Wireless World

ELECTRONICS, RADIO, TELEVISION

AUGUST 1964

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NEW MULLARD PACKAGE FOR PORTABLE RADIOS

PFL200 TEN-PIN VALVE

UNIQUE DOUBLE PENTODE FOR DUAL-STANDARD RECEIVERS

DEVELOPED by Mullard to meet the needs of the latest dual-standard television receivers, the PFL200 is a video valve of unique construction. A novel feature in its design is the use of a 10-pin B10B valve base. This new base—the decal base—makes possible the inclusion of two completely separate pentode systems in one envelope.

Mullard

What's new in the new sets

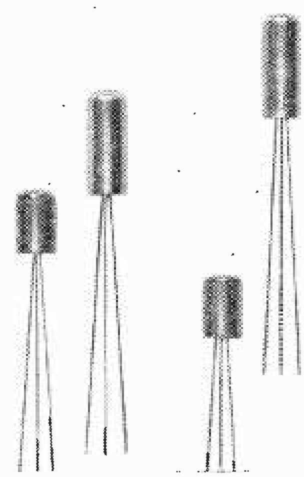
The pentodes in the PFL200 are dissimilar, and have been given complementary electrical characteristics which make possible the design of exceptionally economical full-performance television receivers. Particular care has been taken in the pinning and in the screening between the two sections of the valve to provide independence of operation.

The PFL200 'L' section is designed to operate as a high-gain video output pentode capable of producing a large output voltage across a low-value anode load resistor. The 'F' section is a voltage-amplifying medium-slope pentode designed principally for application as a synchronising pulse separator.

Mullard LFK4 forms basis of economical audio stages

COMPACTNESS, good performance and economy of operation are prerequisites of present-day portable radio receivers, and all three are achieved in the latest models using the new Mullard LFK4 transistor audio package.

Two n.p.n. and two p.n.p. transistors comprise the LFK4. A complementary matched pair of an AC127 n.p.n. transistor and an OC81 p.n.p. transistor form a transformerless output stage. Preceding this stage is an OC81D driver stage, and the package is completed by another AC127 used as a pre-amplifier. (When ordering replacements for the LFK4, the particular transistor required should be specified.)



Because the package can be d.c. coupled throughout, the number of interstage coupling components is reduced. This, together with the elimination of the comparatively bulky transformers, results in notable savings in space and cost.

D.C. coupling also offers improvements in terms of performance. An extended frequency response is obtainable, and the amplifier has a better response to rapidly changing audio signals.

The sensitivity of the LFK4 is such that an output of 700mW can be obtained using a 9V battery, or approximately 1W using a 12V supply.

An attractive feature of the LFK4 package is that the OC81D driver transistor can be run at low quiescent current. Battery drain is therefore reduced even with the large outputs obtainable with the LFK4. Extended battery life—an obvious benefit—is therefore a significant "extra" of the new Mullard audio package.

AC107 LOW-NOISE TRANSISTOR FOR TAPE RECORDERS

THE Mullard AC107 low-noise junction transistor is now frequently used as a voltage amplifier in inexpensive hybrid tape recorders. In this application, it offers the required amplification while introducing the minimum of hum and microphony. In addition to hybrid recorders, the AC107 is particularly suitable for battery-operated all-transistor tape recorders.

Use of the AC107 is not limited to inexpensive equipment, however. Manufacturers of high-quality audio equipment who wish to employ transistor pre-amplifiers because of their inherently good microphony properties are making increasing use of the device. The Mullard AC107 is thus contributing greatly to the high standards attainable with the wide present-day range of audio equipment.

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11WW—082 FOR FURTHER DETAILS.

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Signal Processing

PIONEERS of wireless communication and of radar whose faculties were trained to a high pitch in hearing morse through atmospherics or in recognizing a target return in "grass" are apt to look askance at the growing complexity of receiving equipment and the tendency to delegate human control to a supervisory and maintenance role. There will always be a division of opinion about this as there is between the devotees of ripe Stilton and those who prefer the uniformity of cheese which comes ready wrapped and "not touched by human hand." But if you find yourself in a strange new town and must have protein in a hurry, the supermarket will give you what you want long before you can hope to locate the grocer with the real thing.

