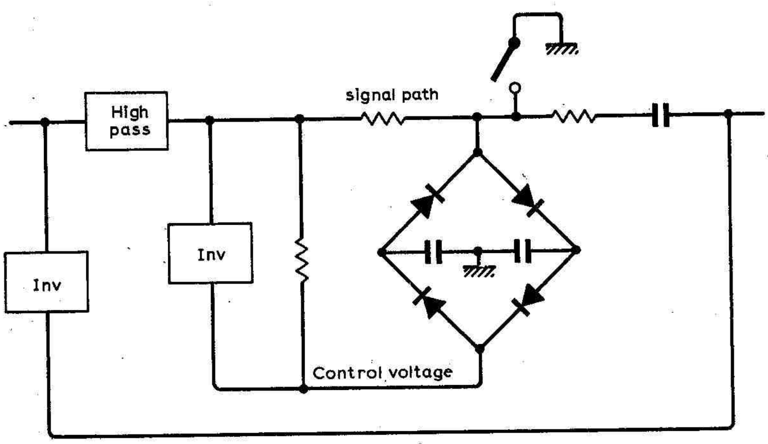
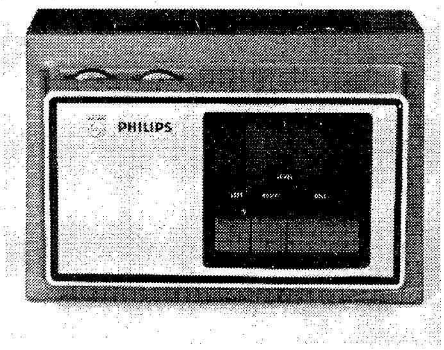


Fig. 3. Simplified diagram of dynamic noise limiter. High-frequency signals from the filter in the auxiliary signal path (top of diagram) partially cancel the h.f. content of the inverted main signal path (bottom) by an amount depending on the h.f. signal level (control voltage).

*'Quadraphony and home video steal the Berlin show' *Wireless World* October 1971 pp.486-8. This article gives a detailed description of the CBS/SQ matrix system and also discusses some other four-channel systems, including the JVC subcarrier system.

in this kind of set up, which has been found to be subjectively more satisfactory than in-phase signals. In-phase signals would produce an undesirable well-defined centre back image.) There were seven other makes of such 'surround-sound' equipment shown, some of which introduce cross talk between the two front speakers and some of which put $L-\delta R$ and $R-\delta L$ in the rear speakers, and known under various names like Quadralizer (Pioneer range), Quadrixer (Kenwood KA-8044), Quadrizer (Sanyo DCA1700X), Sound Field Composer (JVC 5444 and MCA-V7E) and Surround Composer (Onkyo 1631). National and Skandia also showed equipment with a 2-2-4 system, while Sony – who are making equipment for the CBS system – also have their rear-channel-delay system (TA2244). Some of these systems can be used with certain coded discs.

As well as having the matrixed kind of four-speaker distribution (like $L+\delta R$, $R+\delta L$, $L-\delta R$, $R-\delta L$) Pioneer equipment also has a facility for feeding the raw difference signal to the rear loudspeakers with – unlike other systems – a 90° phase difference between them. This has the effect of spreading the image between the two sources. We imagine this might use a simple phase shifter that gives a frequency-dependent phase shift, and if this is so a central image would occur at some frequencies. The JVC models have frequency-dependent rear speaker signals, in that substantially below 300Hz signals are in phase and above are out-of-phase. (Possibly at around 300Hz there is a 90° phase difference here too).



Philips add-on dynamic noise limiter – circuit is shown in Fig. 2.

Loudspeakers

Intended for high quality domestic and professional programme monitoring the Acoustic Research AR LST employs nine drive units — four mid-range and treble units and the same bass unit used in the AR3a. There is a control providing several alternative frequency response characteristics (through an auto transformer) including a 'flat energy position'. The price is about £300.

Arthur Radford has improved his Studio 270 loudspeaker by degrees – it is now truly omnidirectorial having drivers on all four sides. The units are made by Goodmans. Radiation is through 360° horizontally and 90° vertically from 30Hz to 30kHz. Impedance is 8Ω and power handling capacity 100W. Price £147.50.

JBL demonstrated several new speakers. Their stand was very well worth visiting for their closed demonstration of how monitoring speakers are used in recording studios. The new speakers demonstrated were the L200 Studio 2 (based on monitor model 4320), an efficient bookshelf model the L100 Century, a modernistic looking L45 Flair, and the L55 Lancer.

Besides the two new conventional loudspeaker enclosures — the Havant and the Double Maxim — Goodmans have developed a bi-directional enclosure, the Dimension 8. This is a mass-loaded reflex system using a 12in bass radiator cone driven by four 5in bass drivers. The 12in unit comes into operation at 80 Hz. The four small bass drivers cross over at 700 Hz to two mid-range units which cross over at 4kHz to two dome tweeters. A pair of these enclosures, when set up for stereo as intended by the makers is claimed to produce an increased stereo image area because, we are told, 'the precedent effect (time of arrival of the sound at your ears) tends to be offset by the sound level differences when sitting nearer the axis of the more distant loudspeaker'. The trouble is that above 1kHz intensity is dominant in establishing stereo images and much of this intensity information is lost by the off-axis position. The Dimension 8 demonstration revealed a deficiency of transient information. This could no doubt be cured by abandoning the 'super stereo speaker angle'.

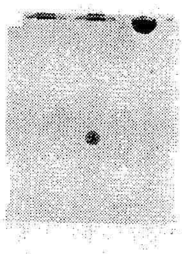
The Ferrograph speaker designed by Arthur Bailey and demonstrated in his *W.W.* lecture is a 2.6 cu ft enclosure with a frequency range of 45Hz to 15kHz ± 3dB. The mid-range and treble units are both made by Goodmans and are exceptionally smooth performers. A section of the crossover notches out the fundamental cone resonance of the tweeter and there are, it is claimed, no remaining resonances in the system. The bass unit is a K.E.F. B139. A long wide wool-filled port pipe is used to achieve low system resonance, the wool fibres contributing to the port mass.

Two new headphone sets are worth mentioning. The AKG K180 is a high quality headset with a 'seat selector' control on each phone which varies the volume between the transducer and the ear. The price is about £30. From Koss the K-711 introduced at Sonex '71 have appeared in a red plastic version named the 'Red Devil'. The transducer system is obviously of very high quality and at £10 a pair is excellent value for money.

Equipment notes

Miniature tape cartridges

A new miniature four-track cartridge has been developed by Pioneer and is backed by a consortium of ten companies, which includes Toshiba, Sharp and Hitachi. Known as Hipac, it is a quarter of the size of conventional eight-track cartridges, measuring only $2\frac{3}{4} \times 3\frac{3}{8} \times \frac{1}{2}$in. Operating on the continuous-loop principle it requires a simpler mechanism than cassettes. The $\frac{1}{8}$in tape can be played at $3\frac{3}{4}$in/sec if required as well as $1\frac{7}{8}$in/sec. An adapter allows the miniature cartridge to fit existing cartridge players and a tuner unit is available which slots into the tape player. Cartridges and equipment are in production in Japan, but availability in the U.K. depends on whether record companies adopt the system. Autocar Electrical Equipment Co. Ltd, 1 Lyon Close, Chantry Road, Kempston, Bedford.

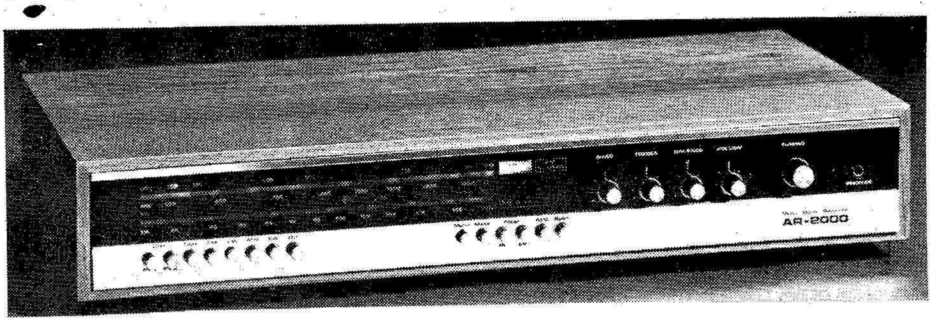


Single-play turntable

A single-disc version of the Zero-100 turntable unit is introduced by Garrard. It includes the tangential-tracking pickup of the automatic version (p.237 May issue). Wow and flutter figure is 0.14% peak and rumble is 51dB down relative to 1.4cm/sec at 100 Hz. Garrard Engineering Ltd, Newcastle Street, Swindon, Wilts.

Tuner-amplifier

New Heathkit tuner-amplifier model AR-2000 is U.K.-designed specially for the British and European markets. Featuring long-, medium- and short-wave bands as well as the v.h.f. band, it gives an output of 20 watts (continuous r.m.s.) per channel. The f.m. tuner features f.e.ts



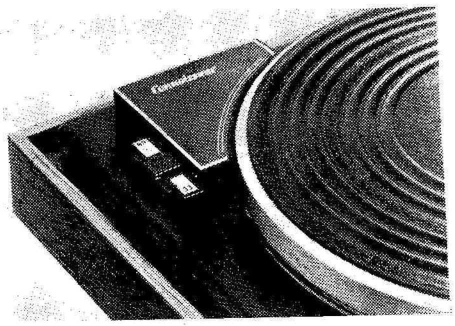
in the r.f. section and new integrated circuits and ceramic filters in the i.f. amplifier. The stereo decoder uses a single i.c. Kit price is about £90 plus £7 for a teak cabinet. Heath (Gloucester) Ltd, Bristol Road, Gloucester GL2 6EE.

Quadraphonic receiver/amplifier

The QR-4500 is one of a new range of Sansui equipment incorporating the QS matrix. The matrix circuit used, unique to Sansui, has 90° phase shifters to give good quadraphonic performance from Sansui-coded discs and avoids cancellation problems as a result of using phase inverters in certain other matrices. This can also be used as a 2-2-4 system of course for four-speaker reproduction from ordinary stereo sources. Also available are the QS-100 and QS-500 amplifiers, the now well-known QS1 synthesizer and a QS6500 receiver, all equipped with the same matrixing system. Vernitron Ltd, Thornhill, Southampton SO9 5QF.

Press-button speed change for belt-driven turntable

Connoisseur BD2 turntable is now available with press-button speed change. The 33 and 45 rev/min buttons move the belt mechanically onto the appropriate



pulley diameter. Specifications of this latest turntable unit are identical with the original unit, e.g. rumble level is given as −60dB measured with the R.I.A.A. characteristic and referred to 7cm/sec recorded velocity (−43dB re 1cm/sec) and wow and flutter is quoted as 0.1%, presumably "r.m.s.". Suggested price with pickup arm is £32 without plinth and £40 with. A. R. Sugden & Co., Market Street, Brighouse, Yorkshire, HD6 1DX.

Leak amplifiers and tuners

Based on the well-known Leak Stereofetic design, the Delta 75 a.m./f.m. receiver has a sensitivity that permits Continental v.h.f. stations to be received with good quality (2.5μV for 30dB s/n), with harmonic distortion of 0.5% at full deviation. Image rejection is −72dB and capture ratio 3.5dB. Suppression of 19 and 38kHz signals is at least 40dB. Amplifier gives 35 watts into an eight-ohm load with 0.07% harmonic distortion at 1kHz and all power levels. The a.m./f.m. tuner and amplifier are available separately, and a lower-power amplifier giving 15 watts into an eight-ohm load is available. H. J. Leak & Co. Ltd, Bradford Road, Idle, Bradford, BD10 8SQ.

Quadraphonic cartridge player and receiver

The "Stereo Center" by Skandia (model SK-804) includes a cartridge player for four- or two-channel cartridges and a matrix for "surround sound" from two-channel sources. The tape player accepts either two-channel or four-channel cartridges at $3\frac{3}{4}$ in/sec and has a fast forward speed of $7\frac{1}{2}$ in/sec. In the two-speaker mode power is 20+20 watts (continuous r.m.s.) and 12 watts × 4 in the four-speaker mode. Wow and flutter is 0.42% peak. The a.m./f.m. receiver has good sensitivity and a crosstalk of −26dB at 1kHz. U.K. agents: Golding Audio, London Road, Marks Tey, Colchester, Essex.

Low-power audio combination

As well as catering for high-power levels in the Deccasound range, Decca cater for the low-power end of the market in the new 403 system. It includes 3+3 watt (r.m.s.) amplifier, BSR autochanger, and two small loudspeaker enclosures using 5-in dual-cone drivers. Price is about £60. Decca Radio & Television, 9 Albert Embankment, London SE1 7SW.

High-quality cassette recorder

The Uher Compact Report Stereo 124 is fitted with a new four-track head and double capstans to allow automatic

reversing. Low-level amplitude response extends to 12.5kHz (3dB down). Signal-to-noise ratio is quoted as 48dB DIN weighting and 58dB A-curve. Wow and flutter amounts to 0.17% peak. The recorder includes a built-in capacitor microphone with a polarizing potential of only 5V. Power supply can be lead-acid battery, nickel-cadmium battery or from the mains. Price is £182. U.K. agents: Bosch Ltd, P.O. Box 166, Rhodes Way, Watford WD2 4LB, Herts.

Cassette recorder with crystalline ferrite head

A cassette tape machine using a crystalline ferrite GX head, as used on Akai open-reel recorders, is Akai model GXC-40D. It is claimed that head life is up to 100 times that of ordinary heads. The set is equipped with a switch for chromium dioxide tapes which alters bias and the equalization characteristic. As well, there is an "over-level suppressor" switch to prevent overloading on high-level passages — useful if you *know* over modulation is going to occur. Wow and flutter is less than 0.3% peak and a tolerance of ±2% is quoted for tape speed. Distortion is 2% at 0 V.U. (1kHz) and s/n ratio 48dB. Price: £87.50 deck version. U.K. agents: Rank Audio Visual, P.O. Box 70 Great West Road, Brentford, Middx.

In brief

- Both Ferrograph and Revox demonstrated versions of their tape recorders incorporating the Dolby B noise reduction system.
- Goodmans revealed a professional tape recorder, the R73, which employs twin capstans and has switchable NAB or DIN 45:513 equalization. There are two speeds — 15 and $7\frac{1}{2}$ in/sec. or $7\frac{1}{2}$ and $3\frac{3}{4}$ in/sec.
- The Beocord 1200 tape deck from Bang and Olufsen is a two-speed four-track unit with slider mixing controls. Frequency response is to DIN 45:500 for $7\frac{1}{2}$ and $3\frac{3}{4}$ i.p.s. Distortion is <5% from a fully modulated tape. Signal-to-noise ratio is high, and erase capability is >70dB. Recommended tape is BASF LP 35LH. Model 1600 has a built-in stereo amplifier delivering 10W r.m.s. per channel, but is otherwise the same as the 1200.
- Goldring revealed two new turntable units — the GL85 and G101. The GL85 is a belt driven turntable with pick-up arm. Fine speed adjustment is electronically controlled. At the end of the record, current is switched off and the arm raised from the record surface. The G101 is a compact turntable/pick-up arm unit, also belt driven, and having an adjustable antiskating device.

The Trinitron Colour TV Tube

Comparison with the three-gun shadow-mask tube

*by Senri Miyaoka**

The Sony Corporation released a new colour picture tube called the Trinitron in April, 1968, and sold the first 13-inch colour television set using this tube at the end of the year. Its excellent colour picture quality, in brightness, resolution and contrast, became the focus of the world's attention, and already more than one and a half million television sets incorporating this tube have been manufactured and sold in two and half years in Japan, U.S.A., Canada, U.K. and France. In this article, the basic electron optical principle, the mechanical structure and other features of the Trinitron are described in comparison with the three-gun shadow-mask tube which was developed by RCA and is now widely used as the conventional display device for colour receivers.

* Sony Corporation, Japan.

Electron gun and electron optics

In a colour picture tube the electron gun is necessary to form the electron beam spot, and consists of cathodes which emit three electron beams, corresponding to the red, green and blue primary colours, and electron lenses which make these three beams focus on the phosphor screen; convergence devices being added to

Senri Miyaoka, who is 34, was born in Buenos Aires and studied physics at the Gakushuin University, Tokyo, Japan, obtaining his B.Sc. in 1959. He joined Sony in 1959 and developed high-frequency power silicon transistors for television receivers until the end of 1961. In 1962 he started research into various types of colour picture tube and electron guns. Co-inventor of the Trinitron, he is now assistant manager of television development. He has published several papers in the field of colour television and has many patents in Japan and foreign countries. In 1969 he received the best paper award from the Broadcast and Television Receivers group of the I.E.E.E.

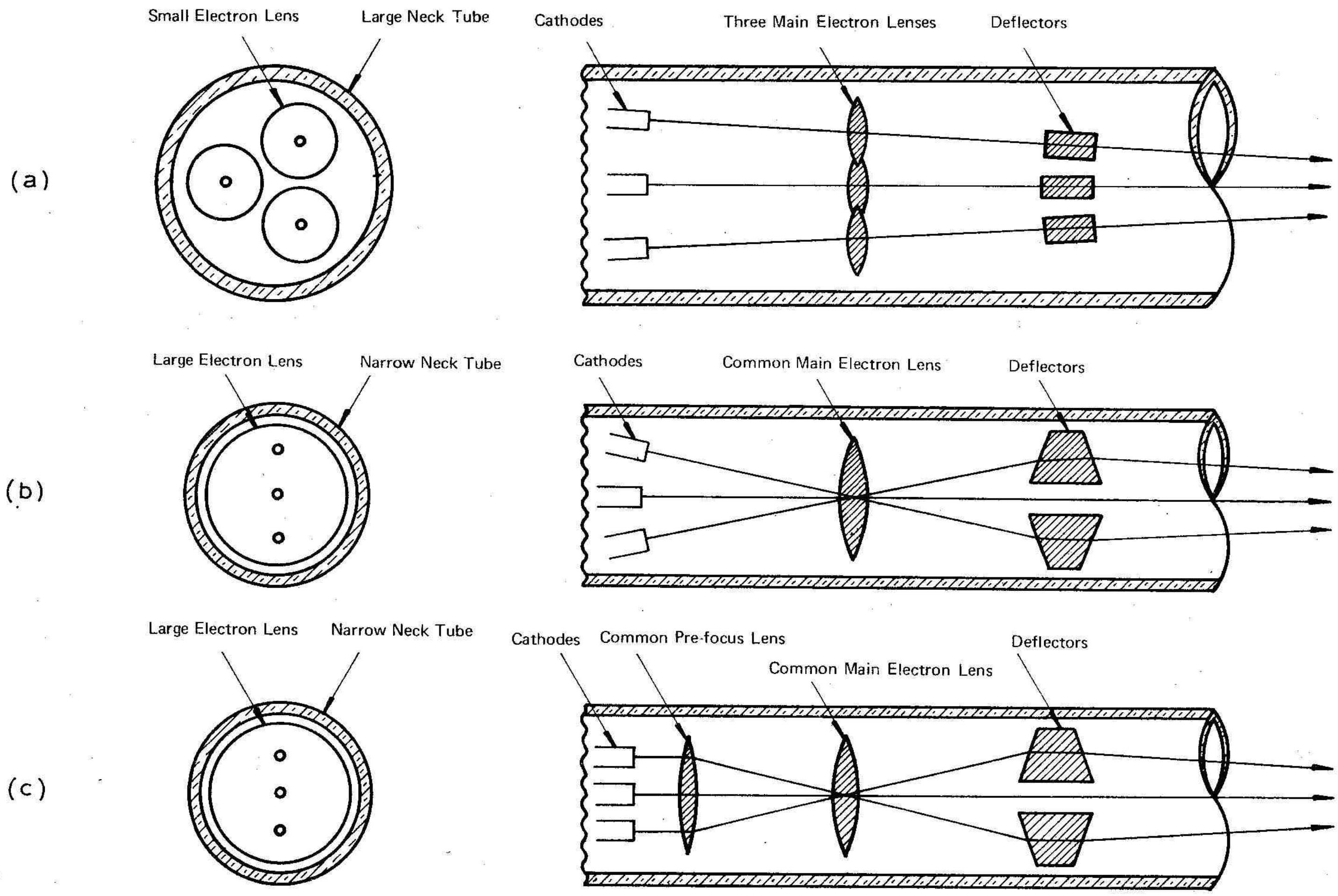


Fig. 1. Structures of electron guns of tri-colour cathode-ray tubes, shown in equivalent optical form: (a) the conventional three-gun system; (b) basic principle of Trinitron gun; (c) modified Trinitron system used in smaller tubes (10-inch and 13-inch).

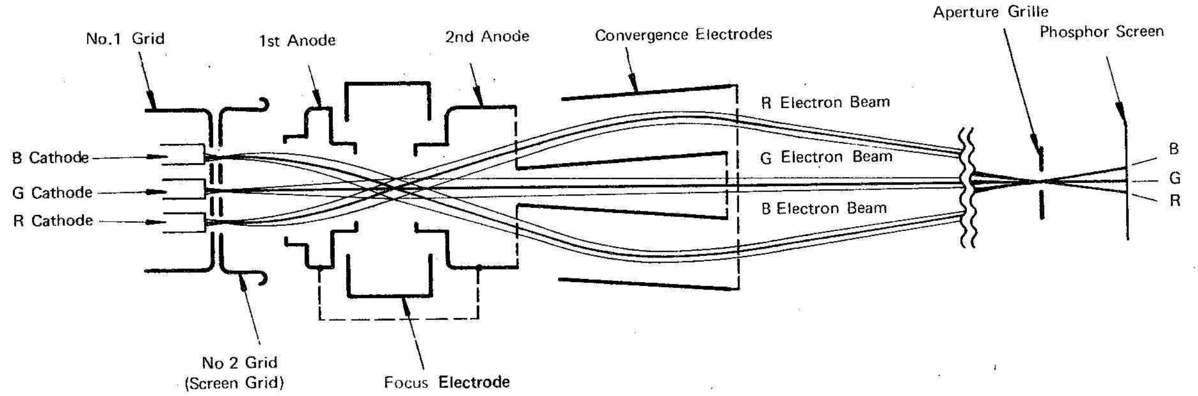


Fig. 2. Schematic cross-section of Trinitron electron gun and its beam trajectories for a 13-inch tube.

converge the focused beams onto the required points on the screen.

As its name indicates, the three-gun system consists of three independent guns which have the above functions respectively. Its electron optical system is shown in Fig. 1(a).

In the Trinitron tube, all of these functions are achieved by a single gun, which can emit three beams simultaneously. Some efforts have been made in the past by other workers to achieve these functions with a single gun, but no attempt was known to be successful in making the single-gun, three-beam system give better resolution because of the difficulty in focusing the electron beams which pass through the edge portion of the electron lens.

In the electron optical system of the Trinitron, all three beams pass through the centre portion of the main electron lens. In other words, they all occupy the same position in the lens.

The basic principle of the electron optical system is shown in Fig. 1(b). In this system, three electron beams are emitted from three cathodes in such a way that they cross one another at the centre of the main electron lens. The outside beams, diverging from the crossing point, are deflected back by a pair of electron optical 'prisms' (deflectors) so that the three beams finally converge on the phosphor screen.

If an electron lens is used for this converging process, the outside beams are not only distorted by aberration resulting from astigmatism but also cannot be focused on the phosphor screen because they pass through the edge portion of this lens, which makes the image of the beam bundle of rather large cross section at the cross point where it falls on the fluorescent screen. However, the three electron beams in the Trinitron tube's electron optical system are focused sharply, since the centre of a large-aperture main electron lens serves in common to focus the three electron beams.

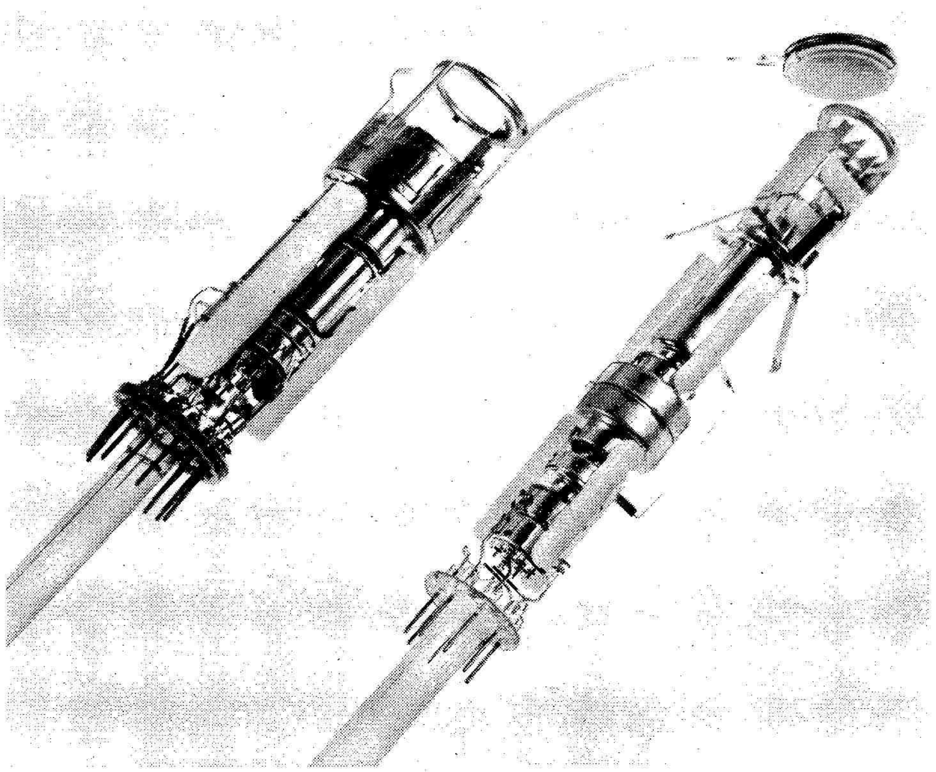


Fig. 3. Trinitron electron gun for 13-inch tube (right) compared with a conventional three-gun assembly (left).

The electron optical system shown in Fig. 1 (b) is utilized in 18-inch and 16-inch Trinitron tubes to give a large beam spacing at the convergence plane with a short length of gun. However, in a small sized colour picture tube in which the beam spacing is relatively small, the electron optical system can be modified, as shown in Fig. 1 (c), in order to simplify the cathode arrangement in the gun structure. In this system, which is utilized for 10-inch and 13-inch Trinitrons, the three cathode surfaces are in the same plane. The two outside electron beams, emitted from the same plane and in parallel with the centre beam, are both deflected towards the centre beam by a weak electron lens, called a pre-focus lens, positioned just in front of the cathodes, and the three beams are made to cross each other at the centre of the adjacent main electron lens. Although the outside beams pass through the edge portion of the common pre-focus lens as mentioned, it has only a negligible effect in introducing aberration. In general, the aberration increases in proportion to lens strength and the spot distortion due to aberration depends on the cross section of the beam bundle at the lens position. However, this pre-focus lens is a very weak one, the deflection angle produced by it is very small, and the electron beam bundles are still very narrow when they pass through it. Therefore, the outside beam spot deformation due to the aberration is negligibly small.

A cross section of the electron gun for the 13-inch tube and its beam trajectories are shown schematically in Fig. 2. The pre-focus lens is formed between No. 2 grid (screen grid) and the 1st anode, and the main electron lens is formed between the 1st anode and 2nd anode. The outside beams diverging from the centre of the main electron lens are deflected by two sets of electrostatic deflector electrodes in front of the 2nd anode so that the three beam spots on the phosphor screen can be converged to one point. Fig. 3 is a photograph of the Trinitron gun for a 13-inch tube, with a conventional delta three-gun assembly for a shadow-mask tube.

Table 1 is a comparison of the electron gun system of the Trinitron and the delta-type three-gun assembly for a 13-inch colour picture tube. This table indicates that:

1. The Trinitron gun needs fewer parts than the three-gun assembly, so that its structure is simplified and its production cost can be reduced.
2. The small neck diameter of the Trinitron colour picture tube makes possible a reduction in the beam scanning power required, and allows the deflection yoke assembly to be small and light-weight. Consequently it makes transistorization easier and also helps to reduce the size and weight of the colour television set.

Table 1.
Comparison of electron gun structures of Trinitron and three-gun tubes

	Trinitron	Three-gun tube
Type of electron gun	Uni-potential	Bi-potential
Number of guns	1	3
Cathodes	3	3
No. 1 grids	1	3
No.2 (screen) grids	1	3
Main focus lenses	1	3
Deflectors for convergence	2	3
Neck diameter	28.6mm	36.5mm
Effective electron lens diameter	17mm	9.0mm

3. Despite the small neck diameter, the effective electron lens diameter of the Trinitron is almost twice that of the three-gun system, because of the single gun. This large opening of the electron lens permits sharper focusing of the electron beams.

Fig. 4 shows a deflection yoke for the Trinitron tube compared with a deflection yoke for a conventional shadow-mask tube.

The Trinitron electron gun is a uni-potential type, using a low focus voltage of 0—300 volts, and this makes the associated circuits very simple compared with those of the three-gun system which requires 3500 — 4500 volts for focusing.

In the conventional three-gun tube, to make the best possible use of a given neck diameter the three guns are positioned in delta formation so as to permit the largest possible lens aperture. However, the adjustment of the electron beam direction in the delta-type three-gun tube is complicated because the beams emitted from the electron guns do not originate in a common plane. A certain amount of effort was made to simplify the convergence adjustment by arranging the three electron guns in line. In this case, however, the effective diameter of the guns was about 30% smaller than that of the guns in the conventional delta formation.