These somewhat irreverent thoughts obtruded during the periods (rather more frequent than we could have wished) when we lost track of the mathematical argument put forward by delegates to the symposium last month on Signal Processing in Radar and Sonar Directional Systems, organized jointly by the I.E.R.E. and the Electronic and Electrical Engineering Department of the University of Birmingham. The published proceedings will in due course reveal the complexity of the task and the magnitude of the mathematical research and experimental development which has been brought to bear on this problem, which is now of prime importance in civil air traffic control and in radio astronomy as well as in military radar and sonar.

The need for signal processing arises from the complexity of the reverberation responses evoked in the ocean by a sonar pulse and by the mass of irrelevant "paint" on a radar screen due to aerial side lobes, interference from other radars, natural or unfriendly generation of noise, inadequate directional resolution, etc. Superdirective aerials, multiplicative arrays and other forms of selection and cross-correlation of signals are now well-established tools of the systems engineer. Their design and evaluation will keep applied mathematicians well supplied with problems for the foreseeable future.

Although some of us may sigh for the good old days of simple on-off power signalling when, if you couldn't get through, you put an extra weight on the engine governor or boiler safety valve and doubled up the fuses, the pulses were, even then, being shaped by the tuned-circuit parameters and there is really no such thing as a "raw" signal. At the receiving end we are presented with an event which carries potential information, not only of the source, but of the medium and of all the vicissitudes of its passage. At the transmitting end there are clearly advantages to be gained—particularly in radar—by processing the emitted pulse train to a form which will probe for the required information, but the processing of received information must be done with care and with a full recognition that in throwing away information which is regarded as redundant or irrelevant we may be throwing away the baby with the bath water. This may be particularly true when clipping is used to reduce noise and the only information left is the time spacing of zero crossings. Any process designed to clarify the effect one is looking for may well at the same time obscure what the signal is trying to tell.

The increased sensitivity of masers and parametric amplifiers and the information gathering power of modern aerial arrays together produce too complex a picture for analysis by other than computer techniques in the time available for decision and action, but we hope that somewhere in the set-up there will always be at least one "raw" display "warts and all" to which someone skilled in the art may refer when the machine comes up with an incredible answer.

An Introduction to

MICROWAVE TECHNIQUES

1—MICROWAVES, PAST, PRESENT AND FUTURE

By K. E. HANCOCK*

ABOUT two decades ago the term microwaves made its appearance, and has since turned up regularly, in both the newspapers and technical Press, in articles on such widely differing subjects as steak grills and Telstar.

In this article we are going to see what, if anything, makes microwaves different from ordinary r.f., how they were first used, and the rapid increase in knowledge and use up to the present day, concluding with some likely future developments. Succeeding articles will cover a little microwave theory, microwave power sources, microwave components and instruments, and a final chapter on microwave measurements.

Whilst there is no fixed definition of the term "microwaves," it is generally taken to mean that section of the frequency spectrum below infra-red, and above the range where normal circuit techniques using resistance, capacitance and inductance can be used. In terms of frequency this is from approximately 1000 Mc/s to 300,000 Mc/s, with a band between about 300 Mc/s to 1000 Mc/s in which either fairly conventional circuits or microwave techniques may be used. At the upper end of the range there is again an overlap where either microwave or optical techniques are in use.

The first thing that will be noted about this band of frequencies, is that in terms of wavelength, the waves are small. If the formula $f=c/\lambda$ is applied where f = frequency in cycles per second, c = speed of propagation in free space in metres per second, λ=wavelength in metres, it will be seen that wavelengths in the microwave range are from one millimetre to thirty centimetres. In this band therefore normal components are comparable in size to a wavelength or numbers of wavelengths.

About this point revolves the whole microwave technique. Nothing is done in the microwave field that is not theoretically possible at lower frequencies. However, at the lower frequencies the size of the equipment used would become impossibly large.

The fact that a component such as a resistor is an appreciable fraction of a wavelength long at microwave frequencies means it no longer functions as a resistance alone. Nor is its function determined only by its value, but by its dimensions, position in the circuit or transmission line, and the characteristics of the generator, transmission line, and its load.

Most microwave components therefore take a completely different form from those used in low-frequency circuit techniques, and in many cases are not directly comparable with familiar devices. The resistor is replaced by an attenuator, an LC tuned circuit by a precise length of tubing called a resonator, a R circuit by a device termed a phase shifter, and normal connecting wire by waveguide, to quote but a few differences. Detailed reasons for these changes will be given in the fourth article in this series dealing with microwave components, but most of them revolve around the short wavelength and means of propagation.

It is possible and, at the higher microwave frequencies, necessary to propagate signals through hollow metal tubes called waveguides. At comparatively low frequencies normal wires will carry a signal with little radiation or attenuation. Above a few megacycles per second, attenuation due to skin effect and radiation, begins to become a problem. Both these factors are alleviated by the use of coaxial cable, but as frequency increases so does loss, until at about 1000 Mc/s the practicability of coaxial line becomes marginal and over about 9000 Mc/s it gives way to the use of waveguide entirely. In the next article we will see why it is possible to propagate a signal through a waveguide. In the meantime, a reminder that the technique is limited to the microwave frequencies only by practical limitations of size may be given by the fact that much of the present day research in very *low* frequency propagation is carried out using microwave theory in relation to the massive waveguide formed between the earth and the various layers of the ionosphere.

History of Microwaves

The use of frequencies in the microwave range, albeit fortuitous, is as old as radio itself. As early as 1894, Sir Oliver Lodge[1] in a demonstration before the Royal Society surrounded his spark generator with a cylinder closed at one end. From present-day theory we know that this cylinder acted as a high-pass filter and waveguide, allowing efficient propagation of the microwave content of the spark signal only. Although some theoretical work on the propagation of waves in cylinders had been carried out at this time[2], the whole field of what we now know as electronics was so new that the phenomena, after receiving some interest soon after[3], was more or less forgotten in the face of the many new advances in the succeeding years. However, in 1933 after some brilliant theoretical and practical work by George C.

1. O. Lodge—*Proc. Royal Institution*, Vol. 14, p. 321, 1894.
2. J. J. Thomson. "Recent Researches in Electricity & Magnetism," pp. 344. 1893. J. Lamor, "Electrical Vibrations in Condensing Systems," *Proc. London Math. Soc.*, Vol. 26, p. 119, 1894.
3. R. H. Weber, "Electromagnetic Waves in Metal Pipes," *Ann. d. Phys.*, Vol. 8, pp. 221, 751, July 1902.

* Canadian Marconi Company.

Southworth[4] at the Bell Telephone Laboratories in the U.S.A., work in the microwave field began in earnest, and has been continuing at an increasing pace ever since.

Southworth's interest in the possibility of propagation through waveguides was first aroused during work involving a Lecher bar resonator in a trough of water, in 1920. The trough acted as a waveguide, and being filled with water, which has a high dielectric constant and thus slows down the wave, the wavelength was only a little more than one-tenth that of the same signal in free space. Waves propagated in the trough waveguide were therefore superimposed on the phenomena being studied. This annoying side effect turned out to be of immense importance, as it allowed the study, several years later, of this form of transmission at a frequency then obtainable, that is, around 300 Mc/s. Power sources for frequencies in the normal microwave range were not available at that time, and much basic work was carried out with cylinders filled with water, transmitting frequencies of about 300 Mc/s at wavelengths of around 11 cm.

In the early 1930s power sources became available in the 2000 Mc/s range, and Southworth continued his work using air filled copper plumbing pipe. The somewhat derisory term of "plumbers" has stuck to microwave engineers ever since. Even without the usual accelerating factor of war, progress was so rapid that by the end of 1933 a five-inch circular waveguide run, 875 feet long, was in use for transmission of c.w. and voice modulated signals[5, 6]. One of the discoveries of prime importance made with this apparatus was the low-loss and non-radiating nature of this form of transmission line.

Although Southworth's research was for the Bell Telephone Laboratories, and chiefly aimed at communications applications where advantage could be taken of the very wide bandwidth available at these frequencies, the first production equipment making use of this technique was in all probability radar.

Radar began its life in the early 1930s mainly as the result of work by Sir Robert Watson-Watt. By the beginning of the second world war in 1939, Great Britain was protected by a ring of operational radar stations. However, these early "Chain Home" stations did not operate on frequencies in the microwave range but in the h.f.-v.h.f. region of the spectrum. They suffered from several limitations. The first concerned definition. At the low frequencies in use only very wide beams could be transmitted, with the result that a number of aircraft at the same range would be detected as one target. Secondly, a vertical section through the polar diagram of the aerial showed the lobe curving fairly sharply away from the ground a short distance from the transmitter. This meant that ships and low-flying aircraft could not be detected. The aerials required were massive structures mounted on high towers, making the use of radar in a mobile form, or on ships and aircraft out of the question. Lastly, accuracy depended on the production of very short, very steep sided pulses of power, and this was very difficult at the frequencies then in use.