The diameter of the Trinitron gun is not affected by any beam arrangement, so the in-line beam arrangement has been chosen to simplify convergence correction. As a result the diameter of the electron lens can be made effectively 2.6 times that of an in-line three-gun formation.

The variation of beam spot size on the phosphor screen with beam current is shown in Fig. 5. This graph compares a conventional delta three-gun shadow-mask tube (13-inch, 90° deflection angle, 36mm neck diameter) with a Trinitron tube (13-inch, 90° deflection angle, 28.6mm neck diameter). The figure shows that in the Trinitron tube, a smaller spot is obtained from the centre beam than from the outside beams. It is well known that the resolution of a tri-colour picture tube is mainly determined by the resolution of the green spots. Hence the tube is designed in such a way that the centre beam impinges on the green phosphor, and the blue and red phosphors are excited by the respective outside beams to attain the highest possible resolution colour pictures.

If the beam current of a Trinitron is compared with that of a conventional delta three-gun tube for a given spot size, it will be found that the Trinitron gun can focus more beam current into that spot area. The outside beam current can be 1.5 times, and the centre beam current twice, the beam current of the delta three-gun tube for a given spot size. This means that colour pictures more than 1.5 times brighter and sharper can be obtained with the tube using the Trinitron gun.

Colour defining system

The new electron gun is combined with a new colour defining system, called an "aperture grille", to achieve an even greater improvement in the performance of the colour picture tube. This aperture grille consists of a large number of vertical slits, formed by chemical etching of a metal sheet, whereas the shadow mask has a large number of holes evenly spread and aligned vertically and horizontally. Correspondingly the fluorescent screen of the Trinitron consists of a large number of vertical phosphor stripes, red green and blue, instead of the R, G, B phosphor dot triads of the shadow-mask tube. Fig. 6 is a photograph of the aperture grille compared with a shadow mask. The

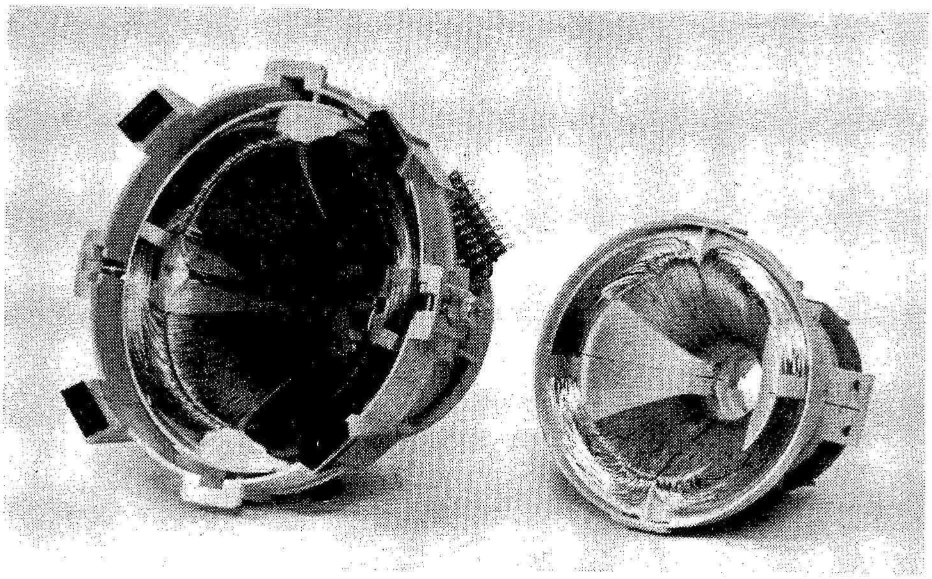


Fig. 4. Deflection coil yoke for Trinitron tube (right) compared with deflection yoke for a conventional shadow-mask tube (left).

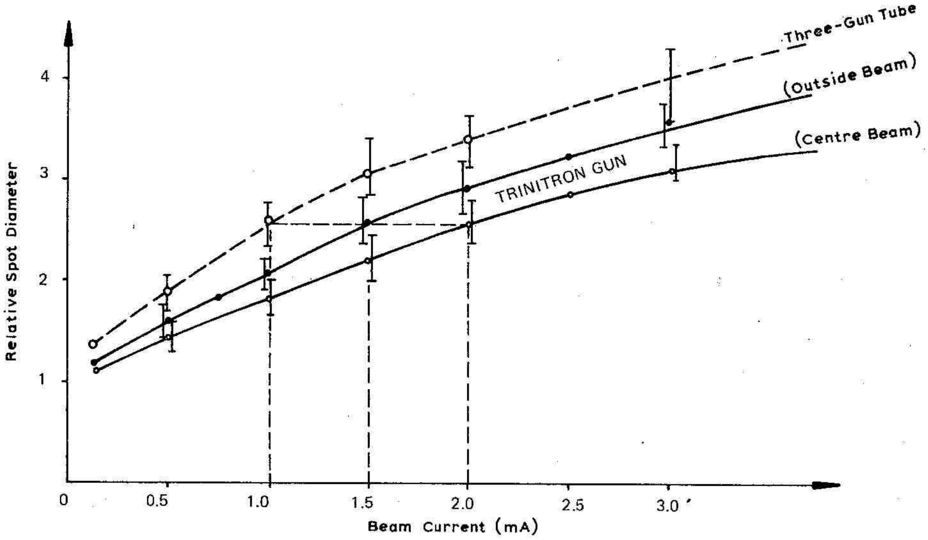


Fig. 5. Variation of spot size with beam current for Trinitron tube and conventional three-gun tube.

electron beam transparency of the aperture grille is more than 20% in the central area and about 15% in the corner areas. On the other hand, the beam transparency of the shadow mask is about 15% at the centre and 11% in the corners. Therefore at a given beam current, 20/15 = 1.33 times the beam current can reach the phosphor screen of the Trinitron tube, relative to the shadow-mask tube, thus giving 1.33 times the colour picture brightness. Because a 1.5 times brighter picture can be obtained with the Trinitron gun, as mentioned above, the combination of this gun with the aperture grille gives approximately twice (1.5 × 1.33) the brightness of the conventional shadow-mask picture tube.

Since there is no factor that can possibly limit the vertical detail of the images on the tube screen with the vertically slitted aperture grille, vertical resolution is determined only by the number of the scanning lines; while in the case of the shadow mask, vertical resolution is affected by the relationship between the number of the scanning lines and the spacing of the vertically aligned holes. In fact the Trinitron tube, compared with the shadow-mask tube, can display a smoother colour picture with relatively higher resolution in this respect.

Another advantage of the aperture grille is that it is less sensitive to terrestrial magnetism, because of the vertically striped phosphors. Colour purity is not affected by changing the orientation of the colour television receiver, so the Trinitron is suitable for use in portable TV sets. Because of the aperture grille having no vertical structural components that could interfere with the scanning lines, there is no chance of generating the annoying moiré pattern that can sometimes appear in the picture displayed by shadow-mask tubes.

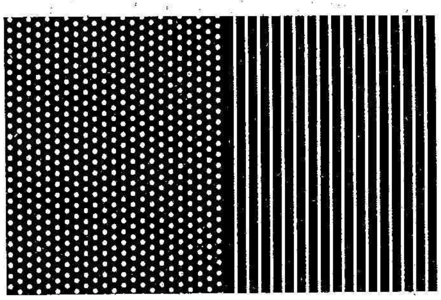


Fig. 6. Section of aperture grille (right) alongside that of a shadow-mask

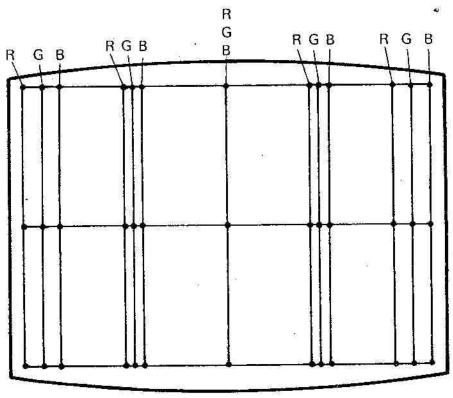


Fig. 7. Mis-convergence of spots on Trinitron screen, showing symmetrical positioning of outside-beam spots relative to centre-beam spot for various places on the screen.

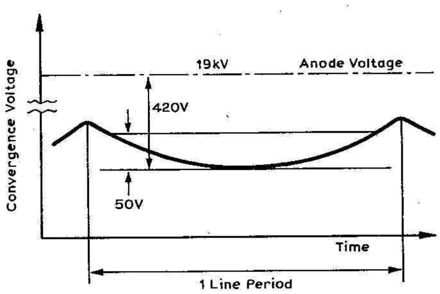


Fig. 8. Waveform of dynamic convergence correction voltage.

Convergence correction

The three beams in the Trinitron tube are aligned horizontally, and their deflected beam trajectories at any deflection angle remain substantially in a single horizontal plane. Therefore the special magnetic field distribution of the deflection yoke can make mis-convergence very small, and the mis-converged outside-beam spots on the phosphor screen are symmetrically positioned relative to the centre beam spot (see Fig. 7).

Correction for the mis-convergence at the corners of the phosphor screen is necessary only for the horizontal direction of the outside beams. On the other hand, the three beams in the conventional three-gun shadow-mask tube are ejected not in a single plane but in delta formation and remain so at any point on their trajectories cut by a transverse plane. Each beam is offset from the real centre of the three-gun assembly or the tube neck and the positional relationship of the three beams has not only a horizontal component but also a vertical component, so that convergence correction for these three beams is necessary for both the horizontal and the vertical direction. Thus convergence correction is more complicated and cumbersome for the delta three-gun shadow-mask tube than for the Trinitron tube.

Table 2.
Typical data of 13-inch Trinitron colour picture tube type E1AJ 330AB22.

Optical Data	
Face-plate	
Light transmission at centre (approx)	48.5%
Screen on inner surface of face-plate	
Type	aluminized, tricolour, phosphor stripes
Phosphors	
Red	rare-earth
Blue and green	sulphide
Mechanical Data	
Deflection angles	
Diagonal	89°
Horizontal	75°
Vertical	59°
Minimum useful screen dimensions	
Diagonal	302mm (min)
Width	245mm (min)
Height	192mm (min)
Typical Operating Conditions	
Unless otherwise specified, voltages are positive with respect to No. 1 grid.	
Anode voltage (1st and 2nd)	19kV
Convergence electrode voltage	18.585 to 18.535kV
Focusing electrode voltage	0 to 400V
No. 2 grid voltage	240 to 450V
(when 100V applied to cathode for visual extinction of focused spot)	
Heater voltage	
Under operating conditions	6.3V
Under standby conditions	3.5 to 4.3V

In the Trinitron there is a pair of symmetrical electron-optic prisms consisting of four deflection plates. Since the deflectors work on an electrostatic principle, static (centre) convergence correction for the two outside beams, red and blue, is achieved simply by adjusting the voltage applied to the deflector electrodes. The dynamic convergence correction is done by applying a synchronized voltage of parabolic waveform to the deflection plates (Fig. 8). As the ratio of static convergence potential difference and dynamic peak-to-peak potential difference between the deflection plates is always constant, individual adjustment of these two voltages is not necessary. Therefore if the static convergence is adjusted, the dynamic convergence will be adjusted automatically.

Comparing a typical 13-inch conventional shadow-mask receiver, for example, with a Sony 13-inch Trinitron receiver, the shadow-mask set has associated with the tube 39 electrical components and 16 adjustment points, while the Trinitron set has 13 components and 6 adjustment points.

As is well known, the fewer the components the less the weight and cost, and as a result the greater the simplicity and the higher the reliability. It can be concluded that the most dramatic achievements of the Trinitron system are its convergence system and its picture quality. Table 2 shows typical data in the specification of a 13-inch Trinitron tube.

Future possibilities

The principles of the Trinitron system have considerable potentialities for future development. One such line of development is to design a wide-angle deflection tube, and for this the system described would be helpful in solving many problems such as focus deterioration, increase of deflection power, and more complicated convergence correction. Application of the system is not limited to colour picture tubes with three beams. Many types of cathode-ray tubes with multiple guns and beams could be modified to single-gun types, thus simplifying their structure and improving their performance.

Editor's note. We understand that Sony is considering licensing tube manufacturers to make the Trinitron and also considering selling Trinitron tubes to equipment manufacturers for incorporation in their sets. It remains to be seen whether the Trinitron will dislodge the shadow-mask tube from its present monopolistic position.

Dual-trace Oscilloscope Unit

5. Protection circuitry and mistakes

by W. T. Cocking, F.I.E.E.*

In Part 3 we discussed how the amplifiers could be protected at their inputs from damage due to severe overloads. The inputs are the most vulnerable points because it is all too easy to connect a probe to the wrong point in the circuit which one is examining. We showed, and proved by a practical test, that a pair of biased diodes across the inputs would provide protection against inputs of up to ±360V, which is rather more than the peak value of 240V r.m.s.

It is necessary, however, to satisfy ourselves that the unit cannot be damaged by its connections to the oscilloscope.

There are three connections between the unit and the oscilloscope which must be considered. These are

(a) the signal output to the Y input
(b) the signal output to the external sync terminal
(c) the triggering signal from the timebase output.

The precise dangers depend on the particular oscilloscope employed and are likely to be greatest when this is a valve instrument. It is not practicable to consider in detail every oscilloscope with which the unit may be used and we shall discuss in detail only the Marconi Instruments TF1330, a valve oscilloscope.

Fig. 1 shows in simplified form the input stage of the oscilloscope. This is a cathode follower with its cathode resistor returned to −150V. The input coupling capacitor is 0.25μF and the grid leak is 1MΩ. A multi-range attenuator is connected between C and R_g, but we can ignore this. Fig. 1 also shows on the left the output stages of the amplifiers in the dual-trace unit. The practical danger is that when the unit is connected to the oscilloscope the coupling capacitor C_g may be charged by up to 500V positive or negative from some recent previous use of the oscilloscope. The maximum rating for the collector of the BC107 is 45V.

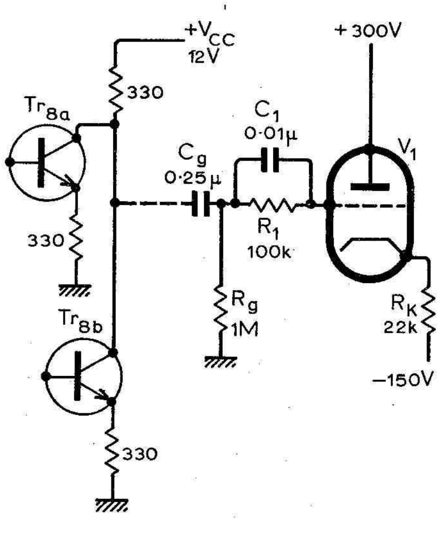


Fig. 1. Output stage and input circuits of a typical oscilloscope.

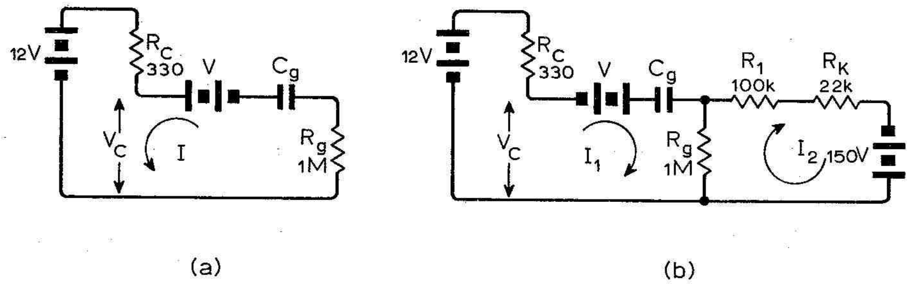


Fig. 2. Equivalent circuits for positive (a) and negative (b) initial charge on the input capacitor of the oscilloscope.

The charge on C_g can be represented by a battery V in a series with it and the equivalent circuit (without V_1) is shown in Fig. 2(a). The current flows in the direction indicated and is initially

$$I = \frac{V-12}{R_C+R_g} \approx \frac{V}{R_g}$$

and

$$V_C = 12+IR_C = 12+(V-12)\frac{R_C}{R_C+R_g}$$

With

$V = 500\text{V}, R_C = 330\Omega$ and $R_g = 1\text{M}\Omega$

$$V_C = \frac{12\times10^6-0.165\times10^6}{1{,}000{,}330} \approx 11.835\text{V}$$

The change of voltage on the transistor caused by the charge on C_g is only 0.165V. The voltage is dropped almost entirely across R_g and no risk to Tr_8 arises. The grid of V_1 goes negative to earth by almost 500V and so negative to its cathode by about 350V. This seems rather a lot, but is a matter for the oscilloscope designer, not for us.

*Editor-in-chief, *Wireless World*

If the polarity of V is reversed the position is the same except that the grid of V_1 is now driven positively and V_1 will almost certainly be driven into grid current. Assuming the grid-cathode path to have negligible resistance the equivalent circuit then has the form shown in Fig. 2(b). We now have

$$V-12 = I_1(R_C+R_g)-I_2R_g$$
$$150 = -I_1R_g+I_2(R_g+R_1+R_K)$$
$$V_C = 12-I_1R_C$$

whence

$$V_C = 12-\left[V+150\frac{R_g}{R_g+R_1+R_K}-12\right] \times\frac{R_C}{R_C+\dfrac{R_g(R_1+R_K)}{R_g+R_1+R_K}} = 10.26\text{V}$$

with the values given.

Thus no precautions against a residual charge on C_g are needed.

Let us now consider the sync output from the amplifier to the external sync terminal of the oscilloscope. The conditions are, in fact, very similar. The signals are fed either directly or through a capacitor to a cathode follower operating from supplies of +150V and −150V. There is a 1MΩ grid leak and a 470kΩ grid stopper. In this case the capacitor is rated for only 400V, so it is not envisaged that such a large voltage will be applied to the sync terminal as to the Y inputs.

In the dual-trace unit, the coupling resistors between collector of Tr_{11} and $+V_{CC}$ total about 700Ω which is about twice as great as in Tr_8. The changes of V_C were previously +0.165V and −1.74V. At worst, they will now be twice as great. Once again, therefore, no precautions are needed.

We now have to consider the sawtooth output from the oscilloscope. This is about 8V pk-pk and comes from a cathode follower. There is a 22kΩ cathode resistor returned to −150V and the anode is taken to +150V. The d.c. level of the output is about 2V above earth on most ranges, but rises to 11V if the switch is set to stop the timebase. A coupling capacitor in the unit is thus necessary.

The oscilloscope includes a time-delay switch which enables the valve heaters to reach operating temperature before h.t. is applied. Nothing drastic is thus likely to happen at switch on. However, if the heater of the cathode-follower fails, then the 'T.B. out' terminal will go to −150V. If the failure occurs during operation the change will take place slowly enough for the capacitor charge to follow it and no harm will result. However, if the valve has failed previously and the oscilloscope is switched on with a faulty valve, the closing of the delay switch will apply −150V suddenly to the 'T.B. out' terminal and the results may be disastrous.

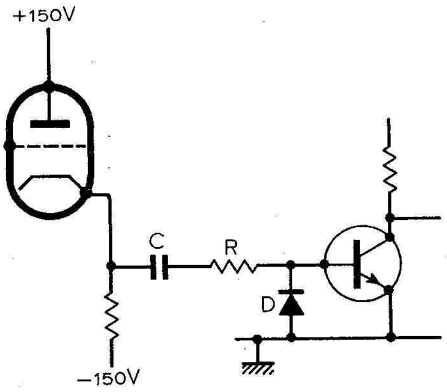


Fig. 3. Output circuit of oscilloscope sawtooth and input of phase reverser.

A protective diode, as shown in Fig. 3, is thus necessary. If R is zero then, ignoring the diode resistance, a valve failure will result in a current in D of almost $150/22 \approx 6.8$mA and the base of the transistor will be clamped at about 1V below earth. The transistor will then be cut-off and its emitter will be at earth potential. In practice, R is quite large, perhaps 15kΩ, and an overload current is correspondingly smaller.

Design mistakes

We said in Part 1 that we should discuss errors in design as well as successes. In spite of successful bench tests, when the final model was constructed several faults became evident. These were:

1. Excessive cross-talk between the channels
2. Poor high-frequency response
3. Grossly excessive thermal drift in the differential stages.

Taking these in order, with a signal applied to one channel and no signal to the other an appreciable output was obtained from the latter and one which was considerably distorted. Examination soon showed that the distortion was arising in the sync amplifier. What we had overlooked was the effect of the cable capacitance plus the oscilloscope input capacitance, perhaps 40pF total. We knew it was there, and knew that the low output impedance of the sync amplifier would prevent it from affecting the frequency response appreciably. What we forgot was that the amplifier would have to be able to supply a much larger output current at high frequencies in order to develop the output voltage across the capacitance. It was its inability to supply this current which caused the distortion.

A few simple sums indicated that about three times the original mean currents were required, and so we reduced all three resistors to the nearest preferred values to one-third of the original ones. This cured the distortion.

The fact that the distorted wave appeared as interaction in the other channel and also caused some distortion in the wanted channel indicated that the signal was being picked up from the sync amplifier. It was originally mounted on one of the main amplifier boards. When we changed the resistor values, therefore, we removed it from this board and gave it a small separate board of its own.

These changes cured the distortion, but there was still cross-talk between the channels. Experiment showed it to be markedly dependent on how the earthing of the boards was carried out, and we started trying various leads and points of connection. Some reduced it, some increased it, and the effect depended on frequency. An arrangement which would substantially eliminate it at one frequency would make it worse at another!

When this sort of thing happens there is usually only one remedy, heavy earth leads returned to one point on the chassis. The two input coaxial sockets were necessarily earthed to the front panel. Earth leads had been taken from each into the input attenuator sections and thence to the output sections and finally to $-V_{CC}$ in each amplifier board. Basically, therefore, each amplifier was earthed only at the input coaxial socket. This appeared quite satisfactory. The trouble arose at the output ends where the power supplies had to be connected.

There were three coaxial output sockets on the panel and close together, for signal output, sync signal output and timebase input. The proper thing to do turned out to be to make the sync signal output the earth point. The sync amplifier was mounted against it with a half-inch earthy lead. A piece of 16 gauge wire was bent to a U and its centre soldered to this earth point and the two arms to the $-V_{CC}$ tags on the amplifier boards. The negative power supply lead was taken to this same point.

The addition of 0.1μF across the power supply tags of each board then further reduced cross-talk. It proved impossible to remove it completely above about 5MHz and it was too small to measure accurately. In the end, it was under $\frac{1}{20}$ of the main signal output.

Turning now to the high-frequency response, the original bench amplifier readily gave a −6dB response at 10MHz. The gain having been set to 10 times by a 100-Ω preset resistor, the response was −8.4dB at 9.6MHz and with the main gain control at minimum only −12.6dB. We felt that the response might not be quite so good in the final model because the capacitances might well be higher with Veroboard and closely spaced components than in the more open bench model. We did not expect anything like this, however.

The only other difference lay in the variable resistors. The bench model had a fixed resistor instead of a preset and the gain control was a moulded-track type, whereas we were now using wire-wound resistors. We judged that the inductance of the windings was probably responsible and a trial showed that we were right. With moulded-track resistors the response was −4.8dB at 9.6MHz.

We used wire-wound types because they were more readily available than moulded-track types in low values and we realized from the start that they might affect the frequency response. We did not expect the effect to be quite so great.

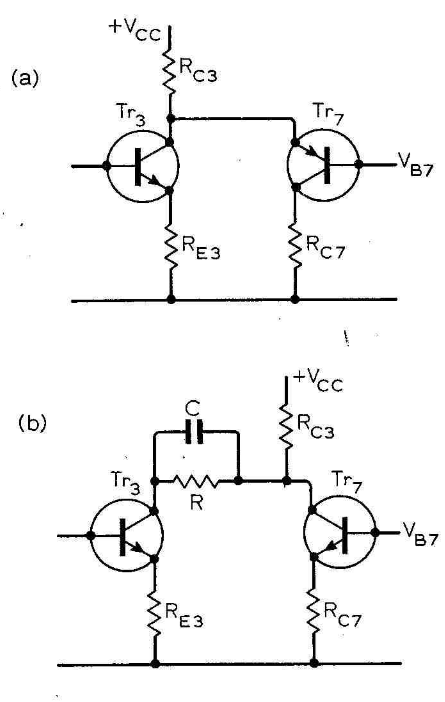


Fig. 4. The basic circuit (a) of one side of the differential amplifier and (b) modified by adding R and C in order to make V_{CE} less than half the supply voltage.

In spite of the care taken in design, the 'final' model was found to suffer from excessive drift in the differential stage. The basic overall drift was entirely satisfactory, but the differential drift made the gain control alter the position of the trace on the screen. Some time after careful balancing, altering the gain over its full range would give an output shift voltage of up to 120mV. As the normal signal output is 500mV, this is almost one-quarter of the signal amplitude. It amounts to 12mV between the emitters of Tr_3 and Tr_4.

It was thought at first that it was caused by collector dissipation in Tr_3 and Tr_4 since the collector circuits are not alike. If the ambient temperature rises, the junction temperature must rise also. This reduces V_{BE} and so increases I_C. If $V_{CE} > V_{CC}/2$, as in our case, the collector dissipation increases further and the junction temperature rises again. There is a positive feedback effect. Because of the difference in the collector circuits of Tr_3 and Tr_4 the magnitude of the effect would not be the same in both and so it would cause an unbalance.

If $V_{CE} < V_{CC}/2$ an increase of collector current *reduces* the collector dissipation and a negative feedback effect occurs. This would not prevent a differential effect between the transistors but it should greatly reduce its magnitude. It was an easy thing to try since it meant only the inclusion of a 2.7kΩ resistor shunted by 0.001μF between the collector of Tr_3 (and Tr_4) and the rest of the circuit as shown in Fig. 4. Unfortunately, it made no noticeable difference.

A few sums then showed that the change of collector dissipation needed to produce the observed voltage change was far greater than could occur through this mechanism!

We then observed that after the usual initial settling down period, the drift was very small indeed if the unit were left quite undisturbed on the bench. If we used the unit, however, and particularly if we turned it on end, large and erratic drifts occurred within minutes. This gave us the clue to what was happening.

The unit was not in a case and it was subject to draughts! The air disturbance caused by our movements around it affected the two sides of the differential amplifier differently. To prove this, we made a little cardboard box with one side open and placed it over the six transistors of the differential stage. It was far from a perfect enclosure, for it did not fit well and on one side there were the holes in the Veroboard. Nevertheless, it effected a large improvement, the drift being reduced to little more than the trace thickness!

The box not only shields the transistors from draughts, it also tends to equalize the ambient temperatures of all the transistors within it.

We fitted the box to one only of the two amplifiers, so that we had a ready comparison of its effect. We then tried the unit in its case with the power supply. The case had ventilation vents of the usual pattern, but these do not actually give good ventilation, for they are the wrong shape and wrongly placed to permit a free flow of air through it. We expected, therefore, that the temperature rise might be considerable and that the initial drift after switch on might not only be large but take a long time. Rather to our surprise neither occurred. Very little drift occurred after the first half hour. We observed, too, that the drift of the amplifier without the screening box was no longer excessive or erratic. This proved that it was caused by air currents.

The individual draught screens are thus not needed when the unit is in its case. However, the unit must be outside the case when the initial adjustments are made and so it is necessary to fit the screens in order that these adjustments can be made properly. Very simple screens cut from thin cardboard and held together with Sellotape suffice.

Input capacitance

We said in Part 4 that additional capacitance would probably be needed in the attenuators in order to meet the required conditions for frequency response and that these could not be computed because it was impracticable to estimate the stray capacitance with sufficient accuracy. Initially, we just added the appropriate values without much regard to what they were and the performance was satisfactory. Later we looked into this and found that they seemed rather large, so we investigated further.

The attenuator unit with the switches set for zero attenuation added 30pF shunt capacitance. This seems rather a lot but there is not much that can be done about it. It obviously arises partly from the switches and partly from the capacitance to earth of the two series isolating capacitors. These are physically large and quite close to the screening. The use of wafer switches and larger screens would probably reduce the capacitance appreciably, but we doubt if it could be brought below 15pF. The effect on the input capacitance of the probe would be only 1.5pF and it did not seem worth while to make any change.

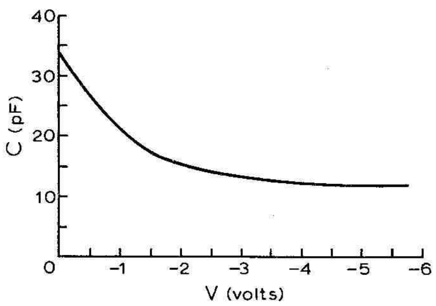


Fig. 5. Curve of capacitance of BA145 diode plotted against the back-bias voltage.

A change would be a drastic one, for it would involve a complete mechanical redesign of the attenuator unit and this could not be done without using a larger cabinet. We decided, therefore, to leave things alone and accept a larger input capacitance than we had originally envisaged.

We were not at that time able to measure the input capacitance of the amplifier because the equipment was temporarily out of action. We had inadvertently short-circuited the reservoir capacitor of the power supply and blown the rectifier, and it was while waiting for a replacement that we were investigating the capacitances.