4. U.S. Patents No. 2129711 (16 March 1933) and No. 2129712 (9 Dec. 1933) both in the name of G. C. Southworth.
5. G. C. Southworth, "Hyper Frequency Waveguides—General Considerations and Experimental Results," *B.S.T.J.*, Vol 15, pp. 284-309, April 1936.
6. G. C. Southworth, "Some Fundamental Experiments with Waveguides," *Proc. I.R.E.*, Vol. 25, pp. 807-822, July 1937.

Fortunately Southworth's early work pointed the way to the use of microwave frequencies and techniques, and several English groups were vigorously pursuing this approach. Much work remained to be done, particularly in the fields of power sources and aerials, but under the pressure of war, development went on apace and soon radar equipments using frequencies in the 3000 Mc/s and 9000 Mc/s ranges made their appearance in land, sea and air applications.

The main factor that enabled this rapid advance to take place was the development in England of the magnetron, a high-power microwave oscillator.

Up to this time much experimental and theoretical work had been carried out on microwave techniques, and many components had been developed. It was known for instance that at these frequencies it was possible for a half-wave dipole aerial a few inches long, and backed by a parabolic reflector a few feet in diameter, to produce a sharply defined beam only a few degrees wide. This immediately overcame to a large extent the problems of definition, low cover, and mobility. However, to provide sufficient range, kilowatts of power were required, and the klystrons and high-frequency triodes available at that time produced in general milliwatts, and at best watts of power.

In 1939 Drs. J. T. Randall and H. A. H. Boot, working under Prof. Oliphant at Birmingham University, produced the first workable high-power magnetron, a microwave oscillator capable of producing many kilowatts of pulsed power. In 1940 the information on this great advance was passed to the U.S. Naval Research Laboratory, thus beginning the vast amount of intimate collaboration in electronic research and development which took place between the two nations during the war.

The development of the magnetron into a repeatable, reliable component was completed in an incredibly short time, leaving the path open for the development of the astounding array of radar devices used during the war.

Present Applications of Microwaves

At the end of the war much research carried out on microwave techniques was published. This aided the application of microwave techniques to a number of fields other than radar.

Present-day applications in probable order of proportion of the overall field would include radar and navigational aids, communications and television relay, radio astronomy, molecular and other research, and such diverse industrial applications as the rapid cooking of food, the measurement of moisture in bricks, the detection of salt in crude oil, and the breaking up of concrete and rock. Radar and communications between them account for an estimated eighty-five per cent of the total and are themselves divided into many facets. In these articles we have space for little more than a brief mention of the main branches of application.

With radar, undoubtedly the largest field is marine radar. Operating mainly in the 3 cm bands, the use of search-type radar for both collision avoidance and navigation, is almost universal for all classes of trading vessels. Currently an effort is being made, particularly by American manufacturers, to extend this field to the smaller type of fishing and pleasure boats. There are even models available for boats as small as 15-foot pleasure boats driven by outboard motors. The narrow beams and short pulses used give good definition, and the maximum range of about 30 miles, due to the fact that microwaves penetrate the ionosphere and are therefore limited to line-of-sight ranges, is no limitation to comparatively slow-moving ships.

Airborne radar perhaps ranks next. The air forces of the world use 3 cm and 1 cm search radar for interception and bombing, both operations now being almost automatic. Range increases with flying heights as line-of-sight increases. Navigational radars use several bands down to around 2 cm, whilst electronic countermeasures employ both radar and other microwave techniques across a large portion of the microwave spectrum. Airlines use radar in ever-increasing numbers, both for navigation and storm avoidance, whilst one of the latest developments is putting Doppler navigational radar into helicopters. Ground radar employs what are probably the largest and the smallest radar systems. The largest radar systems, as far as the author is aware are the massive B.M.E.W.S early warning radars with outputs of several megawatts using huge waveguides to give low loss at a few hundred megacycles. With these lower frequencies and very great power, a vastly extended range is obtained.

At the other end of the range we have the tiny self-contained Doppler radars that are mounted in police cars to record the speed of other road users. These ingenious devices, which are in common use in North America, can record with high accuracy the speed of a following or approaching vehicle, whilst the radar car is itself in motion. The frequency difference between the transmitted and received signals caused by the moving target car giving Doppler shift, is measured accurately and, as it is proportional to speed difference between the cars, is processed to give the target car's speed directly on a meter.

It is understood that the "father" of radar, Sir Robert Watson-Watt, was fined on a recent visit to the U.S.A. on the evidence of one of these devices. His comments are not available.

Between these limits are a large number of equipments with such applications as air traffic control, ground controlled approach for aircraft and harbour guidance radar. The majority of these systems operate in the 10 cm band.

The second field of microwave application, communications, is also very diverse.

Most countries of the world now have their major cities interconnected by broadband radio relay systems. These vast systems operate in the 2000, 4000 and 6000 Mc/s bands, making use of the bandwidth available at these frequencies to carry up to 1,800 telephone conversations on a single r.f. channel. The aerials transmit and receive simultaneously and can carry four or more r.f. channels in each direction. The narrow beamwidth obtained with fairly small aerials increases gain and reduces interference. Microwave frequencies are relatively free from man-made interference in any case, and the restriction of the gain of the receiving aerial to a narrow beam increases this advantage. The limitation of line-of-sight transmission is in some cases a disadvantage, as is the fading caused, particularly in the 6000 and 11000 Mc/s bands, by changes in atmospheric conditions. However, these points are far outweighed by the obvious disadvantages of the overcrowded low frequencies and expensive low-capacity cable transmission. The unmanned relay stations are 30 to 60 miles apart and are ideal for covering the vast distances found in many parts of the world. For greater hop distances in inaccessible country, the high power forward scatter systems are used.

The latest advance in microwave communications are the active and passive satellites, the Telstar and Syncom systems operating in the 4000 Mc/s and 6000 Mc/s bands, again taking advantage of the high aerial gain and large traffic capacity of microwave techniques.

A further use of microwaves in communications is for rocket telemetry where microwave frequencies can penetrate the plasma plume of the rocket engine.

In research, waveguide techniques are used for the study of spectral line resonances of various substances, and in linear accelerators for the study of high-energy particles, to name but two applications.

The new but fast-developing science of radio astronomy is yet another user of these techniques. Much work has already been carried out on such diverse subjects as attempting to measure the length of the Venus day, the temperature on the surface of Jupiter, and a study of the immense clouds of interstellar hydrogen gas.

One of the more ingenious industrial applications is the use of microwave techniques by one of the major oil companies to measure the salt water content of crude oil from the wells. This is done by the comparison of the phase shift through an uncontaminated sample and the output of the well. Other applications included the determination of the moisture content of bricks and similar materials by the measurement of the attenuation of a 10-cm signal passed through them; and the use of a high power beam of similar wavelength to crack rock and to strip concrete from reinforcing rods.

It can be seen from the foregoing that microwave techniques have found application in many fields, and the subject is still wide open for further expansion. Some of the new problems currently occupying scientists and engineers are inter-satellite communication, taking advantage of the high aerial gains available from the higher microwave frequencies usually attenuated by the atmosphere; hovercraft radar, which poses some unique problems of signal attenuation by spray; and very high density point-to-point communications through circular waveguides operated in a very low loss mode. These and many other problems seem likely to keep the microwave industry an expanding one for some time in the future.

NATIONAL RADIO SHOW

AFTER a two-year interval the National Television and Radio Show opens at Earls Court, London, on 24th August but admission on the first two days will be restricted to *bona-fide* members of the trade. There will also be trade periods from 9.30-11.0 each morning except Saturday the 29th and Friday and Saturday, September 4th and 5th.

In our next issue we shall include a preview of the equipment to be seen on the stands at the show, together with a plan and a list of the 80 exhibitors. This will be in addition to the normal quota of pages devoted to technical articles, including the first of a new series on transistor circuit design, and regular features.

The October issue will include a review of trends in television and sound receivers as exemplified at Earls Court and also a survey of aeronautical electronics as seen at the Farnborough Air Show.

The Light-Emitting Diode

ITS APPLICATION TO A SHORT-PATH TELEVISION LINK

By A. J. GOSS,* Ph.D., F.Inst.P., and A. E. SARSON,* B.Sc., A.Inst.P.

THE application of the light-emitting gallium arsenide diode to the transmission of audio or video information follows naturally from the observation that its infra-red emission can be modulated at frequencies up to 100 Mc/s.[1] The first demonstration of such a television link was given by workers at Lincoln Laboratory, M.I.T., in October 1962,[2] who transmitted a television signal via an infra-red beam over a path length of 50 feet.