Instead, we took some measurements of the capacitance of the BY145 diodes used to protect against overloads. With zero bias it is 33.5pF! We made measurements at various back-biases with the results shown in Fig. 5. Now the BA145 is rated at 4pF, but this is at a back bias of 150V.

In one unit one diode is biased by about 4.6V and so will have a capacitance of some 12.5pF. The other will have a bias of 0.5 to 1.65V, depending on tolerances and so its capacitance will be 26 to 16pF. The two diodes will thus add 28.5 to 38.5pF to the input capacitance of the amplifier proper.

Now the BA155 is listed to have a capacitance of 3.5pF typical at zero bias, 2pF at 3V back bias, but the figures for a high-tolerance diode may be 10pF and 5pF. We may guess that a pair will add 5–12pF only and that we can reduce the capacitance by 25pF by using them.

The voltage and current ratings of the diode are adequate. The back resistance does not seem to be so high. At 25°C the reverse current is 1.5μA max. at 100V whereas the BA145 at 75°C is 10μA at 300V. The figures are not comparable and so it is a matter for trial.

We have not actually tried the BA155 for to do so would have involved quite a lot of work in dismantling and reassembling the equipment. This will be obvious when the form of construction used is seen in next month's issue. We judged it not to be worthwhile because the estimated reduction of capacitance by 25pF would affect the input capacitance by only 2.5pF. With the BA145 diodes the probe input capacitance is only about 12pF to 14pF, and this is not unduly high.

A further curious effect was noticed. Only one probe was readily adjusted to give almost perfectly square corners to the square-wave test signal, the other could not be made to do so. It gave rounded corners after the vertical transitions or overshoot, but no square corner. Naturally, we first suspected a difference between the two amplifiers, but changing over the probes, showed the trouble to lie in one probe.

This seemed unlikely, because there were involved only a resistor, a trimmer capacitor and a length of cable. We could not imagine that the cable could cause the trouble, but we suspected it because we had used different batches of cable for the two probes. We replaced the cable with no effect. We then changed the resistor and this effected a complete cure!

In the 'good' probe we had used two 1.8MΩ resistors in parallel to obtain 900kΩ; in the 'bad' one we had used one 2.2MΩ in shunt with one 1.5MΩ (nominal values) and the two resistors were of different types. We replaced them by one 1MΩ, which actually measured 960kΩ, so it was almost 4.5% high.

It is certainly not the use of parallel resistors which caused the trouble, for the 'good' probe had them. The obvious thing is that the resistor was a film type with a spiral track and thus had inductance. The resistor was of unknown type. It is hard to imagine that the inductance would be sufficient to cause trouble. We tried inserting 250μH in series with a 'good' resistor and it had no observable effect. The actual cause is thus a mystery. The result is clear, however; if a good square-wave output cannot be obtained, try changing the probe resistor for a different type.

Electronic Building Bricks

18. The integrator

by James Franklin

A dictionary definition of the verb "to integrate" is to complete something by the addition of parts. When this term is used in mathematics it means that the parts are quantities added arithmetically. The electronic integrator is based on this mathematical operation of integration.

A simple illustration of the integration process is given in Fig.1(a) and (b). The graph (a) plots the speed of a moving vehicle over an interval of time. By integration we can obtain from this information the distance travelled by the vehicle at any particular time. In effect what we do is to start by saying that at the beginning of the period the vehicle has travelled no distance; then, at a tiny interval of time after that we read off the speed from graph (a) and calculate the distance travelled in that interval, on the basis that distance = speed × time. After a further tiny interval we take another speed reading from (a), do another calculation to get the distance travelled in this second interval; add this distance to the first distance . . . and so on, adding up the small increments of distance for as long as we wish. We can then plot the running total of distance increments, as shown in (b), and from this we can read off the distance travelled after any required interval of time. Curve (b) is, in fact, a graphical representation of the *integral,* with respect to time, of the variable plotted as curve (a).

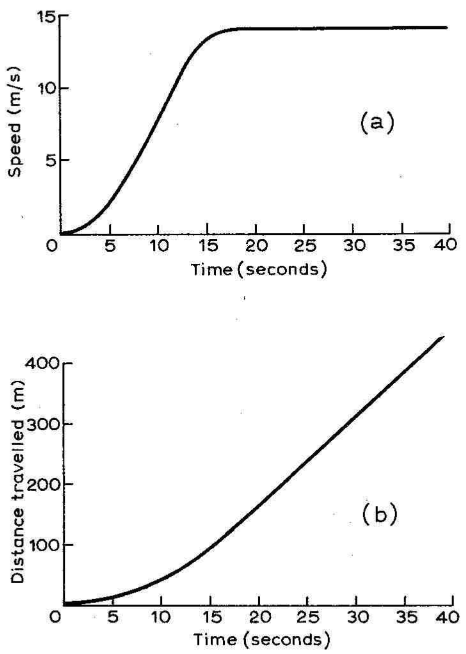


Fig.1. Graphs of a vehicle's speed (a) and distance travelled (b) with respect to time. (b) is derived from (a) by integration.

Integration can be done with respect to other variables. But in electronic systems we are mostly concerned with integration with time, simply because the information conveyed in them is in the form of electrical quantities which are changing with time. For example, if in some system we had a voltage proportional to mechanical acceleration (metres per second per second), as shown in Fig.2, this could be integrated with respect to time to give a voltage proportional to velocity (metres per second) and this voltage in turn could be integrated with respect to time to give a voltage proportional to distance travelled (metres).

How does the electronic integrator work? Considering the example of integrating speed illustrated in Fig. 1, the integrator must receive an electrical variable which at each instant is proportional to speed, must multiply this by a tiny interval of time, which we shall call *dt,* present the product as an electrical value, and add this to previous (speed × *dt*) products to give an electrical output proportional to the running total of products.

All this sounds very complicated when spelled out, but in practice is not, for the reason that in mathematical integration — of which the electronic device is an analogue — the time interval *dt,* besides being infinitely small, is a constant. Thus in the integrator the electrical variable representing speed is continuously (at each successive instant) multiplied by a constant, and therefore the product turns out to be proportional to the speed itself. So all that is necessary electronically is to take the successive values of the "speed" electrical variable and from them form a "distance" variable which is proportional to the running total of "speed" values.

These operations can be done by means of a charge storage device such as a capacitor, in which the running total of electrons stored (the charge) depends on the rate of flow of electrons (current) into the capacitor. How this would be applied

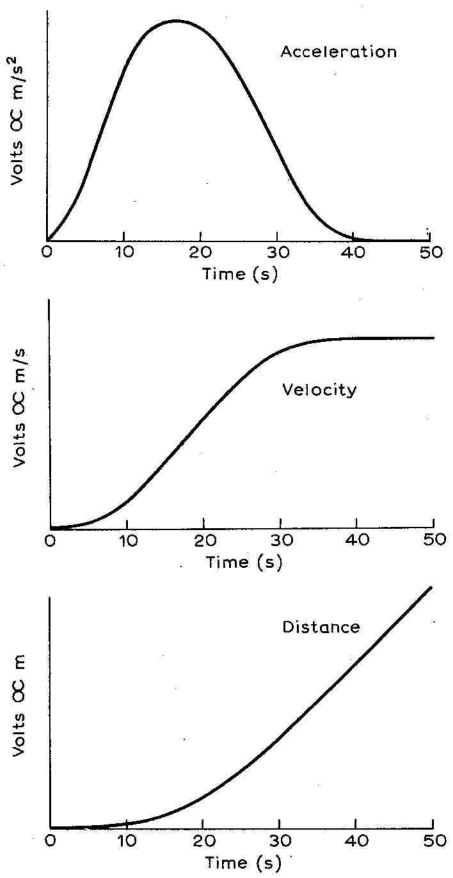


Fig.2. Graphs of voltages proportional to acceleration, velocity and distance plotted against time for a given system.

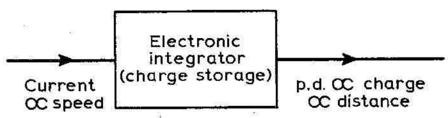


Fig. 3. Functional block of an electronic integrator based on charge storage.

to the integration of speed to obtain distance is shown in Fig.3. In practice a capacitor alone is not suitable, because at any given time the current that can flow into it is affected by the amount of charge already there. So it is necessary to use, in addition, an electronic circuit which "linearizes" the process, making the charge stored at each instant proportional to whatever current is flowing at that instant. The charge in the capacitor cannot be used directly as a signal representing distance, but the charge gives rise to a potential difference and this can be conveyed as information.

In mathematical integration we have to specify the range of values over which integration is to be performed — what is known as deciding the "limits of integration". For example in Fig.1(a) one might wish to integrate speed between the limits of 0 and 19 seconds on the time scale. The analogue electronic integrator, however, is usually a continuously operating device and so does not set limits of integration in the formal mathematical sense, though in practice some integrators can be reset to zero, i.e. started afresh integrating the input variable.

Displaying Frequency Digitally

How a digital frequency meter can be constructed and added to your receiver

by C. Attenborough

Fig. 1 is a simplified circuit of a digital frequency meter. During the one second pulse applied to the input gate, the 7490† counters are triggered by pulses of the input frequency. The output states of the counters are decoded by the 74141 decoder/drivers, and displayed on the numerical indicator tubes. During the one second pulse the numerical indicator tubes do not display a steady reading because the state of the counters is changing, but when the gate pulse ends they display the number of cycles of the input frequency which occurred in the one second when the input gate was open.

Before the measurement can be repeated, the 7490 counters must be reset to zero, so if continuous monitoring of the input frequency is needed, there must be a pulse to open the input gate for a known time, a pause for the numerical indicator tubes to show the number the counters accumulated while the input gate was open, and a reset pulse to return the counters to the zero state. This cycle may be repeated automatically.

The confusion due to the numerical indicator tubes flickering while the count is proceeding can be avoided by using a bistable latch circuit to memorize the states of the counters after the count has ended, and using the output of the memory to drive the decoder/drivers. If this is done the numerical indicator tubes will display a steady reading when a constant frequency is being measured. The 7475 may be used as a memory: it contains four latches, and thus can memorize the states of the four output lines of a 7490 counter. A positive-going pulse is needed to instruct the 7475 to memorize its inputs.

A one-second gate pulse will make the numerical indicator tube connected to the counter nearest to the gate read in units of 1Hz: the gate time may be decreased (and the number of reading per second increased) if a less fine resolution is acceptable. For example, a gate time of 1ms will give a resolution of 1kHz. Fig. 2 shows how the gate pulse, the commit-to-memory pulse, and the reset pulse may be generated in the correct order: each 7475 needs an inverter to provide its commit-to-memory pulse because one inverter has only enough output drive to feed one commit-to-memory terminal. Because the accuracy of the frequency meter depends on the gate pulse being exactly the right length, the gate pulse must be derived from an accurate and stable frequency standard. A 1MHz crystal oscillator is shown in Fig. 2. The choice of standard frequency is arbitrary: other frequencies may be used if the appropriate division ratio is used to give the desired gate time.

That concludes the description of a simple digital frequency meter: how may we make a version to indicate the frequency to which a radio receiver is tuned? The frequency meter cannot be fed from the signal input to a receiver's frequency changer, because the signal frequency tuned circuits are not selective enough to select one signal from the spectrum fed in by the aerial (and if they were selective enough, the modulation would be removed from the received signal).

The local oscillator is free from unwanted spectral components, but is not at the same frequency as the signal (except for direct conversion receivers). Usually the local oscillator frequency is above the signal frequency. The easiest way of making the counter measure the oscillator frequency but display the signal frequency is to reset the decades in the frequency meter, not to zero, as is usually done, but to minus the intermediate frequency. Resetting to a negative number may sound odd until it is realized that a counter with M decades is in the

†All i.cs used in this article are from the 74 series of t.t.l. To avoid repetition type numbers have been shortened. When buying components, for 74—, read SN74—N.

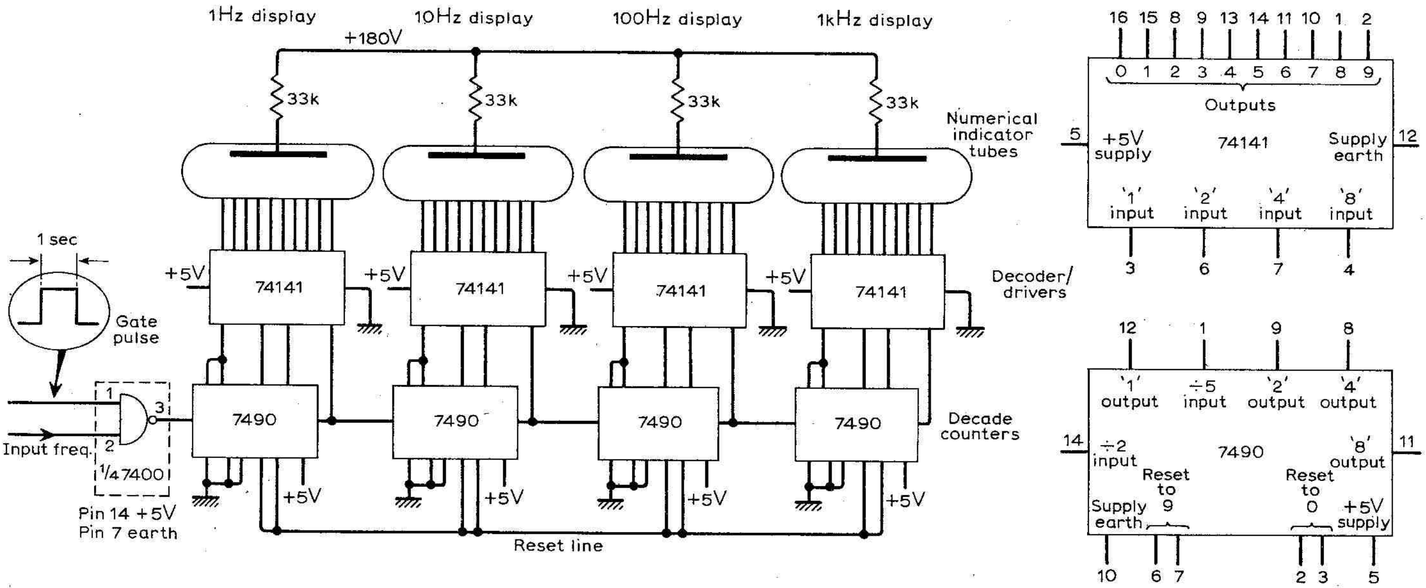


Fig.1. Simple frequency meter with the circuits which produce the various control and reset pulses omitted.

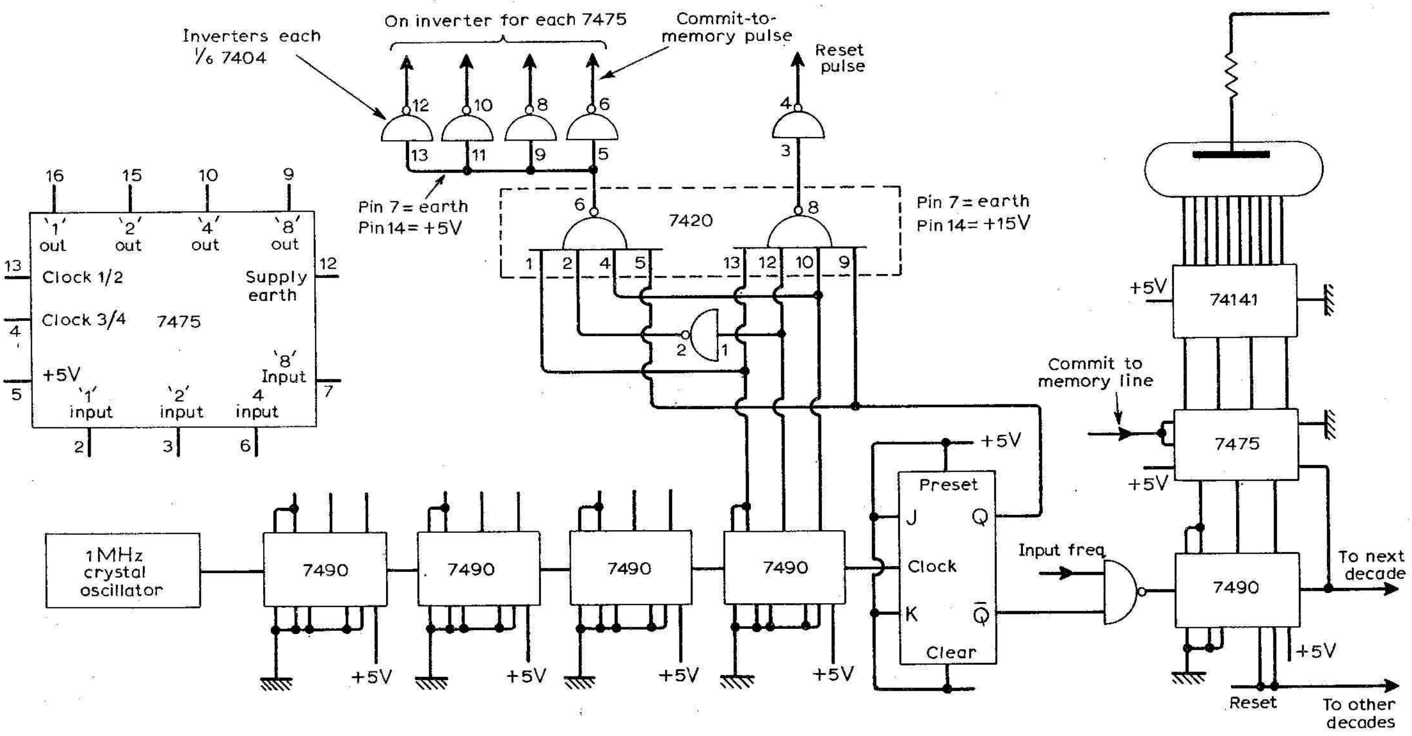


Fig.2. Pulse generation and how a display memory can be added.

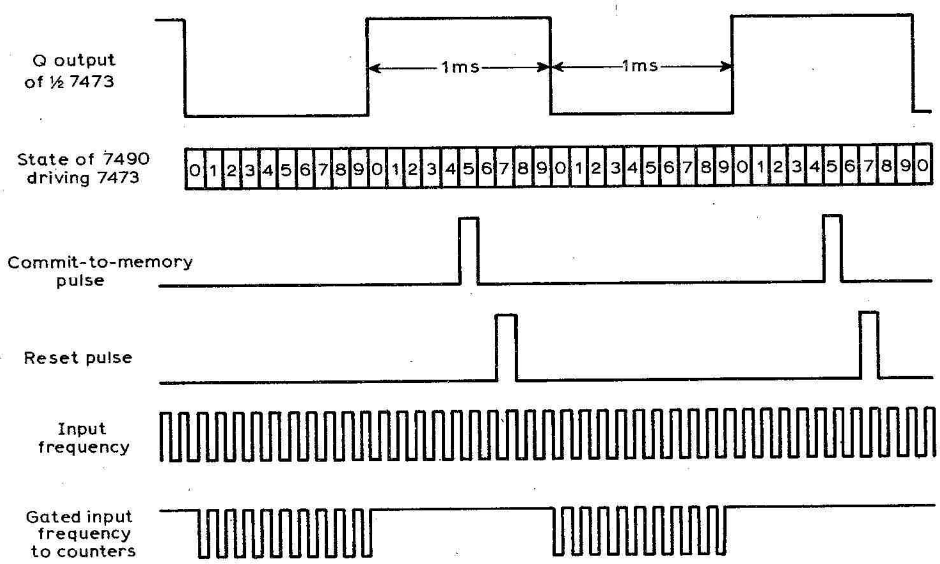
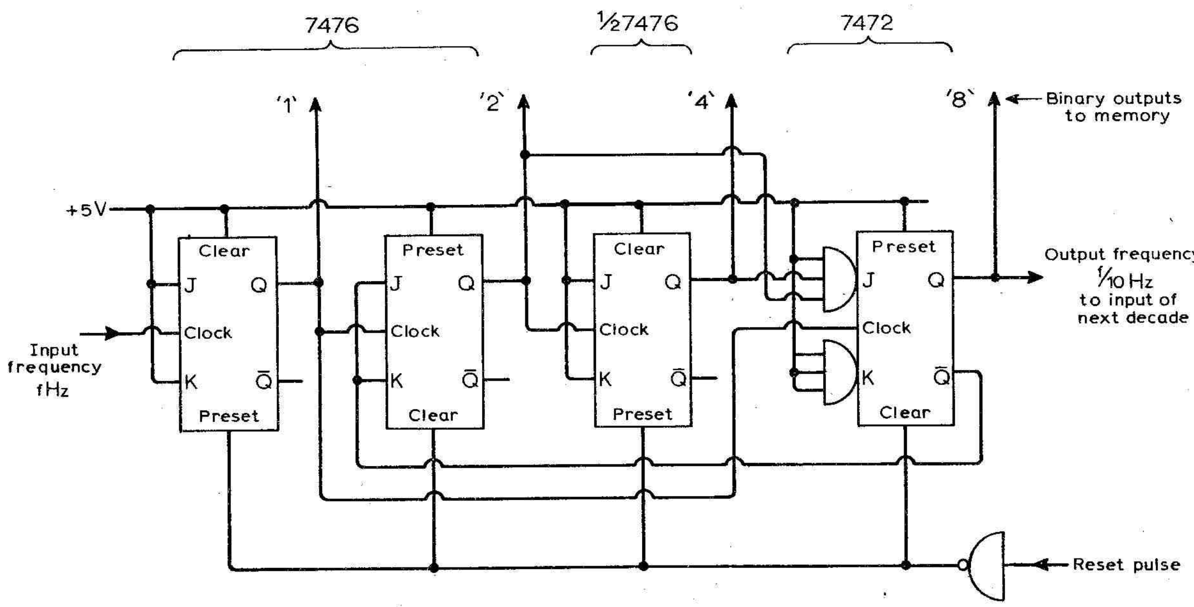


Fig.3. Waveforms produced by the circuit of Fig.2.

Fig.4. Decade divider which can be reset to five using 7472 and 7476 devices.



Pin	7472	7476
1		Clock 1
2	Clear	Preset 1
3	J_1	Clear 1
4	J_2	J_1
5	J_3	V_{CC}
6	$\bar{Q}$	Clock 2
7	GND	Preset 2
8	Q	Clear 2
9	K_1	J_2
10	K_2	$\bar{Q}_2$
11	K_3	Q_2
12	Clock	K_2
13	Preset	GND
14	V_{CC}	$\bar{Q}_1$
15		Q_1
16		K_1

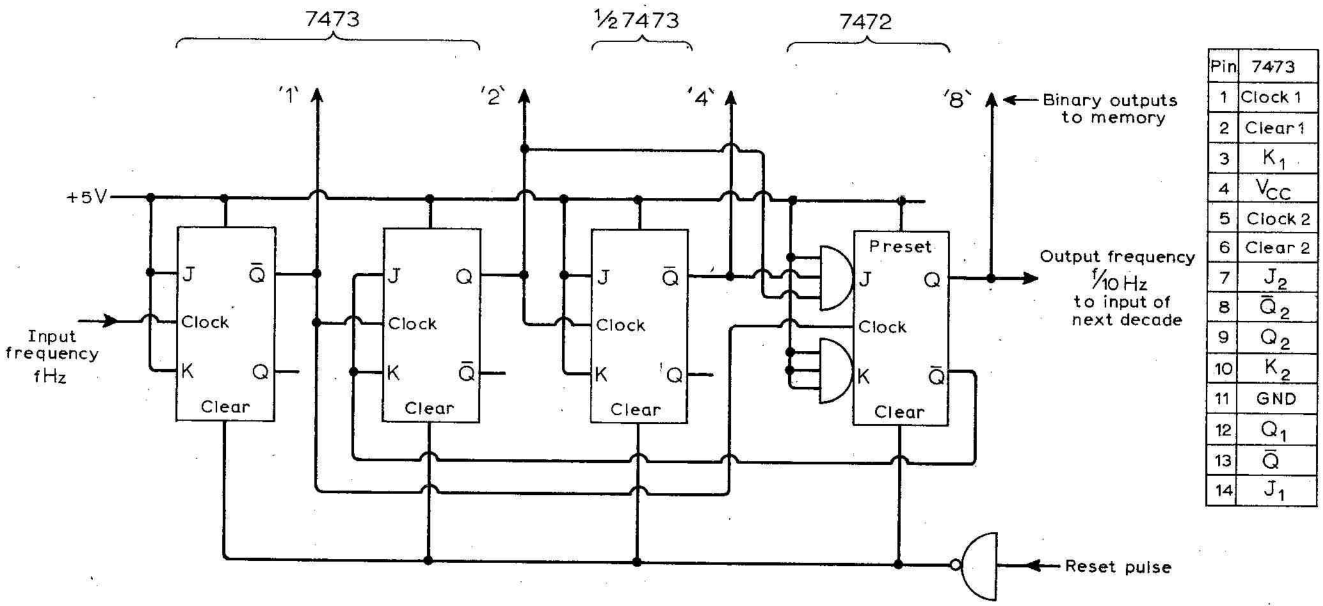


Fig.5. Decade divider which can be reset to five using 7472 and 7473 devices.

same state after 10*M* input pulses as after no input pulses.

Suppose we want to design a digital frequency meter with a discrimination of 1kHz to measure the input frequency of a receiver with an intermediate frequency of 455kHz, and a maximum input signal frequency of 5MHz. Such a counter has four decades (for example, it may display 3,725kHz) and thus *M* is four in this case. Therefore the decades in the counter must be reset to $10^4 - 455 = 9545$. Notice that the intermediate frequency is measured in units of the counter's discrimination: for example, a counter as above, but with a discrimination of 100Hz, would have five decades and would need to be reset to $10^5 - 4550 = 95450$.

If the decades in the counter are to be reset to a number other than zero or nine, the 7490 cannot be used, and in these cases a decade divider can be assembled from single and dual *J-K* flip-flops, types 7472 and 7476. Fig. 4 shows such a decade. All the flip-flops have preset and clear inputs, allowing them to be set to either state, so the decade can be reset to any number. A flip-flop is reset to the 'zero' state (that is, its *Q* output is made to assume the low-voltage state) by taking its clear input to 'zero' and leaving its preset input at '1', while resetting to '1' is done by taking the preset input to 'zero' and leaving the clear input at '1'.

Consider the first example given: the kHz decade must be reset to five. The binary representation of five is 0 1 0 1, so, remembering that the '1' on the far right represents the output of the flip-flop on the left of Fig. 1, the flip-flops must be reset to 1 0 1 and 0 going from left to right in Fig. 1. This drawing also shows how the preset and clear inputs are connected to allow the decade to be reset to five. Table one gives the states to which the flip-flops must be reset to drive a decade to any one of its ten states.

Some reduction in cost may be made by using the type 7473 dual *J-K* flip-flop instead of type 7476: the 7473 has no preset

Table one

decade to be reset to	reset binaries to			
	8	4	2	1
0†	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9†	1	0	0	1

†use 7490 decade

input, and thus its *Q* output cannot be reset to '1'. The clear input, however, allows the *Q* output to be reset to the '0' state: when this is done the *Q* output assumes the '1' state. Thus 7473 devices can be used normally in place of type 7476s when resetting the *Q* output to '0' is needed, but when resetting to '1' is required, the *Q* output must be used as the *Q* output, and vice versa. (In general, the *J* and *K* inputs should also be interchanged, but in a decade divider each section of dual *J-K* flip-flop has its *J* and *K* inputs connected together.) Fig. 5 shows a decade using 7473 devices, which can be reset to five: resetting to any number is possible by using the information given above.

The inverters in the reset line in Figs 4 and 5 serve two purposes: they allow the decades made of 7472 and 7476 or 7472 and 7473 devices to be reset by the same positive going pulse which resets the 7490 decades, and avoid excessive demands on the fan-out of the inverter in Fig. 2 which drives the reset line.

High-value i.c. resistors

In the past it has been difficult to make high value, linear resistors suitable for use in silicon integrated circuits. They had either to be simulated, using active devices — a technique which had the disadvantage of producing non-linear resistors — or more complex methods had to be employed.

Ion implantation enabled, thin, lightly doped layers to be produced with results which were repeatable and which raised the maximum sheet resistance value to about 50kΩ per square. However, as with epitaxial resistors, the voltage linearity was poor for values above about 50kΩ per square, due to loss of carriers to the depletion layer between the resistor and the substrate.

Work at the Mullard Research Laboratories, under a Ministry of Defence contract, has shown that by implanting neon into the region of the resistor the linearity is improved and the sheet resistance raised. The radiation damage introduced by the neon serves to reduce the mobility thus raising the sheet resistance for a given linearity and number of carriers.

Reductions in mobility by a factor of five have been observed and work continues in order to confirm the initial indications that resistors made by this method are stable and have acceptable leakage currents. Investigation of the application of these resistors to m.o.s.t. bipolar circuits is also in progress.

Circuit Ideas

A stable Q-multiplier

The cathode-follower type of Q-multiplier[1] can be implemented very conveniently using a junction-gate field-effect transistor as the active element. Such a system is inherently very stable and it is even more stable when an f.e.t. replaces the traditional valve. Only three extra components are required to raise the Q of a centre-tapped inductor. Resistor R (Fig. 1) controls the extent of Q-multiplication and its value depends on the original loaded Q of the particular inductor. Fig. 2 shows how the circuit is used to increase the image rejection of the tunable i.f. section of a miniature two-metre amateur-band receiver which has a second i.f. of 470kHz and a tunable i.f. of 10.7 to 12.7MHz. The extra components can easily be included in a miniature i.f. can with an existing coil.