The work to be described below was undertaken as a familiarizing experiment, made possible by the availability of diodes used for assessment purposes in a research on diffusion into gallium arsenide; the main stimulus was a Symposium on R and D in Civil Aviation, held by the Electronic Engineering Association in September, 1963, at which a television infra-red link using a GaAs diode was demonstrated, and later reported in *The Marconi Review*, Vol. xxvi, No. 151, 1963.

Light-emission:—The recent discovery of the high-efficiency emission of radiation, infra-red and visible, from certain semiconductors has led to a very compact light source capable of modulation at megacycle frequencies. A simplified account of the phenomena is given below.

In an absolutely pure semiconductor such as germanium, silicon or gallium arsenide at room temperature there are few current carriers, i.e., holes and electrons, because of the energy gap between the valence and the conduction bands. This energy gap is 0.7, 1.1 and 1.4 electron volts for Ge, Si and GaAs respectively and corresponds to infra-red wavelengths of 1.7, 1.1 and 0.9 μ ($1\,\mu = 10{,}000$ Å $= 10^{-6}$ metre). If radiation of the appropriate wavelength, or less, is incident on the semiconductor, electron-hole pairs are produced. Conversely if electron-hole pairs combine in the semiconductor, then light of the corresponding wavelength may be emitted. Due to the band structure in Ge and Si there is a low probability of combination, and hence very low efficiency of radiation generation. However, in GaAs and some other compounds of the Group III and Group V elements recombination with approximately band-gap energy readily takes place, and infra-red radiation is emitted.

The semiconductor is used in the form of a p-n junction, generally consisting of n-type GaAs with a p-type diffused layer. When voltage is applied in the forward direction i.e., p-type positively biased, a large current flows with holes and electrons meeting at the junction. Recombination occurs, and gives rise to infra-red radiation (Fig. 1) of 1.4 eV or approximately 9,000 Å at room temperature. On cooling the diode, the energy gap is increased and the radiation wavelength decreased, e.g., at 77°K (liquid nitrogen temperature) the gap is 1.48 eV and the wavelength 8,300 Å. The efficiency of the conversion of current to light increases by a factor of 10 by cooling to 77°K and a typical efficiency of 1% is then obtained. The infra-red emission is relatively wide in wavelength range (several hundred Å), in contrast to laser-type emission of less than 1 Å width, which occurs at much higher current densities.

A current of about 0.5 A is used with a diode 1/400 cm^2 in area, i.e., 200 A/cm^2 current density.

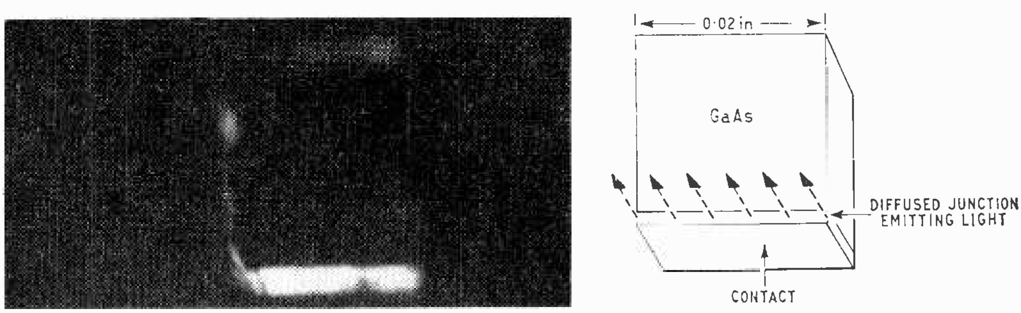

Fig. 1. Infra-red radiation from a gallium arsenide cube.

A linear relationship between the light intensity and the forward current is observed, as described below, so that linear modulation of the light beam can be achieved directly. In the present application the light is modulated at frequencies not exceeding 10 Mc/s but it has been reported by Biard[3] *et al.* that 900 Mc/s can be used.

Similar p-n GaAs diodes can give laser-type action when high current density is used. For example, with about 10^4 A/cm^2 stimulated emis-

* The Marconi Company Ltd.