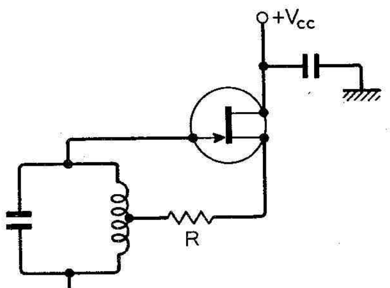


Fig. 1. Basic Q-multiplier circuit.

No deterioration in the overload or cross-modulation performance of the receiver has been observed.

D. A. TONG,
Leeds

[1]H. E. Harris, *Electronics,* May 1951, pp. 130-134.

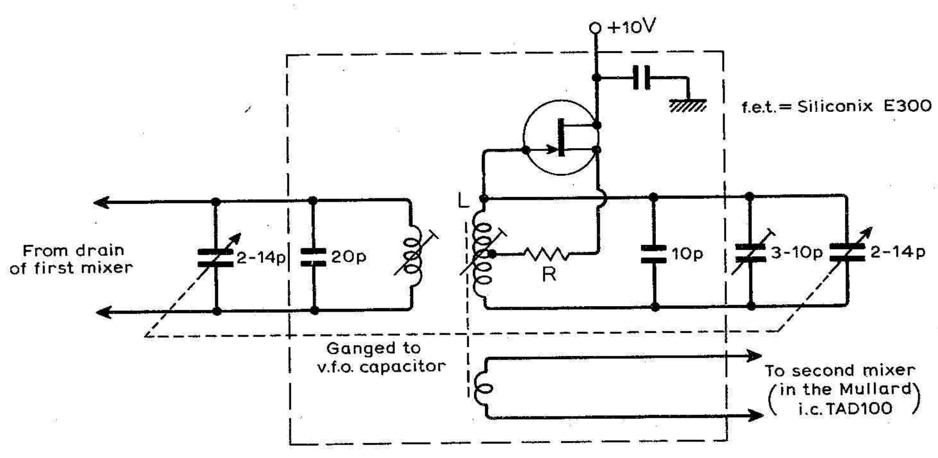


Fig. 2. The value of R used in the author's application is 5.6kΩ, and L consists of 18in of 40 s.w.g. wire close wound on a ⅜in diameter former. The link has 5 turns. The tuned circuit covers 10.7 to 12.7 MHz.

Fractional bootstrap feedback

During tests on the bootstrap circuit shown in Fig.1 it was found that distortion was several times higher than expected. Further investigation showed that this was the result of variation in f.e.t. output admittance (h_{oe}) with drain voltage (Early effect). Several alternative circuit configurations were tried, Fig.2 giving the best results. By feeding only a fraction of the input signal back (say 0.98), the output load seen by the constant current generator at the drain of the f.e.t. is kept low, and the non-linear effects reduced. The distortion/gain ratio was three times better.

The same modification may be applied to a class B amplifier to lower the load seen by the driver stage transistor. The overall effect should be to reduce crossover distortion to very low levels. The extra gain required of the circuit may be obtained from the driver and pre-driver transistors by circuit modification.

J. H. WILKINSON,
Sheffield Polytechnic.

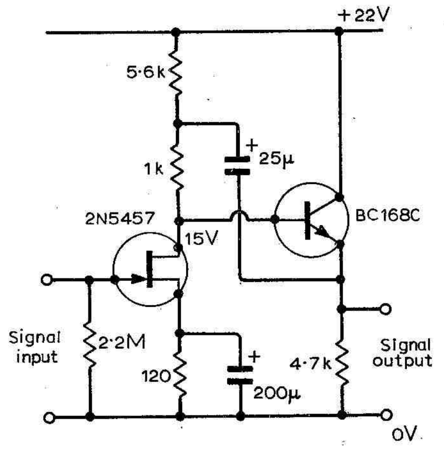
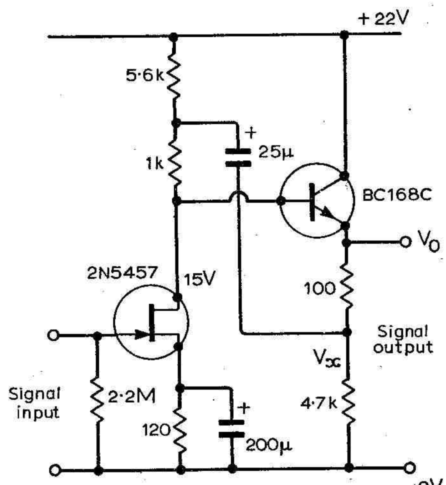


Fig. 1. Standard bootstrap circuit.

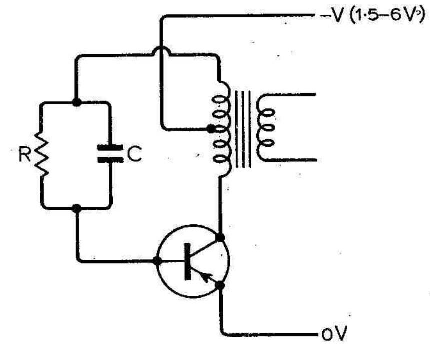


$$V_x = V_o \frac{4{\cdot}7 \cdot 10^3}{4{\cdot}8 \cdot 10^3}$$

Fig. 2. Modified bootstrap.

General purpose oscillator

The novel Hartley type oscillator illustrated can easily be constructed to provide relatively powerful square waves when using a relatively low gain general purpose transistor. The oscillator coil can be any push-pull output transformer. For a given transformer the frequency of the oscillator depends on both C and R which may have values of 0.01 — 10μF and 200Ω — 10kΩ respectively.



T. KOANANTAKOOL,
Norwich.

World of Amateur Radio

Fewer cases of TV interference

A recently issued *MPT Technical Bulletin* "Radio interference complaints for the year 1970" shows that there has been a welcome decline (from 1442 to 1161) in the number of complaints ascribed to the operation of amateur stations. Unfortunately, this decline is rather less significant than may at first appear — for this decline follows a very bad year, and the figure is in fact marginally up on 1968 (1151) despite an overall decrease in interference complaints. The distribution of interference is also changing; 65 cases concerning u.h.f. television (compared with 26 cases in 1969 and only 12 in 1968); a continuing decline in interference to Band I reception (1970, 630; 1969, 821; 1968, 725) but rather less change on Band III (1970, 394; 1969, 492; 1968, 319). It is interesting to note that on every band, without exception, U.K. transmitters other than amateur account for significantly more complaints (total 2206), despite the fact that amateurs normally operate in the middle of residential areas. But it is true, as the Ministry points out, that "the number of households which experience interference to radio and television reception is usually much greater than the number of complaints received". Nevertheless it must be welcome to everyone concerned that the total complaints received in 1970 was down by 7.7% to 64,006 a far cry from the 150,000 or so which were reported annually in the mid-fifties. Amateur operation has never accounted for more than about 2%. Incidentally, a new form of transmitter interference has been reported from the United States: high-power mobile transmitters are capable of interfering with the operation of electronically-controlled braking systems now being fitted in some U.S. luxury cars.

Radio Peking and the 7-MHz band

Amateurs will be watching keenly to see if the invitation to mainland China to join the United Nations has any repercussions on amateur operation. There have, for instance, been some signs recently of limited amateur operation in China; for many years few amateur signals have emanated from the country. More significant could be the position if China were to join the International Telecommunication Union, one of the specialized agencies of the United Nations. For, if this happens, it might result in Radio Peking moving out of the 'exclusive' amateur frequency allocation of 7000 to 7100 kHz. At present, according to lists prepared by the R.S.G.B. Intruder Watch, Radio Peking operates on no less than seven frequencies in this part of the spectrum: 7010, 7028, 7035, 7057, 7075, 7080 and 7095 kHz. Other broadcasters operating in this band in defiance of the I.T.U. Radio Regulations are: Radio Iran (7020 kHz); Radio Cairo (7050 kHz) and "Voice of the Arabs" (7075 kHz); and Radio Tirana, Albania (7063 and 7090 kHz). This occupancy throughout the evening hours of virtually the entire 7-MHz amateur band is undoubtedly the most serious form of intrusion at present, but in the first half of 1971, the Intruder Watch recorded almost 100 different broadcast and point-to-point stations operating within exclusive amateur allocations — 7, 14, 21 and 28 MHz. C. J. Thomas, G3PSM, who organizes this valuable monitoring service, has warned that there has been a significant increase in the use of the 21 MHz band by various diplomatic networks.

In the 'shared' bands, such as 3.5 MHz, amateurs accept that they do not have exclusive rights but it seems a great pity that so many wideband multi-channel teleprinter services (each occupying up to 12 kHz) are now to be heard so often just above 3500 kHz.

New microwave records

A new British microwave record for the 10-GHz band was set up recently between Dr Dain Evans, operating in the Presely mountains in Wales as GW3RPE/P, and Robert Skegg (G3ZGO/P) on Dartmoor. By making a 10-GHz contact over a distance exceeding 150km, these amateurs became eligible for the first of a new series of R.S.G.B. microwave operating awards. A similar contact was also established later with M. J. Aylward (G8APP/P) also on Dartmoor. The previous distance record for this band was 65 miles between A. Wakeman (G3EEZ) and Les Sharrock (G3BNL); these two amateurs still hold the British records for 2.3 GHz (100 miles) and 3.4 GHz (54 miles).

Electronics Australia has described in detail equipment used for pioneering 10-GHz amateur experiments in South Australia by Des Clift (VK5CU) and Barry Wallis (VK5ZMW). Des Clift, formerly G3BAK, is using fixed-station equipment developed several years ago in the U.K. but the portable transmitter/receiver is a new all-semiconductor (including i.cs) unit except for the single 2K25 klystron. Contacts have been made over distances of about 15 miles but a second 12-V portable unit is now being built with which it is hoped to achieve longer distance contacts between two portable stations.

Recent British microwave activity has included crystal-controlled operation on 10GHz by Les Sharrock, using a varactor tripler in conjunction with his 9cm crystal-controlled transmitter, and by the GEC amateur radio society (G5FK) where the output stage is a small travelling-wave tube providing about 1-watt output.

In brief

R. Troughton, 2 King James Road, Knaresborough, Yorkshire (Knaresborough 3494) is attempting to form an amateur radio society for the Harrogate and Knaresborough districts and would welcome enquiries from potential members . . . . The 100th licensed member of the Pye Telecommunications Amateur Radio Group — Miss Barbara Clements, G8FDE — was recently presented with a Pye SSB125T equipment by Dr J. M. Westhead, managing director of the company; the local 144 MHz net includes about 80 local amateurs, but she is hoping to obtain a Class A licence which will permit operation in the h.f. bands . . . . An I.A.R.U. Region I conference is to be held at Scheveningen, Netherlands, in May, 1972. The British delegation will be led by R. J. Hughes, G3GVV . . . . Another 15 convictions for unlicensed use of transmitting equipment have followed Post Office investigation; fines and costs totalled over £650 with forfeiture of equipment in almost all cases . . . . In the year to June 30th, R.S.G.B. membership declined marginally by 41 to 16,493 with 331 societies in affiliation . . . . The Ministry of Posts & Telecommunications is actively investigating proposals that a new form of transmitting licence should be issued, the terms designed to give encouragement to young people . . . . Murphy's Law or 'P.O.I.O.' (perversity of inanimate objects) always seems prevalent at times of amateur contests — a recent experience was the failure of the power amplifier valve just five minutes before the start of the 7-MHz DX contest, leading to hectic work in substituting one of the old but reliable 807 valves so much less temperamental than many modern high-perveance valves!

PAT HAWKER, G3VA

Personalities

Honorary Fellowships of the Institution of Electronic and Radio Engineers, "awarded to persons of outstanding distinction in the field of radio and electronic science and engineering," have been conferred on **Professor Harold M. Barlow,** F.R.S., **Professor Walter Bruch** and **Dr. Maurice J. Ponte.** Professor Barlow, Emeritus Professor of Electrical Engineering of University College London, has made notable contributions to radio engineering research and education, in particular in the propagation of microwaves by means of waveguides. Professor Dr. Bruch, the inventor of the PAL system of colour television, is with AEG-Telefunken, Hanover. Dr. Ponte, president of the French company C.S.F. until his retirement three years ago, has made many important inventions in the generation of microwaves.

Two senior B.B.C. engineers, whose joint service is over 76 years, have retired. **E. L. E. Pawley,** O.B.E., M.Sc., F.I.E.E., chief engineer external relations since 1965 retired on 31st October, after more than forty years' service. Mr. Pawley took his degrees at the City and Guilds Engineering College and after five years with the International Standard Electric Corporation, joined the B.B.C. as a lines engineer in 1931. In 1935 he was transferred to the Overseas & Engineering Information Department. From January 1953 to December 1970, Mr Pawley was chairman of the Technical Committee of the European Broadcasting Union. Mr. Pawley will be succeeded by **R. D. A. Maurice,** O.B.E., Dr.-Ing, Ing.E.S.E., F.I.E.E., with the title of chief assistant to the Director of Engineering. Since February 1969, Dr. Maurice has been head of Research Department, and for a year prior to this he was head of Designs Department. Dr. Maurice joined the B.B.C. in 1939. He has been particularly associated with the international planning of television systems, including colour, in committees of the C.C.I.R. and the E.B.U. **L. W. Turner,** F.I.E.E., retires on 7th December after thirty-six years' service. He joined the B.B.C. at the Daventry short-wave transmitting station where he became assistant engineer-in-charge in 1943. He has been head of the Engineering Information Department since 1952 and has been responsible for establishing and maintaining close liaison on engineering matters with the radio industry and trade, and for the supply of technical advice and information to the public. The new head of the Engineering Information Department will be **C. B. B. Wood,** M.B.E., who joined the B.B.C. Research Department in 1946, after war-time radar service with the R.A.F. He has latterly been head of the image scanning section in the Studio Group.

V. J. McMullan, B.Sc., F.I.E.E., is appointed assistant general manager of Plessey Radar. He will be located at the Cowes, Isle of Wight, establishment and will be responsible for all aspects of control and administration relating to the site. Educated at Royal Belfast Academical Institution and Queens University, Belfast, Mr. McMullan has been with Plessey since 1956. For some time he was the company's resident engineer at the Royal Radar Establishment, and later was site manager for Plessey at West Drayton. In 1968 he was appointed divisional manager of the then Software Systems Division, and immediately prior to his latest appointment was administration executive of Plessey Radar.

In order to reduce his commitments and "to give more time to thinking and recreation" **F. H. Worth** has resigned as managing director of the Technograph Group which consists of Technograph Ltd and its wholly-owned subsidiaries Technograph & Telegraph Ltd, Technograph International Developments Ltd, Printed Motors Ltd and George Washington Ltd. Mr. Worth, who is 60, remains a director of Technograph Ltd and chairman of George Washington Ltd. He is succeeded as managing director of the group, and chairman of three of the subsidiary companies, by **F. G. Dunford,** who joined the group a year ago as deputy group managing director. Mr. Worth joined Technograph, then known as Technograph Printed Circuits Ltd, from *The Times* in 1955 when the National Research Development Corporation made Technograph a loan on debenture because it believed that the Eisler printed circuit patents ought, in the public interest, to be more energetically exploited. It is largely through Mr. Worth's persistence that the validity of the Eisler patents was established by litigation extending over nearly ten years ending in a unanimous decision of the House of Lords favourable to Technograph.

A. G. Russell, marketing director for Marconi Space and Defence Systems Ltd for the past two years, is going to Brussels as director (NATO) for the International Division of GEC-Marconi Electronics Ltd. Mr. Russell, who is 51, served as a fighter pilot with the R.A.F. from 1940 to 1946 following which he worked for Burndept, English Electric, and Ultra Electronics. He was appointed commercial manager of GEC at the Broad Oak factory in Portsmouth in 1965, and later divisional commercial manager of GEC Electronics. He then spent two years in Brussels (1967-9) as commercial manager (Europe) for GEC-AEI (Electronics) Ltd. After the merger between GEC and English Electric and the formation of GEC-Marconi Electronics he returned to the U.K. in 1969 to become marketing director of the newly formed Marconi Space and Defence Systems Ltd.

John Millard-Evans, formerly manager of the Repair and Calibration Department of G. & E. Bradley Ltd, has been appointed commercial manager of Bradley Technical Services. He will be responsible for the further expansion of this division with specific emphasis on sales and customer relations. **John L. Cutmore,** who joined the company in 1970, has been appointed manager of the Repair and Calibration Department in succession to Mr. Evans.

C. Hutton-Penman, M.I.E.R.E., has been appointed sales executive and sales manager designate for the Systems Division of I.D.M. Electronics Ltd, Reading. Aged 28, Mr. Hutton-Penman was previously with Smiths Industries Ltd.

John H. Garside, B.Sc., who has been with Electro Mechanisms Ltd, the Slough transducer company, as chief designer (electronics) since 1968, has become engineering manager. A physics graduate of Liverpool University, Mr. Garside, who is 35, started his career in the telemetry division of EMI and spent two years as project manager, visual flight simulators, with Redifon Air Trainers Ltd before joining Electro Mechanisms.

Robert Hall, formerly managing director, Plessey Australia is appointed managing director of Plessey's Electrical Components Division which comprises Plessey Capacitors at Bathgate, West Lothian, under its general manager, **Peter Holdstock,** and a newly formed business known as Plessey Interconnect, based at Northampton and headed by **Robin Addie,** M.A., F.I.E.E., director and general manager. Mr. Addie was managing director of Painton and Co. Ltd, which was acquired by Plessey and has now lost its identity in this reorganization. Mr. Addie, who is a keen radio amateur (G8LT) specializing in RTTY, joined Painton from E.M.I. in 1962.

OBITUARY

Alec H. Reeves, C.B.E., the inventor of pulse-code modulation, has died at the age of 69. Mr. Reeves joined the International Western Electric Co. in 1921 and worked on the transatlantic radiotelephone systems. He joined the company's Paris laboratories on their inception in 1928 and it was while he was there that he originated the method of p.c.m. From 1940 to 1945 Mr. Reeves worked on radio-countermeasures and on aircraft guidance and bombing systems. From 1946 until his retirement he was at the Standard Telecommunications Laboratories at Harlow, Essex.

S. S. Aiyar, B.Sc., chief engineer of All India Radio for the past six years, died recently at the age of 57. An electrical engineering graduate of Benaras Hindu University he later studied electronics at the Indian Institute of Science, Bangalore. He joined the engineering division of A.I.R. in 1937. Mr. Aiyar was chairman of the technical sub-committee which was set up by the Commonwealth Broadcasting Conference in 1963 to co-ordinate frequency usage in the h.f. broadcasting bands in the Commonwealth. He served on many international committees and study groups.

Samuel Handel, M.I.E.E., best known as the compiler of the Penguin Dictionary of Electronics, died on 15th September at the age of 57. Educated at the Regent Street Polytechnic and University College, London, he worked at S.T.C. from 1937 to 1945 and subsequently at E.M.I. for about 10 years before becoming an independent consultant and author. His Pelican book 'The Electronic Revolution' has been translated into many languages.

Differential Discriminator Circuits

Pulse height discriminators can easily be made with integrated circuits

by H. A. Cole, M.I.E.R.E.*

Differential discriminators, or single-channel analysers as they are often called, are used for pulse height analysis[1]. In their simplest form they often consist of two Schmitt-type discriminators (D_H, D_L), followed by some form of logic and pulse producing facility. The discriminators are individually back-biased so that their operating thresholds differ by a voltage (V_W) which is known as the channel (or 'window') width.

The logic circuit functions as an anti-coincidence gate and initiates a channel output pulse only when the amplitude of the input pulse lies within the confines of the channel. If this pulse fails to reach the lower limit of the channel set by the low-level bias (V_L), or if it exceeds the upper limit set by high-level bias (V_H), then no output pulse appears.

This article describes a very simple differential discriminator circuit (Fig. 1), based upon the dual differential comparator type SN72720N[2]. The logic circuit is composed of NAND-gate t.t.l. elements of the SN74 series[3].

The discriminators are connected to operate with negative values of back bias, and to produce positive-going output pulses for negative input signals. Many other forms of connection are possible[4].

Some small amount of hysteresis (about 50 mV) is provided for each discriminator by the feedback resistors labelled R_3. The actual amount of hysteresis is given by: $V_0[R_1/(R_1+R_3)]$, where V_0 is the output voltage produced by D_H or D_L; this is typically 3.5V. It is important to note that R_1 includes the source resistance of the bias supply.

In this instance R_2 was chosen for correct termination of a 100Ω cable. The resistors R_1 were then chosen so that their parallel-connected resistance equalled that of R_2. Equalizing the source impedances of the inverting and non-inverting terminals of the discriminators in this way helps to minimize the effects of input offset current drift.

The two inverting gates G_1, G_2, serve to provide trigger pulses of the correct polarity for the logic circuit and, at the same time, sharpen-up the output waveforms produced by the discriminators. However, if the discriminators are connected to produce negative-going outputs, or if NOR (instead of NAND) logic is used, then G_1 and G_2 need not be used.

Logic circuit

Three monostable circuits formed from five NAND-gate elements constitute the logic circuit. Two of the monostables (MS_1 & MS_3) are connected as a cascade type[5] in which one gate (G_6) is shared by both monostables. Monostable MS_3 is triggered by the trailing edge of the waveform ($\bar{A}$) produced by MS_1, and is gated by the waveform ($\bar{B}$) produced by the second monostable (MS_2). It is arranged that the duration (t_2) of $\bar{B}$ is always slightly longer than $\bar{A}$ plus $\bar{C}$ i.e.,

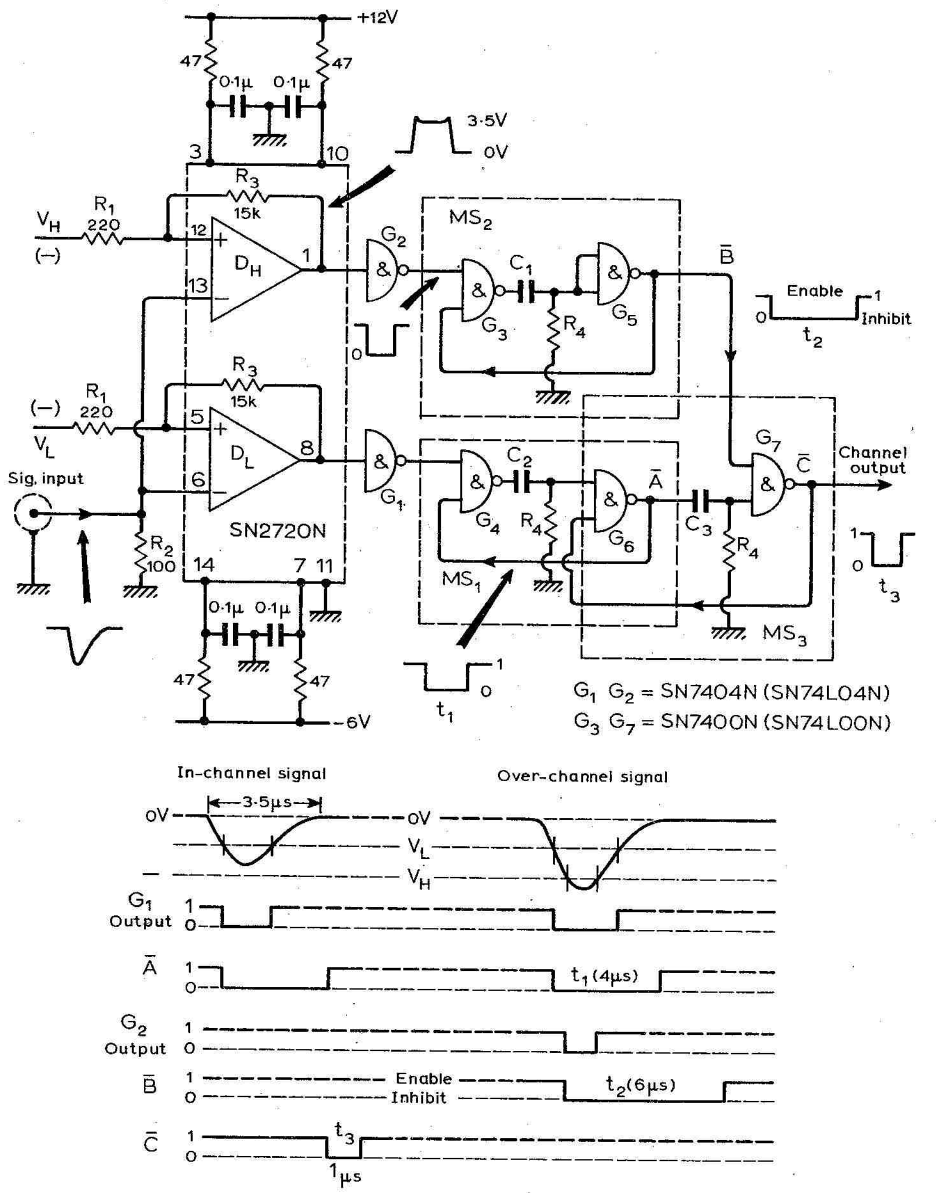


Fig. 1. Circuit diagram of the pulse height discriminator with typical waveforms.

*Electronics and Applied Physics Division, A.E.R.E., Harwell.

$t_2 > (t_1 + t_3)$. It is further arranged that the pulse $\bar{A}$ is always longer than the duration of the input signal. Typical operating waveforms for in-channel and over-channel signals are shown in Fig. 1.

When an in-channel signal is received, the low-level bias of D_L is exceeded and a trigger pulse is applied to MS_1; the waveform $\bar{A}$ is therefore produced. Since the input signal amplitude does not exceed the high-level bias, no trigger pulse is applied to MS_2 and G_7 of MS_3 is held in the 'enabled' state by the high level supplied from G_5 and a channel output pulse $\bar{C}$ is produced when the trailing edge of $\bar{A}$ occurs.

When an over-channel signal is received, both high- and low-level bias thresholds are exceeded and output waveforms $\bar{A}$ and $\bar{B}$ are produced by MS_1 and MS_2. The logical-'0' level produced by $\bar{B}$ holds G_7 of MS_3 in the 'inhibited' state, and thereby prevents it producing a channel output pulse.

The gates which form each monostable are coupled by the components labelled C_1, C_2, C_3 and R_4. To a first approximation, the output pulse duration for the monostables is given by: $t = 1.3\ CR$.

The maximum permissible value for R is approximately 470Ω for normal-power t.t.l., and about 4.7kΩ for low-power t.t.l. If these maximum values are used, so that the values of C may be minimized, the expressions for output pulse duration become:

$t(\mu s) = 6 \times 10^{-4} C$ (normal-power t.t.l.)

and

$t(\mu s) = 6 \times 10^{-3} C$ (low-power t.t.l.)

where C is expressed in pF.

The maximum permissible repetition rate of the input signal is approximately determined by the duration of the pulse produced by MS_2.

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2. Dual differential comparator type SN72720N; Texas Instruments, Bedford. Similar devices are MC1514 (Motorola), and TDC4711 (Transitron).
3. Semiconductor and Components, Data book 1, Texas Instruments, 1968.
4. 'The Application of Linear Microcircuits'. Vol. 1. SGS-UK Ltd. 1969 p.91.
5. Cole, H. A. 'T.T.L. Monostable Cascade' *Wireless World*, Vol. 77, June 1971, p.301.

Linear Ramp Generator

A practical design operating in free-run, synchronized and trigger modes

*by J. B. F. Cairns**

The electronics engineer often has occasion to provide a linear ramp as a timebase for oscilloscopes or similar equipment, and in delay or counting circuits.

This article describes a circuit configuration which is easily designable. An example is given of its use for an oscilloscope timebase for which it is especially suitable.

Circuit description

The basic circuit of Fig. 1 is a standard arrangement. Capacitor C is charged from a constant current source until the voltage across it reaches a pre-determined level. At this point a switch in parallel with the capacitor is closed and the capacitor discharges until the voltage falls below another pre-set level at which the switch is opened. In this way a saw-tooth waveform is generated whose rates of rise and fall are determined, for any value of capacitor, by the current i flowing from the source and the impedance R of the switch.

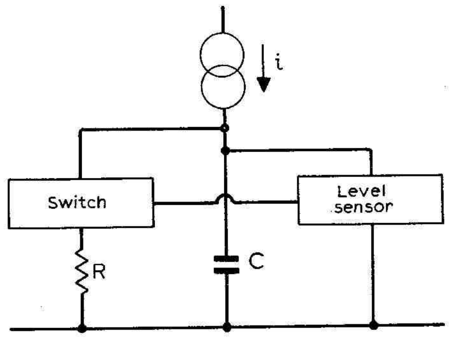


Fig. 1. Basic ramp generator.

Oscilloscope application

In the application shown in Fig. 2, the circuit of Fig. 1 is modified by the addition of a stage which allows the signal to the level sensor—in practice a Schmitt trigger—to be modified by an external signal and/or held off just above the lower trip point. This modification allows the circuit to operate in free-run, synchronized or trigger modes depending on the setting of one control.

One particular advantage of this configuration for oscilloscope use is that the Schmitt provides a blanking signal during flyback (when the switch is closed). Another is that there are no synchronizing pulses generated while the capacitor is charging and so the problem of suppression does not arise.

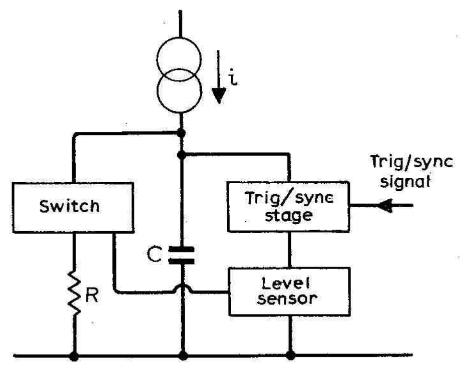


Fig. 2. Adding a triggering and synchronizing stage to the level sensor.

Practical circuit

The complete five-stage generator circuit is shown in Fig. 3. The operating mode is determined by the function of the trigger/sync stage centred on Tr_5. The ramp signal may be clamped by the diode D_1 to the potential at the emitter of Tr_5. This potential is established by the resistance in chain R_{10}, R_{11}, and R_{12} and may, therefore, be set by R_{11}. The sync/trigger signal is introduced via C_c and R_{13} and thus appears as a small-signal excursion about the d.c. level set by R_{11} at the emitter of Tr_5. The method of operation is as follows:

Free run: The potential at the emitter of Tr_5 is set more negatively than the most negative point attained by the ramp. D_1 is thus always reverse biased and the trigger/

*Meteronic Ltd.

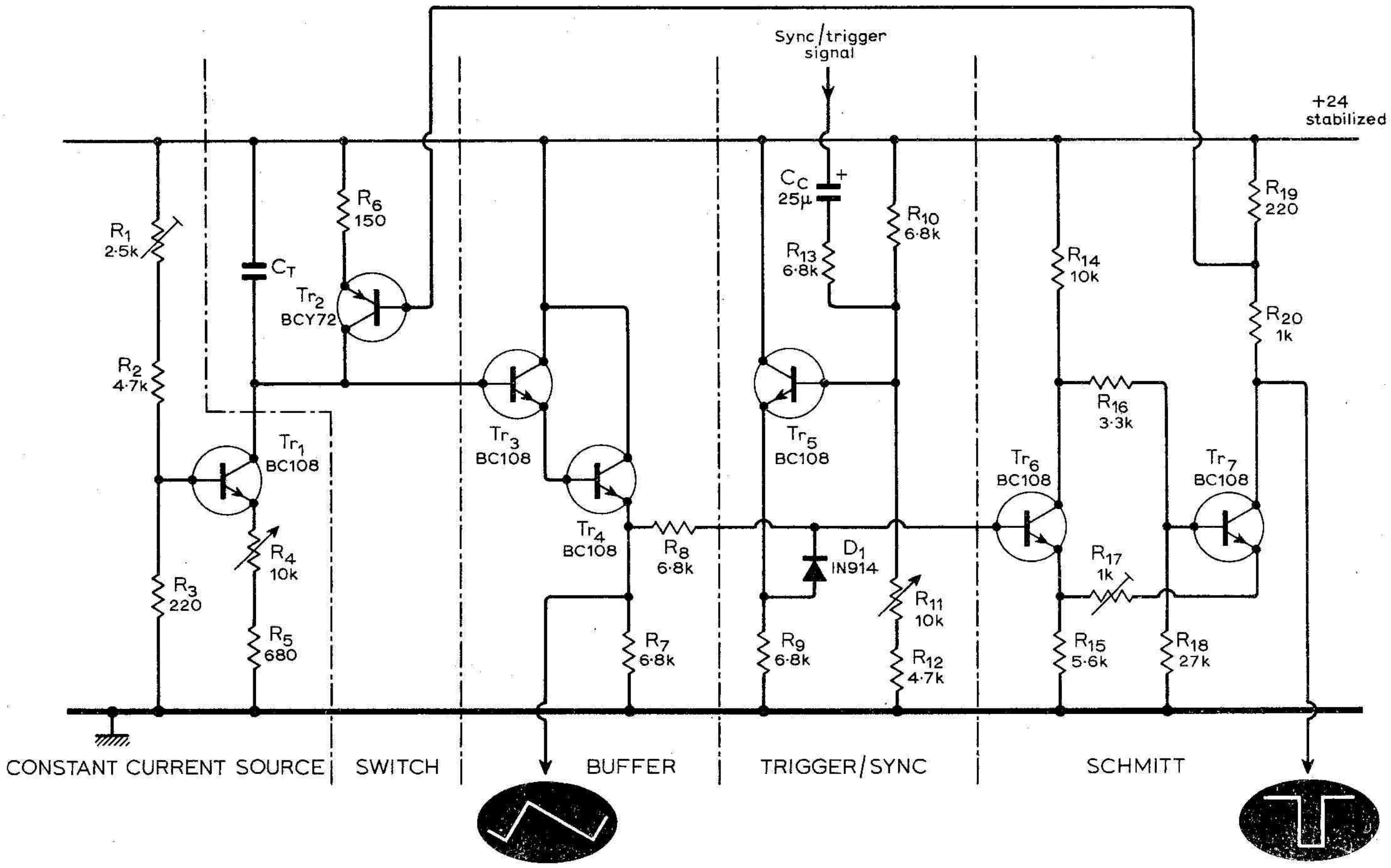


Fig. 3. Circuit of generator. The maximum ramp slope with C_T=470pF is 2×10⁴V/s.

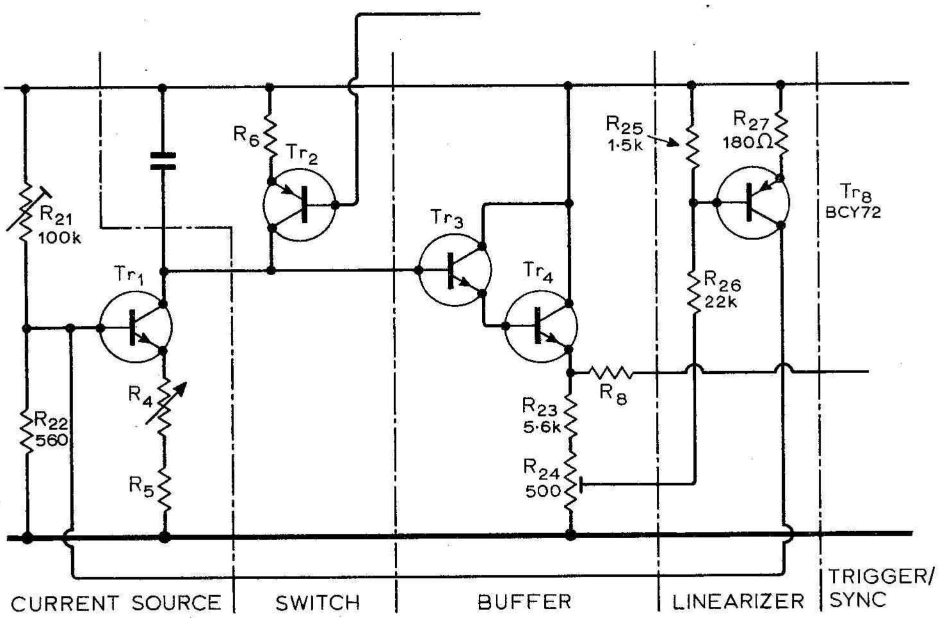


Fig. 4. Modifications to increase ramp linearity.

sync stage has no effect on the operation of the circuit.

Synchronized mode: The potential at the emitter of Tr_5 is set just below the lower trip point of the Schmitt so that in the absence of a synchronizing signal, the operation is as above. However, when a synchronizing signal is present, the diode D_1 may become momentarily forward biased so that the potential at the base of Tr_6 is held just above the lower trip point until the synchronizing signal falls and thus allows the circuit to operate normally. The ramp signal is isolated from this control by R_8 and so the ramp continues to fall until the synchronizing signal allows the Schmitt trigger to operate. The ramp is thus synchronized with the external signal.

Trigger mode: The potential at the emitter of Tr_5 is set by R_{11} somewhat above the lower trip point of the Schmitt trigger. The diode D_1 then comes into forward bias before the Schmitt trips and consequently holds off the Schmitt until the trigger signal provides a momentary drop in the potential at the emitter of Tr_5 so that this level falls below the lower Schmitt trip point and one cycle of the circuit's operation is initiated.

Improved linearization

While the linearity of the ramp provided by the basic circuit is good, it may be improved for highly critical applications by the introduction of a linearizing stage. The operation of this stage depends upon the fact that the major sources of non-linearity may be treated as being equivalent to a single leakage current. This stage provides a means of cancelling out such a leakage current. It also makes a significant reduction in the temperature dependence of the circuit. The mode of operation of the circuit shown in Fig. 4 is as follows:

The resistor R_7 in the basic circuit is replaced by R_{23} and R_{24} so that a small proportion of the ramp signal may be picked off by the slider of R_{24}. This signal is attenuated by R_{26} and R_{25}, which together determine the d.c. bias conditions for Tr_8. This transistor (Tr_8) then inverts and amplifies the signal (approximately in the ratio R_{22}:R_{27}) and introduces a small correcting voltage at the base of Tr_1. Resistors R_2 and R_1 are replaced by R_{21} which is high in value compared to R_1 and R_2, as the principal source of current in R_{22} is now that flowing in Tr_8.

The Decoupling Capacitor

How to calculate its value

*by P. Engstrom**

How to calculate the value of the capacitor bypassing the bias or stabilizing resistor in common-emitter/source/cathode stages does not seem to be well known. It is not sufficient to use the old rule of thumb that the reactance of the capacitor should be one tenth of the resistor value at the lowest frequency, as pointed out in an earlier article (May 1965 issue). The author gives simple formulae for finding the value in valve and transistor circuits and shows how they are derived.

In amplifier stages with bipolar transistors, f.e.ts or valves a resistor is frequently needed for biasing or stabilization of the quiescent point in the common-emitter, common-source or common-cathode configuration. Normally a parallel decoupling capacitor prevents this resistor from decreasing the amplification of the stage.

The value of this capacitor can be calculated from the following formulae and in this article I show how these formulae are derived.

bipolar transistor $C = \frac{h_{fe}}{2\pi f_1(h_{ie}+R_s')}$

f.e.t. and valve $C = \frac{1}{2\pi f_1}\left(g_m+\frac{1}{R}\right)$

where R_s' is the source resistance, R the bypassed resistance and f_1 the 3-dB cut-off frequency. In particular, for a bipolar transistor stage

$$C \approx \frac{6000\, I_c}{f_1}\,\mu\text{F or } \frac{6\, I_c}{f_1}\,\text{mF } (I_c \text{ in mA}).$$

The impedance of the capacitor is of course frequency dependent and the common electrode can be properly earthed only above a certain frequency—the lower cut-off frequency f_1. Below f_1 feedback is introduced and amplification of the stage decreases. The cut-off frequency f_1 is defined as the frequency where the power amplification has decreased by 3 dB, that is when the voltage amplification has decreased to $1/\sqrt{2}(\approx 0{\cdot}7)$ of the value at mid-frequency.

The decoupling capacitor is usually an electrolytic type with a capacitance of the order of 100 μF for low frequencies. It will consequently be rather expensive, sometimes more costly than the active element. It is therefore important to calculate its value with care. However, useful methods of calculation are not well known and the constructor has mostly been forced to trust to trial and error.

An equivalent circuit which can be used with good approximation for the bipolar transistor, f.e.t. and valve is shown in Fig. 1. The symbols of the circuit are related to the more common notations for the three elements, respectively,

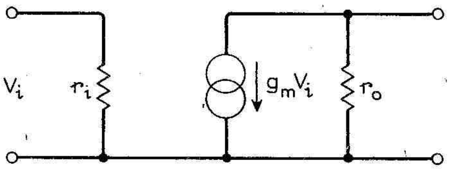


Fig. 1. Simple equivalent circuit for both valve and transistor.

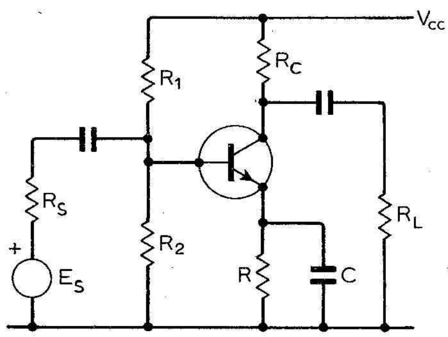


Fig. 2. Typical common-emitter stage which, for the purposes of this article, can also be considered as a common-source and common-cathode stage by making $R_1 = \infty$ and $R_2 = R_g$.

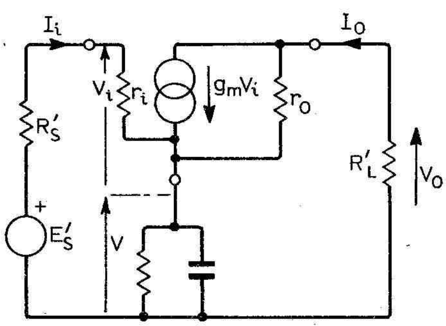


Fig. 3. Ignoring coupling capacitors, this equivalent circuit represents the stage of Fig. 2 for both the valve and transistor cases and allows the formulae for calculating the bypass capacitor to be derived.

bipolar transistor

$r_i \approx h_{ie}$, $r_o \approx 1/h_{oe}$,

$g_m \approx 38\, I_c \approx h_{fe}/h_{ie} \approx 1/h_{ib}$

f.e.t.

$r_i \approx \infty$, $r_o = r_d$

valve

$r_i \approx \infty$, $r_o = r_a$

Assume the active element works in the circuit of Fig. 2. (In the case of a valve and field-effect transistor $R_1 = \infty$, $R_2 = R_g$.)

The active element will look into a source with e.m.f. E_S' and the internal resistance R_S', which in Fig. 2 consists of $R_S \| R_1 \| R_2$, or $R_S \| R_g$ in the case of a valve of f.e.t. The load R_L' of the element will be $R_C \| R_L$. (The sign $\|$ means in parallel with.)

We make the coupling capacitors so large that they have no influence on the cut-off frequency (these are usually much cheaper than the decoupling capacitor) and for all three cases of Fig. 2 the equivalent circuit will be as Fig. 3.

If we further suppose that $I_i \ll I_o$ we get the set of equations

$$E_S' = \frac{V_i}{r_i}(R_S'+r_i)+V$$

$$V_o = -R_L' I_o$$

$$V = I_o \frac{R}{1+j\omega RC}$$

$$I_o = g_m V_i + \frac{V_o - V}{r_o}$$

We are looking for $A_V = V_o/E_S'$ so eliminating V_i, V and I_o, $A_V = V_o/E_S' =$

$$\frac{g_m\Big/\left(1+\frac{R_S'}{r_i}\right)}{\frac{1}{r_o}+\frac{1}{R_L'}+\frac{R}{R_L'}\frac{1}{1+j\omega RC}\left[\frac{1}{r_o}+g_m\Big/\left(1+\frac{R_S'}{r_i}\right)\right]}$$

Let $g_m' = g_m/(1+R_S'/r_i)$ and assume that $r_o \gg R_L'$ and $r_o \gg 1/g_m$, then

$$A_V = -\frac{g_m' R_L'}{1+g_m' R\frac{1}{1+j\omega RC}}.$$

*Lund Institute of Technology, Sweden

The amplification at mid-frequencies ($\omega RC \gg 1$) is $A_{V_o} = -g_m'R_L'$

$$A_V = \frac{A_{V_o}}{\dfrac{1+g^{m\prime}R+j\omega RC}{1+j\omega RC}},$$

At the lower cut-off frequency $\omega_1 = 2\pi f_1$, therefore

$$|A_V| = \frac{|A_{V_o}|}{\sqrt{2}}$$

and so $$\sqrt{2} = \left|\frac{1+g_m'R+j\omega_1 RC}{1+j\omega_1 RC}\right|$$

$$= \sqrt{\frac{(1+g_m'R)^2+\omega_1{}^2R^2C^2}{1+\omega_1{}^2R^2C^2}}$$

$$\omega_1 = \frac{1}{RC}\sqrt{(g_m'R)^2+2g_m'R-1}.$$

To make this real $g_m' > \sqrt{2}-1$, otherwise the gain will never fall by 3 dB. To make the formula practicable assume that $g_m'R$ is somewhat greater than this limit, for example $g_m'R > 5$. With an error less than 3%,

$$\omega_1 \approx \frac{1}{C}\left(g_m'+\frac{1}{R}\right) \text{ or } C = \frac{g_m'}{2\pi f_1}+\frac{1}{2\pi f_1 R}.$$

With f.e.ts and valves $g_m' = g_m$ as $r_i = \infty$. With bipolar transistors $g_m' \gg 1/R$ or $h_{ib} \ll R$. Thus formulae for C are

$$\text{bipolar transistor } C = \frac{h_{fe}}{2\pi f_1(h_{ie}+R_S')}$$

$$\text{f.e.t. and valve } C = \frac{1}{2\pi f_1}\left(g_m+\frac{1}{R}\right)$$

Taking the expression for the transistor, assuming that $R_S' \ll h_{ie}$ and using the expression $g_m = 38\,I_c$ (where I_c is the quiescent collector current in mA, g_m in mA/V) an approximate formula for calculating the decoupling capacitor is

$$C \approx \frac{38\,I_c}{2\pi f_1} \approx \frac{6\,I_c}{f_1}\text{mF} \quad \text{or} \quad \frac{6000\,I_c}{f_1}\mu\text{F}$$

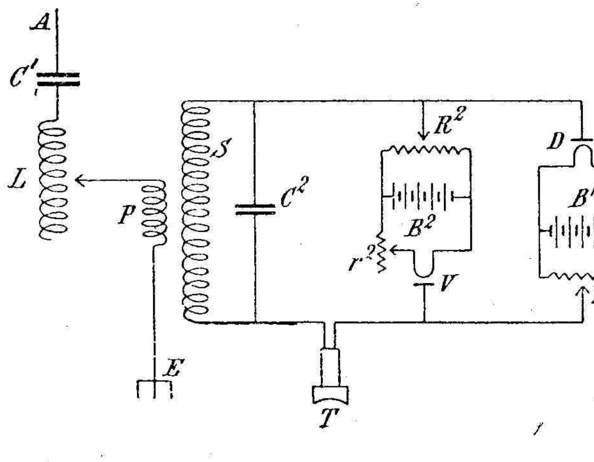
where I_c is in mA and f_1 in Hz.

Sixty Years Ago

December 1911. In an article "Improvements in Receiving Apparatus", which describes a patent filed in 1900 by H. J. Round, the first reference is made in *The Marconigraph* to the thermionic valve. We reproduce the circuit below and let the original text tell the story.

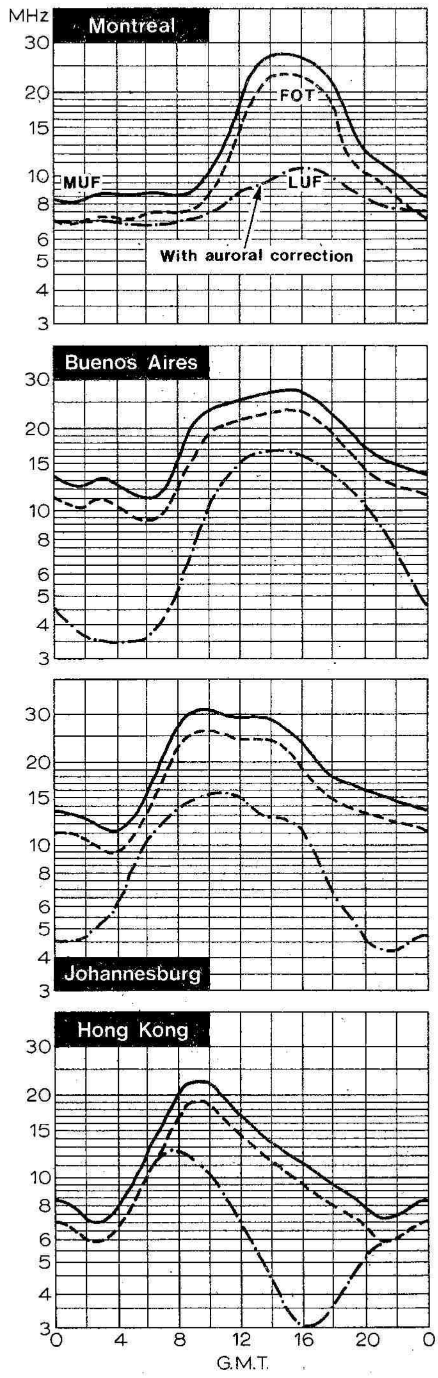
"The specification describes means for reducing or eliminating the effects of atmospheric discharges on wireless telegraph receivers. For this purpose variable conductors are connected across a part of the receiving circuit in such a way that while they do not interfere with the receipt of signals, yet under the action of powerful atmospherics they become good conductors, and offer a shunt-path to the currents which would otherwise affect the detector. These variable conductors consist of practically any form of so-called valves, such as mercury vapour valves, Fleming valves or crystal detectors, and usually two of them are connected in parallel and in opposition.

"In the figure reproduced herewith, which shows one of the many forms of apparatus described, two Fleming valves are employed, one of which acts as the detector and the other as the variable conductor. The aerial, A, is connected to the earth, E, through the condenser, C1, inductance, L, and primary, P. The secondary, S, is connected to the condenser, C2, and across this condenser are the valve receiver, D, and telephone, T. The variable conductor, V, is connected in parallel with the receiver, D. The filaments of the valves, D and V, are rendered incandescent by the current from the batteries, B1 and B2, passing through the adjustable resistances, r1 and r2, respectively. R1 and R2 are potentiometers for varying the voltages across the valves, and thus adjusting their sensitiveness so that the detector, D, is affected by the received signals, while the valve, V, is affected by powerful atmospherics. When the circuits are in tune, signals can be received in the telephone, T, if they are not sufficiently strong to affect the variable conductor, V, but if a powerful atmospheric discharge occurs, the valves, D and V, become almost equally operative, and being in opposition no rectification takes place, and no sound is produced in the telephone, T."



H.F. Predictions — December

The optimum traffic frequency (FOT) is that below which skywave communication should be possible on at least 90% of days during the month and is almost entirely governed by the ionosphere. The lowest usable h.f. (LUF) is the frequency above which a specified signal-to-noise ratio will be exceeded for 90% of the time and, as attenuation of the radio wave is inversely proportional to frequency, depends principally on effective radiated power. Predicted frequencies are generally accurate to better than 10% for given ionospheric conditions. Unfortunately, as with the weather, ionospheric forecasts for several months in advance can be somewhat in error. Regardless of their absolute accuracy however, MUF curves indicate the difficulty of communication at a given time by their slope relative to the time axis and proximity to the LUF.



New Products

Cassette recording heads

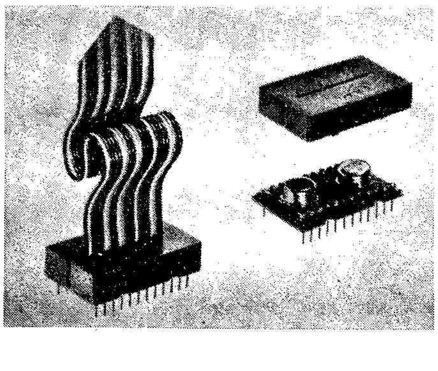
A range of one- and two-track read-after-write magnetic head assemblies designed for cassette recording systems has been announced by Gresham Recording Heads. The heads measure 12.2 × 8.64 × 14.0mm and produce 4.0mV (p-p) output at 1600 f.r.p.i. (flux reversals per inch) at a tape speed of 3¾ i.p.s. from a signal recorded using the optimum write current of 5mA (p-p). Crossfeed is between 20 and 26dB down at 1600 f.r.p.i. depending on tape speed. Intertrack cross-talk is −40dB. Resolution at 1600 f.r.p.i. is 75-90% of output at 800 f.r.p.i. Gresham Recording Heads Ltd, Weybridge Trading Estate, Weybridge, Surrey.
WW319 for further details

Low-cost l.e.ds

Two types of gallium-arsenide-phosphide lamps, each with a red plastic lens giving wide angle visibility, are available from Hewlett-Packard. The HP 5082-4440 has straight leads (most suitable for panel mounting) and type HP 5082-4444 has right-angled leads (for p.c. boards). The lamps are compatible with most i.cs without additional drive components. A simple snap-in clip is available for front panel mounting. Price: 44p each for 100-up quantities. Hewlett-Packard Ltd, 224 Bath Road, Slough, Bucks.
WW323 for further details

D.I.L. pin header/plug

The A23-2054 pin header/plus from Jermyn fits most 24-lead 0.6in pitch d.i.l. sockets. It provides a plug-in housing for



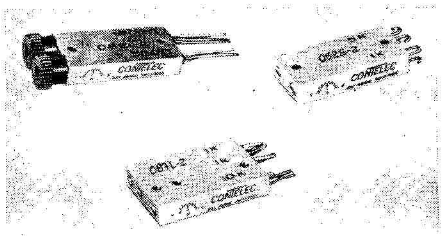
discrete components, which are soldered between terminal extensions and protected by a clip-on cover, and may alternatively be used as a plug, the cover being provided with slots in the top and one end for cable entry. Contact pins are gold plated, and the cover and body are moulded in glass-filled nylon. Insulation resistance between the contact pins is typically 10^4MΩ at 500V d.c. Price: £1 each. Jermyn Industries, Manufacturing Division, Vestry Estate, Sevenoaks, Kent.
WW324 for further details

Spray-on moisture sealer

CRC 2-26 moisture sealer from Electrautom spreads under moisture by virtue of its low surface tension. It is claimed to protect and restore metal contacts, relays and switches. Protection also comes from passivation by bonding to active metal surface ions and from elimination of electrolyte and corrosive media. The film deposited has high dielectric strength. As a lubricant it is equivalent to a 10 wt. motor oil. Solvents evaporate in 4-6 hours. It is available in aerosol and bulk packages. Electrautom Ltd, Queens Road, Maidstone, Kent.
WW305 for further details

Multi-track trimmer resistors

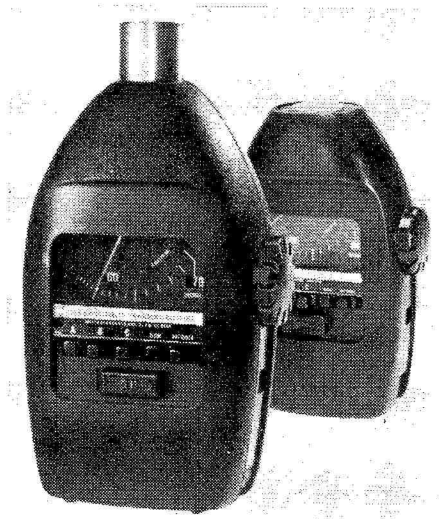
A precise wirewound trimmer with either two or three independent resistance elements and made by Contelec has been introduced by Kynmore. Packaged in a damp-proof anodized aluminium case, type 062 has two resistance elements, and type 087 has three. Both cover the range 10Ω to 125kΩ, and the temperature range −55° to 170°C. The 22-turn units are 6.36mm high and 31.75mm long. Width of the 062 is 15.80mm, and the 087, 22.20mm. Resistance tolerance between multiple elements is ±2%. Units with 45 turns are available to order. Each resistance element in the housing is adjusted individually with a screwdriver, and is self-locking. The wiper brush track provides continuous wiping action under 'extreme



conditions' of vibration, shock and acceleration. Terminals are gold-plated printed circuit pins. Kynmore Engineering Co. Ltd., 19 Buckingham Street, London W.C.2.
WW320 for further details

Sound-level meters

Two sound-level meters which conform to both national and international standards are available from General Radio Company (U.K.). Type 1565-B meets the requirements of ANSI S1.4-1971 type 2. It operates up to 50 hours on internal batteries and permits measurements with



A, B or C weightings. The operator turns a dial to set the dB level, presses a button to select the weighting, and reads the noise level directly from the meter. Type 1563 is similar to the 1565-B but is designed to meet the less demanding requirements of ANSI type 3 survey meters. General Radio Company (U.K.) Ltd, Bourne End, Bucks. SL8 5AT.
WW315 for further details

Eyepiece-less image presentation for microscopes

A new form of image presentation is used in the Dynascope microscope adaptor, developed by Vision Engineering, and seen at Internepcon at Brighton. It avoids close positioning of the head, allows easier examination of the field edge and can allow more than one person to view the image at the same time. In avoiding the usual microscope eyepiece, the limitation on exit pupil

size (normally a fraction of an inch as defined by magnification and aperture) has been overcome by using a novel technique to get a large effective pupil. Because of patent and licensing arrangement in progress, Vision Engineering are not saying exactly how it works but it relies on a pupil scanning technique to increase effective pupil size to 5in diameter. The normal pupil is scanned in an overlapping way using a 1500 rev/min rotor, onto which the image is displayed. The Dynascope is available as an add-on for existing microscopes at £265, and combined with a microscope at £650. Vision Engineering Ltd, Send Road, Woking, Surrey
WW311 for further details.

Solid-state s.s.b. receivers

Two single-sideband general-purpose communication receivers, the Apollo and Nebula, have been introduced by Marconi International Marine. They anticipate forthcoming new s.s.b. regulations, and have been type-approved by the Ministry of Posts and Telecommunications.

Reception modes of the Apollo are A1 (c.w.), A2(m.c.w.), A3(d.s.b.) and A3A/A3H/A3J(s.s.b.). Mode F1 (for f.s.k.) reception is also available. For general-purpose reception the frequency coverage is 15kHz to 28MHz. This is arranged in ten overlapping switchable bands containing all the normal marine s.s.b. and d.s.b. radiotelephone frequencies. Problems of frequency drift due to temperature variations are said to be largely overcome by the frequency control provided by a partial synthesis system, and the use of solid-state devices throughout. In the high stability mode the typical frequency stability figures show a drift of 5Hz per hour at 28MHz sixty minutes after switch-on.

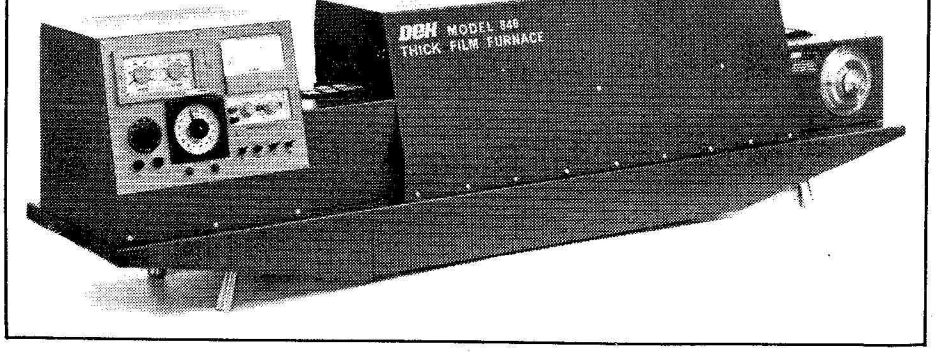
To meet the problem of s.s.b. tuning the Apollo incorporates an accurate frequency counter with a digital read-out. This allows the receiver to be first tuned mechanically to within 100Hz of the required frequency, and then to be tuned electrically to within 10Hz. As this frequency counter measures the incoming radio frequency via the first local oscillator and is not an integral part of the receiver circuitry, the receiver will not be rendered inoperative should the counter fail, as is the case with some fully synthesized receivers. Tuning can still be achieved by use of the logging scales.

The Nebula can be considered a 'junior' to the Apollo and has the same reception modes. Compactness has been achieved by the use of solid-state circuitry throughout and the receiver measures 133mm high, 455mm deep and 483mm wide. The majority of components are mounted on printed circuit cards which are contained in plug-in modules. This feature lends itself to servicing by substitution. The s.s.b. and d.s.b. reception modes are identical to those of the Apollo and the frequency coverage is 10kHz to 30MHz, in ten overlapping bands, with high stability operation for s.s.b. working on all frequencies above 1.6MHz. Audio output is provided via headphones or an internal loudspeaker and arrangements have been made to allow external loudspeakers or transmitter telephones to be connected. Marconi International Marine Co., Elettra House, Westway, Chelmsford, Essex.
WW309 for further details

Thick-film production

A relatively inexpensive furnace for thick-film production, based on a design by a senior lecturer at Brighton Polytechnic, is made by DEK Printing Machines. Previously thick-film furnaces have cost a few thousand pounds and together with the cost of printing machines this may have prevented many potential users from producing thick-film circuits themselves. Now, a complete production unit can be bought for around £1000.

The DEK model 840 furnace differs from other types in that it has a single heated zone. Normally furnaces have regions at different temperatures so that the required temperature profile is obtained with a constant-speed belt. To cheapen the furnace, the temperature is held constant and the belt automatically stopped to allow temperature to rise. The length of time the belt is stopped is controlled by a timer. Belt speed is variable, controlled to within 1%, and temperature can be held to within 0.5%. DEK Printing Machines Ltd, Granby Industrial Estate, Weymouth, Dorset.
WW310 for further details.



Metal film resistors

The range of 50-p.p.m./degC Beyschlag metal-film resistors marketed by ITT Components Group Europe has been extended to include values from 1Ω to 510kΩ. The range includes 0.25W, 0.5W and 0.7W maximum power ratings. Tolerances available are 1% and 2%. ITT Components Group Europe, Resistor Product Sales, Edinburgh Way, Harlow, Essex.
WW318 for further details.

V.h.f. f.e.t.

High-frequency f.e.t., type U310 from Siliconix Ltd, is rated as having a worst-case input match (75Ω) of 1.25: 1 v.s.w.r. and a typical figure of merit $g\ fs/(C_{gs} + C_{gd}) = 2.35 \times 10^9$. Power gain is 16 to 20dB at 100MHz and 11dB at 450MHz,

gate mode. Typical noise figure at 450MHz is 3dB and dynamic range is greater than 100dB. Operating temperature range is −65 to +150°C and power dissipation at 25°C is 500mW – the encapsulation is a TO-52 case. Siliconix Ltd, Saunders Way, Sketty, Swansea SA2 8BA.
WW 313 for further details

R.F. interference measuring transducer

A radio-frequency current transformer designed for use in r.f. interference measurement, is available from Control Technology. The winding of the transformer is electrically shielded and arranged so that when connected to a correctly terminated 50Ω line, resonances are eliminated. The magnetic design is such that the falling frequency characteristic permits the measurement of small r.f. currents in the presence of large power frequency currents. The size of the central bore is sufficient to permit the threading of large coaxial connectors.

Specification:

transfer impedance	4.6Ω (1.0 MHz)
insertion impedance	0.1Ω (0.1 MHz)
usable frequency range	0.1 MHz—100 MHz
power frequency current rating	200A (d.c.—60Hz)
output connector	50Ω coax. b.n.c.
central bore	38mm

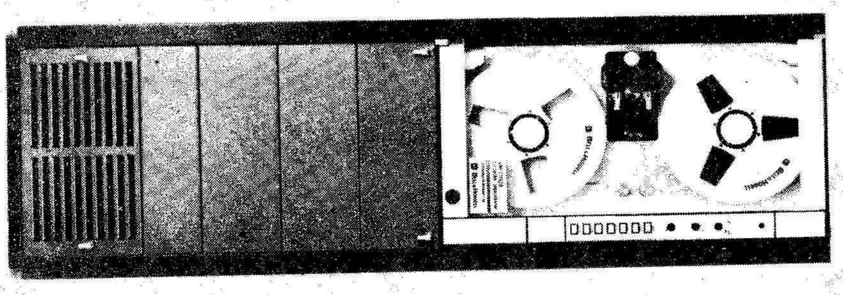
Control Technology Ltd, Meeching Road, Newhaven, Sussex.
WW326 for further details

Trimmer capacitors

A range of tubular ceramic trimmers—the S58-11 series from Wingrove & Rogers – have capacitances up to 16pF and power factors of from 0.0001 to 0.001 at 1MHz. Insulation resistance is not less than 10,000MΩ at 500V d.c. Wingrove & Rogers Ltd, Domville Road, Mill Lane, Liverpool L13 4AT.
WW 316 for further details.

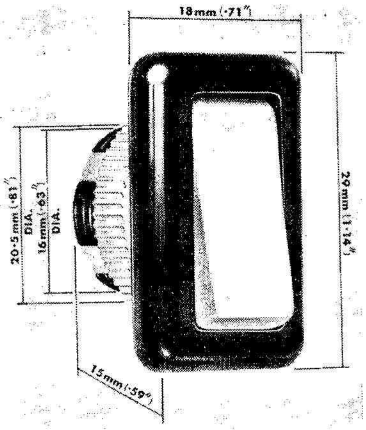
Large bandwidth f.m. recorder

The VR3700B f.m. tape recorder from Bell & Howell has nine tape speeds—from 15/16 to 240 i.p.s.—and will take reels up to 15in diameter. Fourteen, 28, or 42 tracks can be supplied as standard, using 1in tape. There are two ranges of direct operation—600kHz and 2.0MHz at 120 i.p.s. In the f.m. mode frequency response is given in I.R.I.G. group I d.c. as 80kHz and in I.R.I.G. group II d.c. at 500kHz. Bell & Howell Ltd, Electronics and Instruments Group, Lennox Road, Basingstoke, Hants.
WW3 21 for further details



Rocker switches

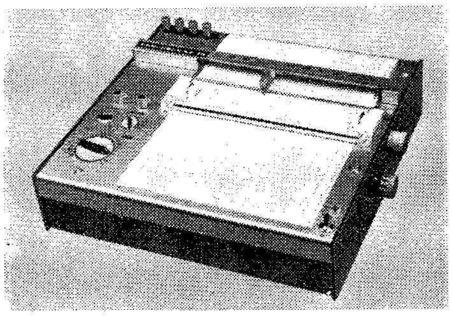
A range of single-pole rocker-action switches for operation up to 250V a.c. at 2A is available from Bulgin. The units are of black or white plastic with a range of coloured rockers. Electrical connections are



by screw terminal. The action is light, and the contacts are of silver. Rear nut fixing and push fit types are available. Price 14p each (1—9). A. F. Bulgin & Co. Ltd, Bye Pass Road, Barking, Essex.
WW325 for further details

Chart recorders

Four potentiometric chart recorders with a response time of 0.5s and a sensitivity of 1μV/mm are announced by Smiths Industries. This 1S range offers four recording modes — linear, lin-log, linear with integrator and lin-log with integrator. The instruments have an accuracy of ±0.5% f.s.d. and a resolution of ±0.25% f.s.d. Operating over the range −10° to +50°C the temperature drift is less than 0.1% per 10°C. Multi-range models are available and f.s.ds from 200μV to 500V can be provided in 17 ranges. Other features are zero supression, gearbox with eight forward and reverse speeds and a rechargeable ink pen.



In the models with integrator, 20mm of the 200-mm paper width are allocated to a separate pen whose writing *speed* is proportional to the applied signal — achieved by the ball and disc technique. Smiths Industries Ltd, Industrial Instrument Division, Wembley Park Drive, Wembley, Middx HA9 ONU.
WW 308 for further details

Switching regulator power supply

The 620 series power supply from Trio Laboratories provides 5V at 12A and either ±12, ±15, or ±18V at 1A. Alternative current and voltage levels can be provided. There is no mains transformer in the design. The unit is 65% efficient and operates between −20° and 70°C without forced cooling. Under severest conditions regulation at the 5V output is ±0.3%, with ±0.1% at the other ± output. Ripple and noise at the 5V output is 10mV r.m.s., 50mV p-p maximum; at the other ± output 3mV r.m.s. 30mV p-p max. Full output is provided with the mains as low as 160V a.c. Trio Laboratories Ltd. 16a Commercial Road, Woking, Surrey.
WW322 for further details

Opto-electronic coupler

An optically coupled isolator, type FPLA 820 from Fairchild Camera and Instrument Corporation, combines a gallium arsenide light emitting diode with a high-gain silicon n-p-n photo-transistor. The unit is i.c. compatible at both input and output terminals. Current transfer ratio is 50%, voltage isolation greater than 1500V. Input-to-output capacitance is low, and switching speed is 3μs. Housing is a six-lead plastic dual-in-line package. Macro-Marketing Ltd, 390 Bath Road, Slough, Bucks.
WW 312 for further details

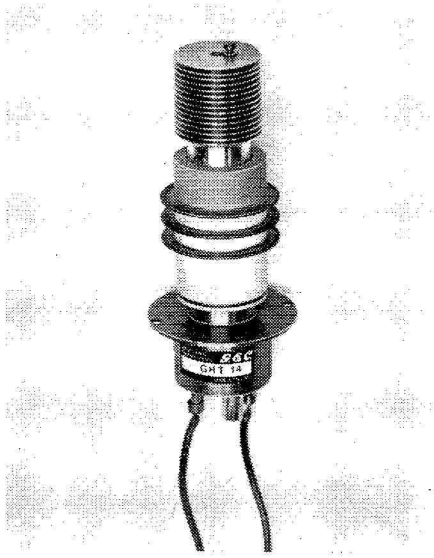
High-speed t.t.l. i.cs

A range of t.t.l. logic circuits, designated RAY III, developed by Raytheon and marketed in this country by Eurosem International have a power dissipation of typically 22mW per gate, a typical propagation delay of 4.5ns and can be clocked at 100MHz. It is also

claimed that the range has improved noise immunity, high fan-out and uniform power pinning. There are split outputs for 'wired-OR' facility. The devices are ceramic encapsulated dual-in-line or flat packs. Operation is at 5V. The operating temperature range is from 0 to +75°C as standard, or from −55 to +125°C. Eurosem International Ltd, 64 High Street, Pinner, Middx.
WW 314 for further details.

H.F. hydrogen thyratron

Hydrogen thyratron type GHT 14, from the M-O Valve Co., is of metal-ceramic construction and is designed for pulse modulator operation at high repetition rates. A new shielded grid structure is employed and improved electrode cooling enables the tube to operate continuously at frequencies up to 150kHz.



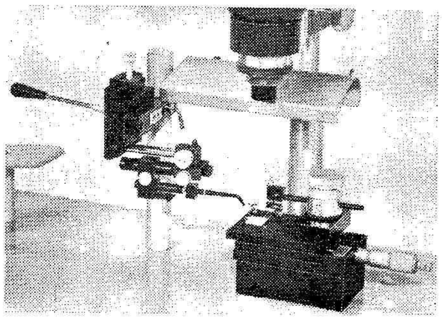
Characteristics:

peak anode voltage	15kV
peak anode current	200A
mean anode current	350mA
rate of rise of anode current	1600A/μs

Maximum height is 140mm, and diameter 57mm. The M-O Valve Co. Ltd, Brook Green Works, London W.6.
WW 303 for further details

Minority carrier demonstration

The Shockley-Haynes experiment, which shows that minority carriers are involved in transport processes in solids, can be demonstrated with equipment available from Research Instruments. The diffusion coefficient and mobility of these minority carriers may be measured directly. Minority carrier injection is also demonstrated. Two point contacts are applied to a semiconductor specimen in the form of a bar which has a sweep field applied along its length. One point contact acts as an emitter and the other as a collector. A pulse is supplied to the emitter and detected by the collector after it has travelled along the bar. The mobility of the minority carriers is



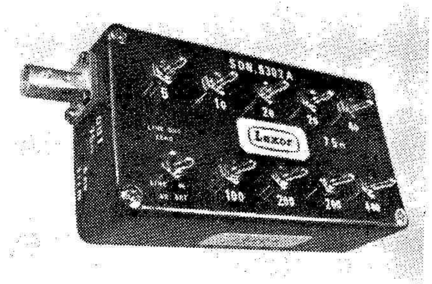
calculated from delay between injection and collection. The diffusion coefficient is calculated from the amount by which the pulse spreads in travelling along the bar from the emitter to the collector. The germanium bar is mounted, together with an emitter contact, on the moving carriage of a micrometer slide. A static 'micromanipulator' carries a probe acting as the collector contact. The distance between the emitter and collector contacts is accurately measured by the micrometer. A microscope is incorporated to view probing and observe the relative positions of the contacts. Price is £97 — microscope is £57 extra. Research Instruments Ltd., Kernick Road, Penryn, Cornwall.
WW 304 for further details

Low-power avalanche diodes

Avalanche ratings of 800 to 1,200V coupled with fast forward recovery and high surge capability are characteristics of diodes A5D and A10D from International Rectifier. These ranges have average forward current ratings at 75°C (ambient) of 0.6 and 1A respectively, and both are capable of absorbing up to 2kW (for 10μs) of reverse power. The new ranges are particularly suitable for series connection to produce high voltage units without the need for resistor and capacitor networks for voltage sharing purposes. International Rectifier, Hurst Green, Oxted, Surrey.
WW 302 for further details

Switched video delay line

Model SDN9302A switched video delay line, from Lexor, has been designed for insertion into 75Ω unbalanced circuits to allow delay adjustments. A switched range of delays from 0 to 995ns is provided in 5ns steps. A further variable 5ns section enables the delay to be trimmed to a total of 1.0μs, and the delay can be switched in and out at will. The network is phase-corrected, and the band-



width accommodates colour video signals. Internal compensation is for a flat frequency response. The unit is housed in a die-cast metal box 110 × 80 × 30mm, and connections are by means of b.n.c. coaxial sockets at each end. Lexor Electronics Ltd., 25/31 Allesley Old Road, Coventry.
WW 301 for further details

Transistors for consumer applications

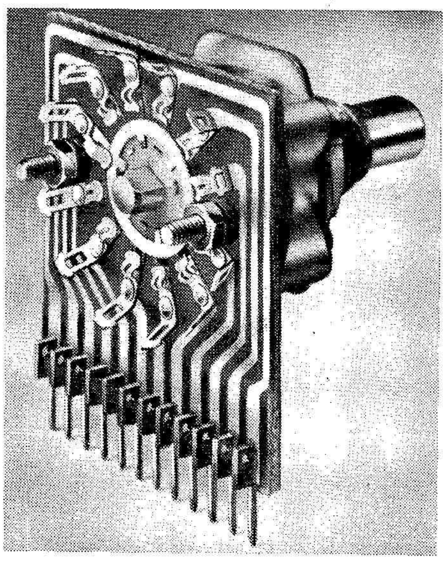
Intended for audio amplifiers in domestic radio sets, transistor types BD135-40 from AEG-Telefunken are now available in the U.K. They have a peak collector current of 1A and a dissipation of 4W (SOT-32 tab package). The complementary pair BD135 and 6 have a V_{CBO} of 45V, and the two other pairs have ratings of 60 and 80V.

Also available are the BF314 and BF414, low-noise v.h.f. transistors. Intended for common-base use in v.h.f. tuners, they are claimed to give very low intermodulation. Gain-bandwidth product (f_T) is around 500 to 600MHz and noise figure is 2dB at 100MHz and 1mA. Feedback capacitance is 90fF (femto farads = 10^{-3}pF). The BF314 is n-p-n and the 414 is p-n-p.

These transistors, first seen at the Paris show (page 229 May issue) are available in the U.K. from MCP Electronics Ltd, Alperton, Wembley, Middx HAO 4PE.
WW 306 for further details (BD types)
WW 307 for further details (BF types)

Printed circuit board switch

A compact miniature switch from Diamond H Controls is constructed in the 'Oak' type A frame size. Twelve solder-coated terminal pins on 0.1in pitch plug directly into a p.c. board. The Oak double wiping contact is



available in a variety of materials ranging from silver-plated brass to gold. Diamond H Controls Ltd, Vulcan Road North, Norwich, NOR 85N.
WW 317 for further details.

December Meetings

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

LONDON

1st. BKSTS—"The use of movie film and video electronics to produce abstract television images" by William Fitzwater and A. B. Palmer at 19.30 at Colour Film Services, 22-25 Portman Close, W.1.

2nd. IERE—Presidential address of A. A. Dyson at 18.00 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

2nd. RTS — Shoenberg memorial lecture: "The next decade in home entertainment" by Dr. Walter Bruch at 19.00 at The Royal Institution, Albemarle St, W.1.

6th. IEE — "Ceramics for use in electron devices" by P. Popper at 17.30 at Savoy Pl., W.C.2.

8th. IEE Grads — "Electronics in motor vehicles" by T. K. L. Dobedoe at 18.30 at Savoy Pl., W.C.2.

8th. IERE — "Propagation measurements on three tropospheric scatter systems in different climatic regions" by A. H. J. Knight and "Diversity combining techniques for tropospheric scatter receivers" by B. S. Skingley at 18.00 at Engineering Dept., University College, Torrington Pl., W.C.1.

8th. SERT — "Cassette tape recorders and the Dolby noise reduction process" by Dr. R. M. Dolby at 19.00 at the Lecture Theatre, Mullard House, Torrington Pl., W.C.1.

8th. BKSTS — "Techniques for compatible stereo today" by Eric Dougharty at 19.30 at Colour Film Services, 22-25 Portman Close, W.1.

13th. IEE/I.Phys. — Colloquium on "M.O.S. integrated circuits" at 10.00 at Savoy Pl., W.C.2.

14th. IEE — Discussion on "The use of computers in design and development" opened by C. Allen at 18.00 at Savoy Pl., W.C.2.

14th. AES — "Sound transmission in structures" by Dr. C. L. S. Gilford at 19.15 at the Mechanical Engineering Dept., Imperial College, Exhibition Rd, S.W.7.

15th. IEE — "Advances in marine navigational aids" by Dr. D. G. Kiely at 17.30 at Savoy Pl., W.C.2.

ABERDEEN

15th. IERE — "The radio amateur" by M. Hately at 19.30 at Robert Gordon's Institute of Technology, Physics Dept. Lecture Theatre, St. Andrews St.

BATH

1st. IERE — "Studio techniques for stereo sound broadcasting" by J. H. Brooks at 19.00 in Room 2 East 3.1., The University.

7th. IEETE — "Concorde — electrics and electronics" by H. Hill at 19.30 at Fernley Hotel, North Parade.

BIRMINGHAM

1st. SERT — "Future trends in television" by B. J. Rogers at 17.30 at the Byng Kendrick suite, University of Aston, Gosta Green.

BOURNEMOUTH

14th. SERT — "Magnetic recording in modern industry" by K. Coombes at 19.30 at Bournemouth College of Technology, The Lansdowne.

BRISTOL

9th. IEE Grads — "An introduction to digital computers" by J. E. P. Lewis at 19.30 at Electricity House, Colston Avenue.

16th. SERT — "Microwave equipment" by J. S. Williams at 19.30 at Cabot House, Bristol Polytechnic, Ashley Down Rd.

CARDIFF

1st. SERT—"The Trinitron television tube" at 19.15 at Llandaff College of Technology, Western Avenue.

8th. IEE/IERE — "Electronics in ships" by G. J. A. White at 18.30 at the U.W.I.S.T.

CHELMSFORD

16th. IERE — "Digital radar handling and display techniques applied to air space control" by J. Wild and M. Lewis at 18.30 at the Civic Centre.

CHESTERFIELD

1st. IEE Grads — "Solid state microwave devices" by G. S. Hobson at 19.30 at the Technical College.

COVENTRY

2nd. IERE — "Modern microwave measurement techniques" by John Pink at 19.15 at Lanchester Polytechnic.

DROITWICH

1st. IEE Grads — "Electronics in the automobile" by W. F. Hill at 19.30 at the Raven Hotel.

DUBLIN

2nd. IEE Grads — "Primary radar systems" by R. W. McLoughlin at 17.30 at the Physical Laboratory, Trinity College.

EDINBURGH

9th. IEETE — "Electronics in the automobile" by W. F. Hill at 18.30 at Heriot Watt University, Lecture Theatre D.34.

9th. SERT — "Electronic instrumentation" by J. W. McNeish at 19.30 at Hewlett-Packard Ltd., South Queensferry (Nr. Edinburgh).

14th. IEE/IERE — "Telemetry" by R. E. Young at 18.00 at the S.S.E.B., George St.

GLASGOW

8th. IEETE — "Electronics in the automobile" by W. F. Hill at 18.00 at the Institution of Engineers & Shipbuilders, Rankine House, 183 Bath St.

13th. IEE/IERE — "Telemetry" by R. E. Young at 18.00 at the Institution of Engineers and Shipbuilders, Rankine House, Bath St.

GUILDFORD

8th. IERE — "Electronics in security systems" by K. Banks at 18.30 at the University of Surrey.

16th. IEE — "Computer graphics" by J. J. Matthews at 19.30 at the Central Electricity Generating Board, Burymead House.

HUDDERSFIELD

6th. SERT — "Thorn 8000 colour television chassis" by A. Martinez at 19.30 at Engineering Tower, The Polytechnic, Queensgate.

LEEDS

9th. IEETE — "Hi-Fi" by A. W. Dakin at 19.00 at the Lecture Theatre, Kitson College, Cookridge St.

LEICESTER

8th. IERE — "Police communications systems" at 18.45 at the Physics Dept., The University.

17th. IEE — "Logic and the engineer" by S. Towill at 19.15 at the College of Technology.

LIVERPOOL

6th. IEE — "Problems of innovation" by J. Sharpe at 18.30 at the University, Electrical Engineering Laboratories.

8th. IERE — "Ultrasoncis in medicine" by Dr. P. N. T. Wells at 19.00 at The Department of Electrical Engineering and Electronics, The University.

MALVERN

1st. IERE — "General aspects of real time computer system design" by B. W. Partridge at 19.00 at The Abbey Hotel.

MANCHESTER

1st. IEE/IERE — "Video recording" by D. M. Bowd at 18.15 in the Renold Building, University of Manchester Institute of Science and Technology, Altrincham St.

16th. SERT — "Loudspeaker systems" by J. Snowden at 19.30 in Renold Building, University of Manchester Institute of Science and Technology, Altrincham St.

NEWCASTLE-ON-TYNE

1st. SERT — "Semiconductor technology and its application to devices" by P. F. Castle at 19.15 at the Charles Trevelyan Technical College, Maple Terrace.

8th. IERE — "Semiconductor devices at microwave frequencies" by Prof. Hartnagel at 18.00 in the Main Lecture Theatre, Ellison Building, The Polytechnic.

NORWICH

1st. IEE/IERE — "Stereophonic broadcasting" by G. J. Phillips at 19.00 at Assembly House.

NOTTINGHAM

7th. IEE — "Optical communications" by F. F. Roberts at 19.00 at the University.

PRESTON

8th. IEE — "Colour television engineering" by C. B. B. Wood at 19.30 at the Torella Restaurant, Friargate.

READING

9th. IERE — "Memories past, present and future" by R. Patrick, D. Stapleton and B. L. Hanlon at 19.30 at the J. J. Thomson Laboratory, University of Reading, Whiteknights Park.

RUGBY

8th. IEE — "Computer graphics" by John J. Matthews at 18.15 at Lanchester Polytechnic.

14th. IEE Grads — "Electronic and mechanical developments in petrol injection" by J. Littlehouse at 18.15 at Lanchester Polytechnic, Eastlands.

SHEFFIELD

8th. IEE—"Electronics diagnosis and performance testing of motor vehicles" by R. Evans and D. Herson at 18.30 at the Y.E.B. Offices, Arundel Gate.

SOUTHAMPTON

7th. IEE Grads—"Learning to live with monolithic transistors" by Dr. J. E. L. Hollis at 19.30 at the University, Lanchester Building.

STAFFORD

15th. IEE Grads — "Electronics in the automobile" by W. F. Hill at 19.00 at N. Staffs. Polytechnic, Beaconside.

TAUNTON

2nd. IEE — "Lasers and holography" by L. A. Cram at 19.45 at the Taunton County Hotel, Residents Lounge.

WOLVERHAMPTON

9th. IERE — "Recent advances in M.O.S. semiconductor techniques" by M. W. Granger at 19.15 at The Polytechnic.

YORK

9th. IERE — "Design of high-fidelity loudspeakers" by A. R. Bailey at 19.00 at Central College of Further Education, Tadcaster Rd., Dringhouses.

Literature Received

For further information on any item include the appropriate WW number on the reader reply card

ACTIVE DEVICES

The range of 74 series t.t.l. integrated circuits manufactured by Texas Instruments are described in a catalogue from Quarndon Electronics (Semiconductors) Ltd, Slack Lane, Derby DE3 3ED WW401

High-power silicon diodes, low-cost bridges, high-temperature rectifiers, Hall multipliers, 'button' or 'capsule' device mounting kits and other items are described in a leaflet produced by AEI Semiconductors Ltd, Carholme Rd, Lincoln. . WW402

Tranchant Electronics (U.K.) Ltd, 100a High St, Hampton, Middx, can supply a catalogue which gives data on the wide range of f.e.ts manufactured by Intersil Inc. of California, U.S.A. . . . WW403

The microwave semiconductor catalogue of Microwave International Ltd, 33-37 Cowleaze Rd, Kingston-upon-Thames, Surrey, includes a description of the functions performed by various types of diode (varactor, p-i-n, avalanche, etc.). . WW404

A U-shaped block of aluminium containing a photocell in one leg and a light source in the other is described in sheet ED.6-271 from Electronic Designs Ltd, Prospect Rd, Cowes, Isle of Wight. . . WW405

A noise producing device, called the Bleeptone, which emits a 1kHz tone (or 2.5kHz) for attracting attention is described in a brochure from A. P. Besson & Partner Ltd, St. Josephs Close, Hove, Sussex, BN3 7EZ. WW414

APPLICATION NOTES

A chopper amplifier, a portable ionization chamber, a digital mains voltage monitor and a process simulator are all topics covered in 'Product Application News, July 71' obtainable from Computing Techniques Ltd, Brookes Rd, Billingshurst, Sussex, RH14 9RZ. WW415

A new gold depositing process (Autronex BC) which operates at up to 80% cathode efficiency with very stable solution characteristics is described in literature from Sel-Rex (U.K.) Ltd, Holyhead Rd, Chirk, Wrexham, Denbighshire. WW416

'Audio amplifier module — type EA1000 — users handbook' deals with a microcircuit a.f. amplifier which is mounted on a small printed circuit board together with the necessary additional components. The publication is available from SGS (U.K.) Ltd, Planar House, Walton St, Aylesbury, Bucks. WW417

'Numerical Indicator Tubes — 1971/72' is the rather uninspired title of a very useful booklet produced by Standard Telephones and Cables Ltd, Edinburgh Way, Harlow, Essex. Section headings of the booklet are: basic theory, characteristics, bulb temperature, life, supply voltages, controlling (circuitry, decoding time-sharing etc.), data sheets and accessories WW418

PASSIVE COMPONENTS

The Components Division of Pye TMC Ltd, Roper Rd, Canterbury, Kent, have supplied us with the following two data leaflets:

- Illuminated edgewheel switches . . . WW406
- Miniature lever keys WW407

Two more leaflets are available in the 'This is Motorola plus' series from GDS Sales Ltd, Michaelmas House, Salt Hill, Bath Rd, Slough, Bucks.

10. Elma collet knobs WW408
11. Elma stud-contact switches . . . WW409

M4 pattern 104 plugs and sockets in aluminium or brass to military standards with from 2 to 62 pins are the subject of a catalogue from A. B. Electronic Components Ltd, Abercynon, Glamorgan WW410

A 150-page catalogue lists a large range of microwave coaxial connectors, cable assemblies and components. Americon Microwave Industries Inc, U.K. Branch, 102 London St, Reading, Berks, RG1 4QB WW411

A probe with a plastics handle housing a NiCr-NiAl thermocouple for surface temperature measurements in the range −100 to 500°C is described in a leaflet from Comark Electronics Ltd, Brookside Avenue, Rustington, Littlehampton Sussex. WW412

News Bulletin No. 79 from A. F. Bulgin & Co. Ltd, Bye-Pass Rd, Barking, Essex, briefly describes some of the companies products (switches, lamp holders, etc) and also gives some company news. WW413

EQUIPMENT

We have received microwave equipment catalogues from the following companies:

- Microwave and Electronic Systems Ltd, Lochend Industrial Estate, Newbridge, Midlothian, Scotland. WW419
- Silvers Lab, Box 42018, S-126 12 Stockholm 42, Sweden. WW420

New catalogues of electronic instrumentation have been produced by the following companies:

- Brookdeal Electronics Ltd, Market St, Bracknell, Berks. (471 signal source, low-noise amp., etc.). WW421
- Techmation Ltd, 58 Edgware Way, Edgware, Middx. (lock-in amplifier systems). . WW422
- Sintrom Electronics Ltd, 2 Arkwright Rd, Reading, Berks. RG2 0LS (systems peripherals and instruments). WW423
- Levell Electronics Ltd, Park Rd, High Barnet, Herts. (wide range of general portable electronic test equipment). WW424
- Hatfield Instruments Ltd, Burrington Way, Plymouth PL5 3LZ (psophometers, mW and level test sets, communications equipment). WW425
- Wavetek, 9045 Balboa Ave, San Diego, California, U.S.A. 92123 (function and signal generators, sweepers, calibrators and phase meters). WW426
- Dynamco Ltd, The Street, Shalford, Guildford, Surrey (digital voltmeters, ohmmeters, multimeters, counters and frequency meters). WW427

The performance and price of the very large range of power supply units manufactured by Hewlett Packard Ltd, 224 Bath Rd, Slough SL1 4DS, are given in a booklet. WW428

We have received a copy of a new news sheet called 'Studio 99' from Studio 99 Video Ltd, 81 Fairfax Rd, Swiss Cottage, London N.W.6. It contains general items on c.c.t.v. and descriptions of the new Sony low-cost slow-motion v.t.r. and the Philips video cassette recorder. A comprehensive guide to video tapes is also included. WW429

Plug-in power supply regulators (called Rokard) with outputs from 3 to 8V or 6 to 30V positive or negative at 1, 2.5, 5 or 10A, or ±4 to ±25V at 2.5 or 7.5A are the subject of a leaflet from Roband Electronics Ltd, Charlwood, Horley, Surrey. WW430

Literature describing instrument cases, racks and panels has been published by F. T. Davis (Kings Langley) Ltd, Primrose Hill, Kings Langley, Herts. WW431

A coloured wall poster describes a range of aerials for television and radio reception together with all the associated masts and fittings. Aerialite Ltd, Aerial and Electronics Division, West Heath, Congleton, Cheshire CW12 4PX. . . . WW432

GENERAL INFORMATION

BS4727: Part 1, 1971 'Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms' can be obtained from BSI Sales Branch, 101 Pentonville Rd, London N1 9ND (postage is 21p per copy)

- Group 02. Terms particular to lighting and colour. . . . . price £1.15
- Group 04. Measurement terminology price £1.15

Aerosols for just about everything are described in literature from DCMC Industrial Aerosols Ltd, Lloyds House, Handforth, Cheshire. . . WW433

Overseas Conferences

Dec. 6 & 7 Chicago
Broadcast & TV Receivers
(R. B. Ashley, Warwick Elec. Inc., 7300 N. Lehigh Ave., Chicago, Illinois 60648)

Dec. 6-9 Miami Beach
Ultrasonics Symposium
(J. E. May, Jr., Bell Labs., 555 Union Blvd., Allentown, Penna. 18103)

Dec. 7 & 8 Detroit
Vehicular Technology
(J. F. Ziomek, Ford Motor Co., POB 2053, Dearborn, Mich. 48121)

Dec. 7-10 New York
Applications of Simulation
(M. Araten, Celenese Chem. Co., 245 Park Ave., New York, N.Y. 10017)

Dec. 15-17 Miami Beach
Decision and Control
(J. T. Tou, Dept. of EE, Univ. of Florida, Gainesville, Fl. 32601)

Real and Imaginary

by "Vector"

'Whither is fled the visionary gleam?'

I was particularly interested in the Editor's discourse on inventors in the November issue because at the time it arrived I was deep in a book on early radio inventions, borrowed from the Great Man himself when I was last in his sanctum.*

Those readers who remember the stone-age days of radio prior to 1928 will need no introduction to it, but for the benefit of those of us who cut our teeth on micro-circuits the book I mean is G. G. Blake's superb "History of Radio Telegraphy and Telephony" (Chapman and Hall 1928). If you can possibly scrounge a copy from somewhere you will find it fascinating reading.

Within its covers is a cavalcade of invention from the Leyden jar to the use of ionized beams as transmitting aerials. All the well-known devices are there, of course, but the real beauty of the book is that it's a monument to those lone inventors the Editor mentioned, and to all those inventions that never caught on; the ones that were going to make fortunes but somehow didn't. In fact, the author is at pains to tell his readers that his prime intention in writing the book was 'to bring into prominence almost forgotten schemes and devices in the hope that new ideas may spring therefrom'.

For the amateur who is casting around for something different with which to experiment, there is plenty here. And it might with advantage be compulsory reading in any laboratory that is hard up for ideas. You will laugh at some of the quaint projects, but the reading stimulates the think-tank.

Interested in different approaches to the loudspeaker problem? Try Chapter 2 for size. Here you'll find Dolbear's electrostatic telephone of 1879, inspired by William Thomson's 'speaking condenser' of 1863. Then there is Bréguet's capillary telephone or you may prefer the various forms of thermo-telephone described. Or what about the Johnsen-Rahbek loudspeaker? This consisted of a small cylinder of agate over which was bent a flat metal strip. One end of the strip terminated in a spring-loaded anchor, while the other end was attached to a diaphragm.

One side of the signal output connects to the cylinder via a slipring while the other side goes to the metal plate. When the cylinder is rotated the signal variations produce variations in the friction between cylinder and plate and so movement occurs in the diaphragm. (Incidentally, has any research been done on agate as a semi-conductor?)

I'll pass over the multiplicity of detectors (coherer, electrolytic, magnetic etc), the principles of some of which may yet be resurrected for something or other. Students of fluidics will want to browse over the various Axel Orling relays but we must press on.

If you have a yen to talk along a beam of light, then see how Alexander Graham Bell and Sumner Tainter managed it (in fifty different ways!) in 1870. Or does König's manometric flame transmitter attract you? There are gas flame microphones and liquid microphones in great variety. And did you know, I wonder, (I didn't) that ultra-violet signalling systems were used during the 1914-18 war? And that in 1907 Heinicke patented X-ray radio telephony – or is that a contradiction in terms? Yes, I suppose it is. Anyway, it sounds a good thing to investigate if you're tired of life.

Incidentally, if your requisition for a paltry seven hundred quids' worth of test-gear has just been stamped upon and you're feeling ill-used, consider the conditions under which some of those lone inventors worked. James Bowman Lindsay, for instance, who in 1843 sent electric signals across the River Tay without using a wire conductor transmission (it wasn't wireless within the meaning of the term, but never mind). Lindsay's total income at that time was £50 p.a. (he was a teacher at the Dundee prison) and upon this he somehow managed to live and to buy materials for the construction of his experimental models.

Then there was D. E. Hughes, a professor of music, who in 1879 and 1880 demonstrated what was beyond doubt the transmission and reception of radio waves. He did so in front of several members of the Royal Society and got squashed for his trouble—so much so that he packed it all in without publishing any account—and not until twenty years later were the circumstances made public.

Hughes had previously invented a type-writing telegraph machine which was adopted by the Post Office, who used it for many years. In the matter of radio however he was strictly a string-and-sealing-wax merchant: his 'aerial' was a kitchen fender and his first microphone (another of his inventions—in 1878) consisted of three nails in light contact on a block of wood. He didn't really know what he was achieving when he generated radio waves, but he did so nine years before Hertz and anticipated the Branly type of coherer detector by twelve years.

Improvization was an integral part of the early inventors' make up; usually it had to be for personal economic reasons, but the trait persisted in the research engineers of quite big radio concerns even up to the onset of World War II. Which reminds me of a story I once heard concerning a well-known research man of the period.

Somewhere about 1930 he was working on the first experimental models of the moving-coil loudspeaker and had decided to try rubber suspension for the coil. With no suitable material immediately to hand he decided to improvise with cut-up rubber contraceptives.

No believer in doing things by halves, he sent his tea-boy, an extremely thin, lanky youth to the chemist's for the requisite articles, to the tune of three dozen. The chemist, after verifying that he had heard the size of the order correctly, took one hard look at this pale-faced customer and decided that some fatherly advice was needed. "Now look, my son", he said. "You're going it altogether too strong. You'll kill yourself at this rate!"

Now imagine the development of the moving coil if it were being done today using the American-style mass attack techniques now in vogue. First, a committee would have to be convened to establish whether any form of coil suspension was really necessary. Then a series of sub-committees would hold interminable meetings to decide how to fix the suspension. Six months' shopping around for material samples would follow; on arrival, these would have to be given an elaborate series of environmental and chemical tests. The data derived would be fed through a number-cruncher; then, after more meetings to eliminate the worst of the errors in the read-outs, the selected material might at last be tried *in situ*. It would then be found to be quite useless for an elementary reason nobody had previously thought of. So, back to square one.

'In any efficiently run R and D department' wrote the Editor 'the time allowable for any given line of enquiry is strictly determined.' True; but this can also be so in an inefficiently run department. It's not only the allocation of a finite length of time that's important but also what you do with it after you've got it. The old-time research men may not have been so hot at organizing meetings, filling in forms and churning out reports, but its my considered opinion that they could run rings around us when it comes to getting a job out.

*So that's where it is. Return it at once!—Ed.

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Components show, London, (preview), 250 May, new products seen, 347 July
CONFERENCES AND EXHIBITIONS: 26 Jan., 101 Feb., 134 Mar., 211 Apr., 220 May, 275 June, 354 July, 398 Aug., 436 Sept., 469 Oct., 553 Nov., 613 Dec.
Crosshatch and dot generator, A. W. Critchley, 368 Aug.

D.C. motor controller, *Circuit Idea*, N. G. A. Boreham, 386 Aug.
Decades of résistance, *Circuit Idea*, J. Johnstone, 66 Feb.
Decoder, stereo, phase-locked-loop i.c., 377 Aug.
——, stereo using sampling, D. E. O'N. Waddington, 71 Feb., *Letters*, 123 Mar., 183 Apr., 233 May, 283 June, 320 July
Decoupling capacitor, P. Engstrom, 606 Dec.
Demonstrating multivibrator action, T. Palmer, 107 Mar.
Developments in audio over 60 years, F. L. Devereux, 156 Apr., *Letters*, 283 June
Diagnosis of logical faults, R. G. Bennetts, 325 July, 383 Aug., *Letters*, 428 Sept.
Differential discriminator circuits, H. A. Cole, 603 Dec.
Digital clock, Roger Buckley, 54 Feb.
—— frequency display, C. Attenborough, 597 Dec.
—— method of obtaining frequency difference, *Circuit Idea*, J. F. W. Bell & J. M. Pelmore, 532 Nov.
—— TV line standards converters, 238 May
—— TV synchronizers and converters, S. M. Edwardson & A. H. Jones, 479 Oct.
Diode switching using charge analysis, B. L. Hart, 139 Mar.
Direct current multimeter, J. Johnstone, 87 Feb.
Discriminator, ceramic, for narrow-band f.m., D. Balfour, 420 Sept.
—— circuits, differential, H. A. Cole, 603 Dec.
Displaying frequency digitally, C. Attenborough, 597 Dec.
Don't look now, Thomas Roddam, 195 Apr.
Drum major, H. J. N. Riddle, 549 Nov.
Dual-trace oscilloscope unit, W. T. Cocking, 362 Aug., 421 Sept., 489 Oct., 533 Nov., 593 Dec., *Letters*, 483 Oct.

EDITORIALS:
Components industry — dead or alive?, 53 Feb.
Concepts and reality in electronics, 103 Mar.
Criteria for frequency allocations, 1 Jan.
Editorial comment, 213 May
Imbalance of trade in U.K. electronics, 313 July
Sixty years, 153 Apr.
The domestic receiver scene, 463 Oct.
The environment of invention, 515 Nov.
The plight of the microcircuit industry, 411 Sept.
Value for money in R & D, 265 June
Wasted R & D, 361 Aug.
World communications, 571 Dec.
Elapsed time graph for tape recording, B. W. Lingard, 452 Sept.
Electro-optical gearbox, J. Dinsdale, 387 Aug., *Letters*, 583 Dec.
Electronic building bricks, James Franklin, 43 Jan., 86 Feb., 126 Mar., 205 Apr., 252 May, 293 June, 390 Aug., 448 Sept., 502 Oct., 540 Nov., 596 Dec., *Letters*, 16 Jan.
—— typesetting, 62 Feb.
—— voltmeter for 2 to 50kV, A. M. Albisser & N. F. Moody, 119 Mar.
Electrostatic headphone design, Philip D. Harvey, 527 Nov.
Elements of linear microcircuits, T. D. Towers, 23 Jan., 76 Feb., 114 Mar., 191 Apr., 253 May, 342 July, 395 Aug., 433 Sept., 503 Oct.
Enclosures, loudspeaker, E. J. Jordan, 2 Jan., *Letters*, 125 Mar.
Equalization, ceramic pickup, B. J. C. Burrows, 321 July, 379 Aug., *Letters*, 374 Aug., 427 Sept., 584 Dec.
Equation-solving aid, V. J. Phillips, 27 Jan., *Letters*, 123 Mar.
European space consortium, 62 Feb.
Experimental broadcasts, s.s.b., 393 Aug.

F.E.T. source-follower circuits, J. O. M. Jenkins, 366 Aug.
—— tester, D. E. O'N. Waddington, 579 Dec.
F.M. stereo tuner, L. Nelson-Jones, 175 Apr., 245 May, *Letters*, 320 July, 584 Dec., *Correction*, 249 May
Festival du son (Paris), 244 May
Field-sequential colour television receiver, T. J. Dennis, 443 Sept., 497 Oct.
Follow-and-hold circuit, *Circuit Idea*, J. F. Roulston, 66 Feb.
Fractional bootstrap feedback, *Circuit Idea*, J. H. Wilkinson, 600 Dec.
Frequencies for space communication, D. E. Baptiste, 431 Sept.
Frequency difference, digital method, *Circuit Idea*, J. F. W. Bell & J. M. Pelmore, 532 Nov.
—— display, digital, C. Attenborough, 597 Dec.
—— divider, negative resistance, *Circuit Idea*, R. M. Youngson, 234 May
—— response measuring instrument, drum major, H. J. N. Riddle, 549 Nov.

Gearbox, electro-optical, J. Dinsdale, 387 Aug., *Letters*, 583 Dec.
Generator, crosshatch and dot, A. W. Critchley, 368 Aug.
—— ramp, linear, J. B. G. Cairns, 604 Dec.
——, sawtooth, v.l.f., *Circuit Idea*, A. J. Barker, 122 Mar.
——, sweep, audio, F. H. Trist, 335 July, *Letters*, 374 Aug., *Correction*, 371 Aug.

H.F. PREDICTIONS: 6 Jan., 93 Feb., 113 Mar., 194 Apr., 255 May, 286 June, 334 July, 388 Aug., 441 Sept., 484 Oct., 536 Nov., 607 Dec.
Headphones, electrostatic, Philip D. Harvey, 527 Nov.
Heat sink abac, J. Johnstone, 22 Jan.
Helical v.h.f. aerial, G. J. Monser, 418 Sept., *Letters*, 525 Nov.
High-definition radar, AVOID, short-range, K. L. Fuller, 110 Mar.
—— gain audio voltage amplifier, D. Leblebici, 203 Apr.
—— quality tape recorder, J. R. Stuart, 19 Jan., *Letters*, 320 July, *Correction*, 32 Jan.

Integrated circuit breakthrough, 526 Nov.
—— —— stereo pre-amplifier, adding an active rumble filter, L. Nelson-Jones, 303 June
Intelligent machines, the search for, R. Baker, 266 June
International congress on acoustics (Budapest), N. F. Spring, 522 Nov.
Intelsat agreement, 547 Nov.

Karnaugh map display, Brian Crank, 185 Apr., memory unit for, 256 May, comments on, by G. T. Lawrence, 555 Nov., *Letters*, 375 Aug.

Letter from America, 143 Mar., 442 Sept.
LETTERS TO THE EDITOR:
Attenuators, Donald S. Reid, 16 Jan.
Audio amplifiers, E. McSherry, 319 July
—— Fair report: putting the record straight, S. J. Court, 65 Feb.
—— sweep generators, A. Falla, R. S. Snell, 374 Aug.
Birthday greetings, J. Redmond, J. C. G. Gilbert, 183 Apr.
Boxcar detector, R. J. Smith-Saville, 124 Mar., J. D. W. Abernethy, 232 May
C-D ignition, Frank Gutteridge, 123 Mar., R. C. Lockwood, 283 June
'Cathode Ray', W. J. Baker, 232 May
Ceramic pickup equalization, John Walton, Gordon J. King, 374 Aug., H. C. Mirams, 427 Sept., B. J. C. Burrows, 584 Dec.
—— —— —— on the stereo mixer, C. R. Whiteley, 318 July

Components for constructors, F. Brian Kyle, Alan Sproxton, 184 Apr.
Compression chambers behind horn drivers, J. Robert Ashley, Samuel A. Guccione, 64 Feb.
Desoldering tip, G. W. Sutton, 16 Jan.
Diagnosis of logical faults, A. H. Boyce, 428 Sept.
Direct radiator loudspeakers, E. J. Jordan, 16 Jan.
Dual-trace oscilloscope unit, M. D. Samain, 483 Oct.
E.M.F. and the volt, Alan E. Smith, 16 Jan.
Electro-optical gearbox, W. H. P. Leslie, 583 Dec.

F.E.T. audio oscillator, V. R. Krause, 427 Sept.
F.M. tuner and stereo, K. Clayson, 320 July
F.M. tuner bandwidths, Richard G. Mellish, 584 Dec.
Ganging potentiometers, K. J. Young, 125 Mar., Roy S. Gibbons, 284 June
Helical v.h.f. aerials, J. L. Eaton & L. F. Tagholm, 525 Nov.
Karnaugh map display, G. J. Naaijer, 375 Aug.
Linear scale millivoltmeter, G. W. Short, 18 Jan., D. J. Farman, 64 Feb.
Loud and clear, Claud Powell, 283 June
Loudspeaker enclosures, R. N. Baldock, 125 Mar.
Loudspeakers in corners, Paul W. Klipsch, 17 Jan.
M.W. broadcasting, C. Higham, 283 June, Stefan Woroniecki, 429 Sept.
Millivoltmeter, linear scale, G. W. Short, 18 Jan., D. J. Farman, 64 Feb.

Morse outmoded?, Juan Aliaga Argue, 584 Dec.
Multi-core cables, R. Williams, 320 July
New names for old concepts, A. G. Jones, 18 Jan.
Optimum scale integration, James M. Bryant, 483 Oct.
Our birthday issue, John Scott-Taggart, W. Kenneth Alford, F. C. Ward, Terry I. Roberts, 231 May
Pickup self-capacitance, B. J. C. Burrows, 283 June, J. L. Linsley Hood, 318 July
Recording characteristics, Charles Nairn, 318 July
Resistance tolerance code, G. David Reynolds, 125 Mar.
Sample and hold, R. T. Portus, 123 Mar.
Soldering and p.c.bs, Henry Manfield, 233 May
Sonic scanning for tubeless TV, G. O. Towler, 429 Sept.
Stereo decoder using sampling, D. R. Birt, R. T. Portus, 183 Apr., R. T. Portus, 283 June
Stereo techniques in Australasia, Garry V. Lambert, 319 July

Television fire hazards, C. J. Stanford, 583, Dec.
Television sound quality, R. Sear, 483 Oct., Peter Small, M. Toogood, C. E. Hayhurst, T. R. Mahoney, R. M. Carroll, B. Darling, John de Rivaz, 526 Nov., J. G. Symons, 584 Dec.
The asymmetric long-tailed pair, B. L. Hart, 484 Oct.
The name of the game, Thomas Roddam, 124 Mar.
These tell-tale women . . . , D. Jones, 526 Nov.
Transformer phase reversal, Victor Mayes, 374 Aug.
Wien-bridge audio oscillator, T. Gaj-Larisch, Max Wien, 232 May

Level-conscious trigger system, *Circuit Idea*, A. R. Bidwell, 430 Sept.
Line standards converters, TV, digital, 238 May
Linear amplifier, 200-W, G. R. Jessop, 273 June
—— ramp generator, J. B. G. Cairns, 604 Dec.
Liniac, J. L. Linsley Hood, 437 Sept.
LITERATURE RECEIVED: 50 Jan., 102 Feb., 150 Mar., 210 Apr., 264 May, 311 June, 360 July, 404 Aug., 462 Sept., 513 Oct., 562 Nov., 613 Dec.
Log-periodic aerial, u.h.f., J. L. Eaton & R. D. C. Thoday, 7 Jan., *Letters,* 233 May
—— Potentiometer, wirewound, *Circuit Idea*, D. C. Hamill, 430 Sept.
Logical faults, diagnosis of, R. J. Bennetts, 325 July, 383 Aug., *Letters,* 428 Sept.
London components show (preview), 250 May, new products seen, 347 July
Loud and clear, F. L. Devereux, 156 Apr., *Letters,* 283 June
Loudspeaker enclosures, E. J. Jordan, 2 Jan., *Letters,* 125 Mar.
—— stereo techniques, E. J. Jordan, 67 Feb., *Letters,* 319 July, *Note,* 519 Nov.
—— system, multiple-array, E. J. Jordan, 132 Mar.
Low cross-over distortion class B amplifier, *Circuit Idea,* A. Sandman, 341 July
—— distortion tone-control circuit, P. M. Quilter, 199 Apr.
—— noise f.e.t. amplifier, *Circuit Idea,* R. L. Hooper, 341 July
—— range ohmmeter, J. Johnstone, 294 June

Map display, Karnaugh, Brian Crank, 185 Apr., memory unit for, 256 May, comments on by G. T. Lawrence, 555 Nov., *Letters,* 375 Aug.
MEETINGS: 42 Jan., 94 Feb., 151 Mar., 211 Apr., 233 May, 300 June, 478 Oct., 561 Nov., 612 Dec.
Microcircuits, linear, elements of, T. D. Towers, 23 Jan., 76 Feb., 114 Mar., 191 Apr., 253 May, 342 July, 395 Aug., 433 Sept., 503 Oct.
Miles-per-gallon meter, S. C. Hambly, 218 May
Milestones in receiver evolution, W. T. Cocking, 160 Apr.
Mixer, stereo, H. P. Walker, 221 May, 295 June, *Letters,* 318 July, 376 Aug., *Correction,* 300 June, 454 Sept.
Monostable cascade, t.t.l., H. A. Cole, 301 June
——, relay, long-period, *Circuit Idea,* J. F. Roulston, 122 Mar.
—— ——, simple, *Circuit Idea,* J. Vickers, 532 Nov.
Morse outmoded?, 402 Aug., Letters, 584 Dec.
Motor controller, d.c., *Circuit Idea,* N. G. A. Boreham, 386 Aug.
Multimeter, direct current, J. Johnstone, 87 Feb.
Multiple-array loudspeaker system, E. J. Jordan, 132 Mar.
Multivibrator action, demonstrating, T. Palmer, 107 Mar.
——, variable astable, *Circuit Idea,* C. C. Ward, 512 Oct.
—— with switched mark ratios, *Circuit Idea,* J. H. J. Dawson, 269 June

Negative feedback in transistor amplifiers, S. W. Amos, 37 Jan.
New approach to class B amplifier design, Peter Blomley, 57 Feb., 127 Mar., *Correction,* 180 Apr.
—— —— to transistor circuit analysis, A. J. Blundell, 287 June, 329 July
NEW PRODUCTS: 45 Jan., 97 Feb., 145 Mar., 207 Apr., 260 May, 306 June, 357 July, 405 Aug., 457 Sept., 507 Oct., 557 Nov., 608 Dec.
NEWS OF THE MONTH: 10 Jan., 62 Feb., 108 Mar., 181 Apr., 226 May, 276 June, 339 July, 372 Aug., 425 Sept., 485 Oct., 520 Nov., 576 Dec.
Nickel-cadmium batter charger, *Circuit Idea,* F. Ballerini, 204 Apr.
Noise in volume controls, reducing, *Circuit Idea,* C. H. Banthorpe, 204 Apr.
Non-linear loops, Thomas Roddam, 239 May

Ohmmeter, low-range, J. Johnstone, 294 June
Oscar-6 satellite, 144 Mar.
Oscillator, audio, Wien-bridge, A. J. Ewins, 104 Mar., *Letters,* 232 May, 427 Sept.
——, general purpose, *Circuit Idea,* T. Koanantakoul, 600 Dec.
——, v.h.f./f.m., simple, *Circuit Idea,* W. H. H. Kelk, 512 Oct.
Oscillators, Wien, P. Williams, 541 Nov.
Oscilloscope trace doubler, W. T. Cocking, 362 Aug., 421 Sept., 489 Oct., 533 Nov., 593 Dec., *Letters,* 483 Oct.

Paris components show, 229 May
Peak detector, waveform, *Circuit Idea,* L. Unsworth, 234 May
PERSONALITIES: 51 Jan., 96 Feb., 149 Mar., 206 Apr., 258 May, 304 June, 355 July, 403 Aug., 456 Sept., 506 Oct., 554 Nov., 602 Dec.
Phase-locked-loop stereo decoder i.c., 377 Aug.
—— splitter, *Circuit Idea,* L. R. Saunders, 9 Jan.
Physics exhibition, 279 June
Pickup arm design for home construction, R. Ockleshaw, 516 Nov. (turntable, 473 Oct., wow and flutter meter, 572 Dec.)
—— equalization, ceramic, B. J. C. Burrows, 321 July, 379 Aug., *Letters,* 374 Aug., 427 Sept., 584 Dec.
Power amplifier for a.c. servomotors, R. J. Wallace & J. M. Clarke, 201 Apr.
—— source, variable, using magnetic amplifier, *Circuit Idea,* W. B. Pickles, 512 Oct.
—— supply modification, *Circuit Idea,* P. Lacey, 234 May
Progress in acoustics, N. F. Spring, 522 Nov.
—— in air traffic control, 200 Apr.
—— in tape recording, Basil Lane, 563 Nov.
Pulse and voltage level indicator, *Circuit Idea,* J. M. Firth, 269 June

Q — Multiplier, stable, *Circuit Idea,* D. A. Tong, 600 Dec.

Radar, high-definition, short-range, AVOID, K. L. Fuller, 110 Mar.
Radio communication, significant steps in, W. J. Baker, 167 Apr.
—— wave propagation, ten more years, R. L. Smith-Rose, 164 Apr.
Ramp generator, linear, J. B. G. Cairns, 604 Dec.
REAL & IMAGINARY 'Vector', 52 Jan., 152 Mar., 212 Apr., 312 June, 410 Aug., 514 Oct., 614 Dec., *Letters,* 232 May, 526 Nov.
Receiver evolution, milestones in, W. T. Cocking, 160 Apr.
—— module, s.s.b., R.C.V. Macario, 314 July
Receiving weather pictures from satellites, J. M. Osborne, 464 Oct., 537 Nov.
Reducing noise in volume controls, *Circuit Idea,* C. H. Banthorpe, 204 Apr.
Regulator, battery supply, *Circuit Idea,* T. R. E. Owen, 234 May
Relay monostable, simple, *Circuit Idea,* J. Vickers, 532 Nov.
Resistance, decades, *Circuit Idea,* J. Johnstone, 66 Feb.
Reversed operation of 'Transfilter', *Circuit Idea,* G. W. Short, 386 Aug.

S.S.B. receiver module, R.C.V. Macario, 314 July
—— experimental broadcasts, 393 Aug.
Sampling oscilloscopes and sampling adaptors, E. B. Callick & A. Lawson, 449 Sept.
——, stereo decoder, D.E.O'N. Waddington, 71 Feb., *Letters,* 123 Mar., 183 Apr., 233 May, 283 June, 320 July
Schmitt trigger, high input-impedance, *Circuit Idea,* J. A. Roberts & J. Driscoll, 430 Sept.
Scientific fellowship for authors, 372 Aug.
Search for intelligent machines, R. Baker, 266 June
Sensitive ± voltage trip, *Circuit Idea,* N. Nicola, 66 Feb.
Servomotors, a.c., power amplifier for, R. J. Wallace & J. M. Clarke, 201 Apr.
70th anniversary of transatlantic radio, 511 Oct.
Single-sideband experimental broadcasts, 393 Aug.
SIXTY YEARS
Basic theory since 1911, 'Cathode Ray', 171 Apr.
Birthday greetings, *Letters,* J. Redmond & J. C. G. Gilbert, 183 Apr.
Loud and Clear, F. L. Devereux, 156 Apr.
Milestones in receiver evolution, W. T. Cocking, 160 Apr.
More birthday celebrations, 278 June
Our birthday issue, *Letters,* John Scott-Taggart, W. Kenneth Alford, F. C. Ward, Terry I. Roberts, 231 May
Radio communication, significant steps in, W. J. Baker, 167 Apr.
—— wave propagation, ten more years, R. L. Smith-Rose, 164 Apr.
Sixty years, *Editorial* by Hugh S. Pocock, 153 Apr.
The world of amateur radio 1911-1971, Pat Hawker, 173 Apr.
SIXTY YEARS AGO: 249 May, 292 June, 328 July, 401 Aug., 436 Sept., 539 Nov., 607 Dec.
Slow-scan TV, British, 44 Jan.
Sonex audio exhibition, preview, 190 Apr., report, 235 May
Sonic scanning for tubeless TV, J. J. Belasco, 353 July, *Letters,* 429 Sept.
Sound synthesizers, 451 Sept.
Source-follower circuits, J. O. M. Jenkins, 366 Aug.
Space communication frequencies, D. E. Baptiste, 431 Sept.
—— projects, American scientific, 63 Feb.
Square-root circuit, B. L. Hart, 371 Aug.
Stability and reality, Thomas Roddam, 81 Feb.
Stabilizer, voltage, *Circuit Idea,* C. H. Banthorpe, 9 Jan.

Stable *Q*-Multiplier, *Circuit Idea,* D. A. Tong, 600 Dec.
Stereo decoder, phase-locked-loop, i.c., 377 Aug.
—— —— using sampling, D. E. O'N. Waddington, 71 Feb., *Letters,* 123 Mar., 183 Apr., 233 May, 283 June, 320 July
——, loudspeaker, techniques, E. J. Jordan, 67 Feb., *Letters,* 319 July, *Note* 519 Nov.
—— mixer, H. P. Walker, 221 May, 295 June, *Letters,* 318 July, 376 Aug., *Correction,* 300 June, 454 Sept.
—— pre-amplifier, i.c., adding an active rumble filter, L. Nelson-Jones, 303 June
—— tuner, f.m., L. Nelson-Jones, 175 Apr., 245 May, *Letters,* 320 July, 584 Dec., *Correction,* 249 May
Sweep-frequency audio oscillator, R. J. Ward, 412 Sept., *Correction,* 478 Oct.
—— generator, audio, F. H. Trist, 335 July, *Letters,* 374 Aug., *Correction,* 371 Aug.
Switching with diodes using charge analysis, B. L. Hart, 139 Mar.
Synthesizers, sound, 451 Sept.

T.T.L. monostable cascade, H. A. Cole, 301 June
TV line standards converters, digital, 238 May
TV synchronizers and converters, digital, S. M. Edwardson & A. H. Jones, 479 Oct.
TV tubeless, sonic scanning for, J. J. Belasco, 353, July, *Letters,* 429 Sept.
Tape recorder, high-quality, J. R. Stuart, 19 Jan., *Letters,* 320 July, *Correction,* 32 Jan.
—— recording, elapsed time graph for, B. W. Lingard, 452 Sept.
—— ——, progress in, Basil Lane, 563 Nov.
Telephone exchanges of the future, 394 Aug.
Teleprinter, alternatives, D. A. Paynter, 270 June
Television broadcasting, centrimetric, J. C. G. Gilbert, 453 Sept.
—— receiver review, 470 Oct.
Ten practical f.e.t. source follower circuits, J. O. M. Jenkins, 366 Aug.
Tester for f.e.ts., D. E. O'N. Waddington, 579 Dec.
The long run, Thomas Roddam, 33 Jan.
Theory, basic since 1911, 'Cathode Ray', 171 Apr.
Titration potentiometer, automatic, D. R. Bowman, 400 Aug.
Tone-control circuit, low distortion, P. M. Quilter, 199 Apr.
Touch-switch controller, R. Kreuzer, 389 Aug.
Transatlantic radio 70th anniversary, 511 Oct.
——, tests, first, 95 Feb.
'Transfilter', reversed operation of, *Circuit Idea,* G. W. Short, 386 Aug.
Transformer phase reversal?, 'Cathode Ray', 285 June, *Letters,* 374 Aug.
Transients and transience (Sonex 71), 235 May
Transistor circuit analysis, new approach to, A. J. Blundell, 287 June, 329 July
Trigger circuit, zero hysteresis, *Circuit Idea,* C. J. Paull, 532 Nov.
—— system, level-conscious, *Circuit Idea,* A. R. Bidwell, 430 Sept.
Trinitron colour TV tube, S. Miyaoka, 589 Dec.
Trip unit using single i.c., *Circuit Idea,* W. E. Price, 204 Apr.
——, voltage, sensitive, *Circuit Idea,* N. Nicola, 66 Feb.
Tuner, f.m., stereo, L. Nelson-Jones, 175 Apr., 245 May, *Letters* 320 July, 584 Dec., *Correction,* 249 May
Turntable design for home construction, R. Ockleshaw, 473 Oct., (pickup, 516 Nov., wow and flutter meter, 572 Dec.)
200-W linear amplifier, G. R. Jessop, 273 June
Two-way d.c. along single wire, *Circuit Idea,* R. C. Alcindor, 9 Jan.

U.H.F. log-periodic aerial, J. L. Eaton & R. D. C. Thoday, 7 Jan., *Letters,* 233 May

U.K.-5 satellite, 10 Jan.
United states of earth, 547 Nov.

V.F.O. operation on v.h.f., 95 Feb.
V.H.F. helical aerial, G. J. Monser, 418 Sept., *Letters*, 525 Nov.
Variable astable multivibrator, *Circuit Idea*, C. C. Ward, 512 Oct.
—— power law video amplifier, A. M. Pardoe, *Correction*, 32 Jan.
—— power source using magnetic amplifier, *Circuit Idea*, W. B. Pickles, 512 Oct.
'Vector' articles:
Electronic communication with the dead?, 312 June
Initial suggestions, 514 Oct., *Letters*, 526 Nov.
On stopping the home fires burning, 410 Aug., *Letters*, 583 Dec.
Sacred cows and other fauna, 152 Mar.
Salute to 'Free Grid', 212 Apr., *Letters*, 232 May
The cross of godl, 52 Jan.
'Whither is fled the visionary gleam?', 614 Dec.
Vidicon, choosing a, D. J. Gibbons, 89 Feb., 135 Mar.
Vision, artificial, 214 May
Voltage reference source, H. A. Cole, 446 Sept.
—— regulator, f.e.t., *Circuit Idea*, C. R. Masson, 386 Aug.
—— stabilizer, *Circuit Idea*, C. H. Banthorpe, 9 Jan.
Voltmeter, electronic, for 2 to 50kV, A. M. Albisser & N. F. Moody, 119 Mar.
—— using f.e.ts measures capacitor insulation resistance, Lloyd E. MacHattie, 13 Jan.

Wave propagation, ten more years, R. L. Smith-Rose, 164 Apr.
Waveform peak detector, *Circuit Idea*, L. Unsworth, 234 May
Weahter pictures from satellites, J. M. Osborne, 464 Oct., 537 Nov.
Wien-bridge audio oscillator, A. J. Ewins, 104 Mar., *Letters*, 232 May, 427 Sept.
—— oscillators, P. Williams, 541 Nov.
WORLD OF AMATEUR RADIO: 44 Jan., 95 Feb., 144 Mar., 173 Apr., 259 May, 305 June, 356 July, 402 Aug., 455 Sept., 511 Oct., 556 Nov., 601 Dec., *Letters*, 184 Apr., 584 Dec.
Wow and flutter meter, R. Ockleshaw, 572 Dec., (turntable 473 Oct., pickup, 516 Nov.)

Zero hysteresis trigger circuit, *Circuit Idea*, C. J. Paull, 532 Nov.

NEW PRODUCTS

Active filter (Barr & Stroud), 47 Jan.
—— ——, v.h.f. (Wessex), 359 July
—— filters, i.c. for (Mullard), 209 Apr.
Amplifier, battery-operated lock-in (Brookdeal), 263 May
——, h.f. linear (Racal-Mobilcal), 457 Sept.
——, high-power audio (Crown), 308 June
——, i.c. audio (Plessey), 349 July
——, measuring, precision (B & K), 98 Feb.
——, oscillator modules, thick-film (Redac), 461 Sept.
——, ten-watt p.a. (Trusound), 309 June
——, transistor, for 3.4 to 4.2GHz (Watkins-Johnson), 461 Sept.
Analogue multiplier (Motorola), 47 Jan.
Analyser, modulation (Green ECE), 261 May
A to D display card (Fenlow), 97 Feb.

Balanced microwave mixer (Microwave), 97 Feb.
Beam tetrodes (M-O Valve), 207 Apr.
Bridge, automatic digital (Wayne Kerr), 351 July
——, resistance (J. J. Lloyd), 49 Jan.

C.R.T., 28-cm (M-O Valve), 348 July
——, 100-MHz (Thorn), 352 July
Calculator i.c. (Texas), 557 Nov.
Camera, c.c.tv (Dodwell), 507 Oct.
——, colour (Shibaden), 359 July
—— tube, vidicon (EEV), 47 Jan.
Capacitor, axial-lead electrolytic (ITT), 408 Aug.
——, axial-lead polystyrene (Waycom), 458 Sept.
——, close-tolerance high-value (Waycom), 559 Nov.
—— discharge ignition system (Mobelec), 147 Mar.
——, discoidal lead-through (Oxley), 460 Sept.
——, electrochemical (Gould Ionics), 560 Nov.
——, electrolytic, range (Colstar), 147 Mar.
—— for s.c.r. commutation (Aerovox), 208 Apr.
——, high-voltage multiplier (Aerovox), 208 Apr.
——, miniature tantalum (ITT), 147 Mar.
——, plastic sleeved (Pye TMC), 352 July
——, polyester foil (Guest), 461 Sept.
——, resin-coated (Aerovox), 560 Nov.
——, solid tantalum (Seatronics), 461 Sept.
——, tantalum (General Instrument), 409 Aug.
——, trimmer (Wingrove and Rogers), 610 Dec.
——, 200pF to 33nF variable (J. Briechle), 307 June
Cases, instrument (Progressive Projects), 97 Feb.
Cassette data recorder (Teac), 457 Sept.
—— recording heads (Gresham), 608 Dec.
Ceramic, high-permittivity (GEC Hirst), 459 Sept.
Chokes, sub-miniature (Cambion), 408 Aug.
Circuit board, instant (Bourns(Trimpot)), 98 Feb.
Coaxial reed relays (Sealectro), 148 Mar.
—— terminations (Sealectro), 98 Feb.
Colinear array (J-Beam), 348 July
Communication receivers (Eddystone), 351 July
Connector, coaxial (Sealectro), 407 Aug.
——, multi-pole high-current (Fischer), 145 Mar.
——, plastic shrouded (Henry & Thomas), 358 July
——, T line (Pressac), 407 Aug.
Construction kits (Stylus Supplies), 352 July
Counter, digital (AMF), 349 July
——, 50MHz (Wayne Kerr), 405 Aug.
——, high-frequency (Dana), 408 Aug.
—— timer (Orbit), 307 June
—— ——, low-cost (Marconi), 352 July
—— ——, 60MHz (Bradley), 347 July
—— ——, versatile (SE Labs), 458 Sept.
Crystal, quartz, l.f. (ITT), 45 Jan.

Data recorder, high performance 42-track (SE Labs), 509 Oct.
Delay line unit, variable (Matthey Printed Products), 148 Mar.
—— ——, video, switched (Lexor), 611 Dec.
Desolder heads, i.c. (Solderstat), 99 Feb.
De- soldering tool (Henri Picard), 458 Sept.
—— wick (Light Soldering), 458 Sept.
Detector, error, digital for p.c.m. (Marconi), 46 Jan.
——, selective (Waverley), 99 Feb.
Digital audio delay system (Gotham), 507 Oct.
—— circuits, l.s.i. (Plessey), 260 May
—— display, large (Unilab), 309 June
—— error detector for p.c.m. (Marconi), 46 Jan.
—— indicator (K.G.M.), 148 Mar.
—— tester, swift (Honeywell), 508 Oct.
—— voltmeter logic module (Integrated Photomatrix), 351 July
Diode, bidirectional regulator (Unitrode), 559 Nov.
——, high-speed leadless (Dickson), 208 Apr.
——, limiter (Sylvania), 46 Jan.
——, low leakage current (Mullard), 45 Jan.
——, low-power avalanche (International Rectifier), 611 Dec.
——, optical position sensor (Techmation), 460 Sept.
——, photo, silicon (Integrated Photomatrix), 48 Jan.
——, power, plastic (AEI), 209 Apr.
——, Schottky barrier (Mullard), 508 Oct.
——, varactor, 60-GHz (Services Electronics), 208 Apr.
Disc store, rugged (Process Peripherals), 405 Aug.
Display 14-numeral (Mullard), 47 Jan.
—— unit, cathode ray (Electronic Visuals), 208 Apr.
Divider, frequency, M.O.S. (Auriema), 97 Feb.
Double balanced mixers (Hatfield), 510 Oct.
Duplicator, tape (Ampex), 146 Mar.

Electrolytics, reliable (Seco Novea), 351 July
Electronic voltmeter (ITT), 100 Feb.

F.E.T., dual voltage comparator (Siliconix), 509 Oct.
——, low-capacitance (Siliconix), 357 July
——, low-cost (Redhawk), 358 July
——, switch/drivers (Siliconix), 263 May
——, v.h.f. (Siliconix), 609 Dec.
F.M. tuner (Millbank), 308 June
Ferrite circulator, gyrotropic (Microwave & Electronic), 557 Nov.
—— limiters (EMI-Varian), 209 Apr.
Field-strength indicator, u.h.f., (Rohde & Schwarz), 209 Apr.
Filter, active (Barr & Stroud), 47 Jan.
—— —— v.h.f. (Wessex), 359 July
——, digital (Rockland), 261 May
——, mains input (Waycom), 457 Sept.
——, quartz crystal (Salford), 458 Sept.
Flash tube (EEV), 310 June
Frequency synthesizer, v.h.f. (Askers), 209 Apr.
Function generator, general purpose (Krohn-Hite), 97 Feb.
Furnace for thick film circuit (DEK), 609 Dec.
Fuses (Belling & Lee), 352 July

Generator, logic level pulse (Grange), 407 Aug.
——, logic pulse (C & N), 310 June
——, pulse (Lyons), 48 Jan., (Texas), 97 Feb., (Advance), 262 May
——, signal, multi-purpose (Rohde & Schwarz), 99 Feb.
Generator; signal synthesizer (Green ECE), 310 June
——, signal, versatile (Marconi), 348 July
——, signal, wide range (Marconi), 459 Sept.
——, waveform (Microdot), 457 Sept.
Gunn oscillator (Mullard), 405 Aug.

Head, magnetic recording (Marriott), 510 Oct.
Headset, lightweight (Amplivox), 508 Oct.
Heat conducting compound (Jermyn), 507 Oct.
Heatsinks, low-power (Jermyn), 310 June

I.C. desolder heads (Solderstat), 99 Feb.
—— for active filters (Mullard), 209 Apr.
—— unsoldering tool (Marconi), 145 Mar.
I.Cs for f.m. stereo receivers (Sprague), 308 June
I.F. amplifier/detector i.c. (National Semiconductor), 260 May
Ignition system, capacitor-discharge (Mobelec), 147 Mar.
Ignitron (EEV), 352 July
Image storage tube (Cathodeon), 557 Nov.
Impedance meter (ITT), 146 Mar.
Incremental indicator (Comark), 461 Sept., *Correction*, 526 Nov.
Indicator, digital (K.G.M.), 148 Mar. (FR electronics), 459 Sept.
——, field-strength, u.h.f. (Rohde & Schwarz), 209 Apr.
—— tubes (Mullard), 262 May
—— tube, numeral (ITT), 207 Apr.
Inductor, solid-state (Cambion), 306 June
Instrument for comparing micro-circuits (Vision Eng.), 306 June
Integrated circuits, linear (Signetics), 49 Jan.
Interference measuring transducer. r.f. (Control Technology), 610 Dec.
Inverter, static (R. Gilfillan), 558 Nov.

Lamp and holder, solid-state (Oxley), 349 July
Lampholder, subminiature (WEL), 146 Mar.
Light detector module (Techmation), 559 Nov.
—— emitting diodes (H-P), 608 Dec.
—— sensing array (Integrated Photomatrix), 348 July
Linear i.cs (Signetics), 49 Jan.
Logic, m.s.i., b.c.d. counter (SGS), 145 Mar.
—— modules (Feedback), 208 Apr.
—— tutors (Limrose), 507 Oct.
Low-noise tape (3M), 148 Mar.

M.O.S.F.E.T. switch, high voltage (Siliconix), 46 Jan.
M.O.S. frequency divider (Auriema), 97 Feb.
—— high speed shift register (SGS), 557 Nov.
—— large scale i.cs (Thorp), 263 May
Magnetron, coaxial (EMI-Varian), 261 May
Memory, high speed (Mullard), 262 May
——, random access (Plessey), 352 July
Meter, capacitance and inductance (Sintrom), 510 Oct.
——, contact resistance (B.P.L.), 350 July
——, edgewise panel (Risso), 357 July
——, impedance (ITT), 146 Mar.
——, panel (Taylor Electrical), 560 Nov.
——, power, for semiconductor devices (Aladdin), 349 July
——, sound level (General Radio), 608 Dec.
——, u.h.f. signal-strength (Labgear), 559 Nov.
Microscope adaptor (Vision Engineering), 608 Dec.
Minority carrier demonstration (Research Instruments), 611 Dec.
Mixer, balanced microwave (Microwave), 97 Feb.
——, double balanced (Anzac), 458 Sept.
Moisture, sealer, spray-on, (Electrautom), 608 Dec.
Motors, d.c. (Portescap), 349 July
——, d.c., efficient (Trident), 263 May
——, miniature d.c. (Portescap), 461 Sept.
Multimeter, digital (Marconi), 147 Mar. (H-P), 352 July, (Bach-Simpson), 460 Sept.
Multiplier, analogue (Motorola), 47 Jan.

Op-amp, high-output (Ancom), 309 June
——, high-performance (Burr-Brown), 45 Jan.
—— output stage (Burr-Brown), 46 Jan.
—— with f.e.t. input (National Semiconductor), 46 Jan.
Opto-electronic coupler (Fairchild Cameras), 610 Dec.
Oscillator, audio (STC), 358 July
——, crystal (Cathodeon), 350 July
——, low distortion (NF Instruments), 459 Sept.
——, mixer/local, 9GHz (Micro Metalsmiths), 558 Nov.
——, video (Wayne Kerr), 49 Jan.
——, wideband high-power (Microdot), 557 Nov.
Oscilloscope amplifier (S.E. Labs), 306 June
—— and curve tracer (Telequipment), 347 July
——, battery powered (H-P), 262 May
—— calibrator (G & E Bradley), 309 June, *Correction*, 359 July
—— camera (Shackman), 99 Feb.
——, portable dual channel 18MHz (Marconi), 260 May
—— probe, high impedance (Meteronic), 560 Nov.
——, Russian (Z &I), 48 Jan.
——, 10MHz, dual-trace (Philips), 559 Nov.
——, 25MHz storage (Advance), 509 Oct.
——, twin-channel (Bradley), 207 Apr.
——, wide bandwidth (Philips), 306 June
Oven for TO-5 devices (Jermyn), 408 Aug.

P.A. acoustic 'equalizer' (Astronic), 310 June
P.V.C. coating for p.c. boards (Plastic Coating), 49 Jan.

Pandicon, 14-numeral (Mullard), 47 Jan.
Panel drilling bit (West Hyde), 408 Aug.
Photoconductive cell (Mullard), 99 Feb.
Plotter, XY, inexpensive (J.J. Lloyd), 406 Aug.
Plug and socket, right-angle (Henry & Thomas), 147 Mar.
——/header, dual-in-line (Jermyn), 608 Dec.
Potentiometer, conductive plastic (Electrautom), 147 Mar.
——, helical (Reliance), 309 June
——, instrument (Welwyn), 350 July
——, linear-law (Bourns (Trimpot)), 459 Sept.
——, precision (Bourns (Trimpot)), 308 June
——, 6-mm (TRW), 209 Apr.
——, slider (AB Electronic), 309 July
——, trimmer, miniature (Kynmore), 409 Aug.
Power meter for semiconductor devices (Aladdin), 349 July
—— NOR gate (ITT), 358 July
—— supplies, high-density (Advance), 352 July
—— —— with isolated outputs (Elcor), 146 Mar.
—— supply, dual (H-P), 98 Feb.
—— ——, dual, for op-amps (Microtest), 45 Jan.
—— —— for logic circuits (Coutant), 508 Oct.
—— ——, klystron (Microtest), 98 Feb.
—— ——, miniature (Rastra), 100 Feb.
—— ——, miniature regulated plug-in (Weir), 359 July
—— ——, modular high-voltage (Velonex), 146 Mar.
—— ——, stabilized (EKB), 146 Mar.
—— ——, switched (Trio), 610 Dec.
—— ——, variable (Roband), 145 Mar.
Precision potentiometers (Bourns (Trimpot)), 308 June
Printed circuit elements (Circuit-Stik), 409 Aug.
Pulse generator (Texas), 97 Feb.

Quadrature coupler, u.h.f. (Motorola), 510 Oct.

Radio microphone (Reslosound), 358 July
——, v.h.f. miniature (Van Dusen), 148 Mar.
Radiotelephone for v.h.f./a.m. (Ultra), 358 July
—— for v.h.f./f.m. (Singer), 359 July
——, h.f. (Hatfield), 348 July
——, marine s.s.b. (RF Communications), 309 July
——, maritime (Kelvin Hughes), 260 May
——, mobile (Burndept), 560 Nov.
Receiver, marine communication (National Radio Co.), 510 Oct.
——, s.s.b. (Marconi Marine), 609 Dec.
——, v.h.f. aircraft (Park Air), 261 May
Record cleaner, automatic (Multicore Solders), 405 Aug.
Recorder, chart (Smiths Industries), 610 Dec.
——, portable instrumentation (Bell & Howell), 405 Aug.
——, slide sync (Sigmatron), 558 Nov.
——, strip chart (Z & I), 261 May
—— test set (Ferrograph), 357 July
——, wide bandwidth, f.m. (Bell & Howell), 610 Dec.
—— with extra low tape speed (Pye TVT), 507 Oct.
Recording system, shock resistant (A.S. Electronics), 559 Nov.
—— ——, very accurate (Gresham Recording Heads), 457 Sept.
—— tape, improved (3M), 409 Aug.
Rectifier, miniature (Solid State Devices), 359 July
——, miniature silicon bridge (General Instrument), 207 Apr.
——, 6A, in plastic pack (Motorola), 358 July
Reduction gear drive (Jackson), 145 Mar.
Reed relay, coaxial (Sealectro), 148 Mar.
—— ——, encapsulated (Keyswitch), 100 Feb.
—— ——, sensitive (Pye TMC), 459 Sept.
—— switches, (FR Electronics), 407 Aug., 461 Sept.
Reel-to-cassette duplicator (Telex), 509 Oct.
Regulators, encapsulated (Roband), 407 Aug.
Relays, mercury-wetted (Associated Automation), 350 July
——, miniature (Londex), 352 July
Resistance bridge (J. J. Lloyd), 49 Jan.
Resistor, metal film (ITT), 609 Dec.
——, metal-oxide (WEL), 100 Feb., (Steatite), 510 Oct.
——, miniature (Solitronics), 45 Jan., (Steatite), 508 Oct.
——, plug-in (Erie), 262 May
——, precision wirewound (Guest), 560 Nov.
—— range (Erie), 352 July
——, trimmer, multi-track (Contelec), 608 Dec.
——, voltage-dependent (ITT), 408 Aug.
—— with heatsink (C.G.S.), 48 Jan.

Screened boxes (Suhner), 352 July
Selective detector (Waverley), 99 Feb.
Semiconductor tester (Levell), 460 Sept.
Shift registers (GEC), 406 Aug.
Silicone adhesive sealant (ICI), 308 June
Sockets, DIN, board-mounting (Guest), 558 Nov.
——, dual-in-line (Jermyn), 148 Mar.
—— for 24-pin i.cs (Texas), 148 Mar.
——, 14-lead (Jermyn), 47 Jan.
——, printed circuit (Berg), 357 July
——, TO-5 (Jermyn), 357 July
Solder tags for inductors (Aladdin), 351 July
Soldering gun (Klaus Schlitt), 100 Feb.
—— iron, battery operated (Antex), 405 Aug.
—— ——, pencil (Weller), 407 Aug.
—— ——, temperature-controlled (W. Greenwood), 460 Sept.
—— ——, thermally controlled (Adcola), 406 Aug.
Sound-level meter calibrator (Rohde & Schwarz), 560 Nov.
Spectrum analyser, r.f., with 10Hz resolution (H-P), 46 Jan.
Stepper switch, sandwich (N.S.F.), 350 July
Stereo simulator (Kampel), 357 July
Stylus balance (Multicore), 409 Aug.
Switch, dual in-line (Erg), 351 July
——, edge, miniature (Plessey), 47 Jan.
—— for printed circuit board (Diamond H), 611 Dec.
——, high-power static (Industrial Instruments), 310 June
——, miniature rotary (Guest), 349 July
——, rotary (Plessey), 98 Feb.
——, toggle, sub-miniature (WEL), 45 Jan., (Guest), 100 Feb.
——, zero-voltage, for thyristors (RCA), 409 Aug.
Switches, heavy duty wafer (Centralab), 146 Mar.
——, press-button (Arrow), 409 Aug.
——, push-button (Guest), 460 Sept.
——, rocker (Bulgin), 610 Dec.
——, rotary-action (Honeywell), 406 Aug.
——, toggle, miniature (Guest), 147 Mar.

T.T.L., high-speed (Raytheon), 610 Dec.
Tachometer, portable (Sapphire), 47 Jan.
Tape duplicator (Ampex), 146 Mar.
—— low noise (3M), 148 Mar.
—— noise reduction unit (Kellar), 507 Oct.
—— recorder, portable (Honeywell), 100 Feb.
Tape recorder, professional (Leevers-Rich), 308 June
Telephone dial testers (Amalgamated Wireless), 207 Apr.
Television waveform monitor (Dynamco), 347 July
Thermistor, positive temperature coefficient (Texas), 147 Mar.
——, fast (Westinghouse), 307 June
——, improved plastic (G.E. USA), 48 Jan.
Thyratron, h.f. hydrogen (M-O Valve), 611 Dec.
Time-standard quartz crystals (ITT), 351 July
Transceiver, portable (Labgear), 100 Feb.
——, s.s.b. (Spilsbury & Tindall), 559 Nov.
——, u.h.f. intercom (Rank), 559 Nov.
——, v.h.f. (Park Air), 307 June
Transformer, miniature (Plessey), 263 May
——, pulse, d.i.l. (Bourns (Trimpot)), 209 Apr., 263 May
——, portable variable (Claude Lyons), 262 May
——, variable (Zenith), 409 Aug.
Transistor and diode test set (Lorlin), 359 July
—— alarm-signal generator (UMED), 560 Nov.
——, audio (Mullard), 309 June
—— for consumer applications (AEG-Telefunken), 611 Dec.
—— for television receivers (Mullard), 48 Jan.
—— for thin/thick film circuits (Mullard), 49 Jan.
——, 4GHz (GEC Hirst), 48 Jan.
——, high-current switching (Mullard), 148 Mar., 262 May
——, planar (Ferranti), 351 July
——, power (G.E. U.S.A.) 148 Mar., (Ates) 407 Aug., (Mullard), 558 Nov.
—— ——, for v.h.f. (TRW), 45 Jan.
—— ——, microwave (GEC-AEI), 352 July
—— ——, u.h.f. (Mullard), 46 Jan.
——, silicon gate (GEC (Marconi-Elliott)), 48 Jan.
——, switching (Sprague), 307 June
—— tester (Levell), 350 July
——, v.h.f. (Communications Transistor), 49 Jan.
——, video (Mullard), 350 July
Transmission-line drivers and receivers (Motorola), 145 Mar.
Transmitter-receiver for amateurs (Hallicrafters), 307 June
Travelling-wave tubes, high-power c.w. (EEV), 260 May
Trimmer potentiometer range (Kynmore), 509 Oct.
——, welded cermet (Amphenol), 261 May
——, wirewound (Kynmore), 457 Sept.
Tubes, flash (Hivac), 49 Jan.
Turns-counting dial (R. C. Knight), 99 Feb.

U.H.F. power transistor (Mullard), 46 Jan.

Variable delay line unit (Matthey Printed Prods), 148 Mar.
—— networks (Sprague), 352 July
Video oscillator (Wayne Kerr), 49 Jan.
—— recording system, portable (Akai), 46 Jan.
—— system trolley (Bell & Howell), 359 July
Vidicon camera tube (EEV), 47 Jan.
——, intensifier (EMI), 406 Aug.
Voltmeter, a.c., high impedance (G & E Bradley), 358 July
——, digital (Fluke), 352 July
——, electronic (ITT), 100 Feb.
——, r.m.s. (Prosser), 207 Apr.
——, transient (Sintrom), 408 Aug.

Wattmeter (Hartmann & Braun), 306 June
Waveform monitor, television (Dynamco), 347 July

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'Cathode Ray', 171 Apr., 285 June, 391 Aug.
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