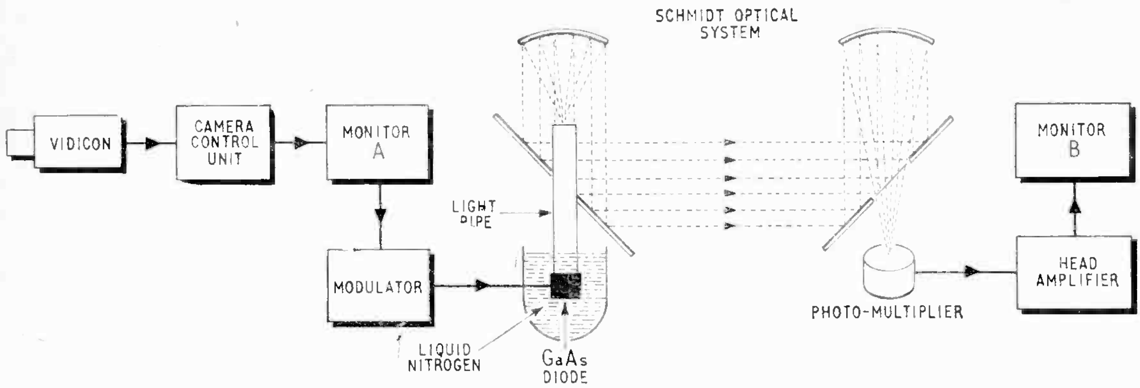

Fig. 2. Schematic arrangement of infra-red television link.

sion has been obtained with line width <1 Å at 77°K. Special optical surface preparation on the diode is necessary to obtain this type of emission. However, in the present application laser action is not used.

A comprehensive review of light emission from GaAs has been prepared by Minden.[4]

Diode Construction:—The diodes were prepared from GaAs single crystals supplied by Mining and Chemical Products Ltd. The crystals, n-type with 10^{17} donors/c.c. were sliced 0.020 inches thick, lapped and mechanically polished. They were diffused in sealed capsules with p-type dope, Cd or Zn metal. The time and temperature of the diffusion were used to control the depth of the p-n junction, e.g., 64 hours at 900°C with cadmium gave a junction depth of 9 μ. After diffusion and a check on the p-layer thickness, aluminium was evaporated to form a contact on the p-region and the slice was reduced in thickness by lapping. Then bars were cut 0.020 inches in width and the cut faces polished mechanically. Finally dice, 0.020×0.020 inches approximately, were cut from the bars. For the present experimental work these dice were mounted on TO-5 headers and a gold wire connected by thermo-compression bonding to the aluminium p-contact. A diode with a slope resistance of about 2Ω was obtained.

The Television System

Early experiments on 625-lines, 50-fields/sec, 8-Mc/s bandwidth standards indicated that, while the achievement of adequate bandwidth was probably not too difficult, signal-to-noise ratio was likely to be a major difficulty, setting a premium on aperture and perfection of the optical components. These forecasts were borne out in practice.

A schematic diagram of the television link is given in Fig. 2.

The principal elements are:

(a) A vidicon camera and camera control unit feeding (b).
(b) A 21-inch monitor (Monitor A).
(c) A modulator circuit which provides a video modulated current through the GaAs diode.
(d) The GaAs diode in its optical system projects a modulated beam of infra-red radiation which is collected by (e).
(e) A similar optical system containing a photomultiplier which receives the radiation and produces a video signal at the input of (f).
(f) The head amplifier. The video output of the head amplifier is distributed to a second 21-inch monitor (Monitor B).

The Modulator:—Both the modulator and the head amplifier (described below) are based on the bootstrap follower,[5] which, through the use of high-frequency transistors ($f_T \approx 300$ Mc/s) and negative feedback, facilitates the attainment of bandwidths of 10 Mc/s and more with negligible phase distortion.

The basic circuit in Fig. 3(a) shows the usual arrangement for use as a voltage amplifier. In the present application, in which a current through the diode proportional to the video (voltage) input is required, the diode is connected in the position occupied by R_2, as in Fig. 3(b). The diode signal polarity is arranged as shown so that the negative-going video signal causes the diode to be driven farther into the forward direction; the bias on the diode is such that the diode conducts throughout the whole of the video signal, including the synchronizing pulses (which in a normal television system would be arranged to be "blacker-than-black"). In this case some infra-red is radiated during the synchronizing period so that synchronizing pulses are transmitted to the receiving end of the system. A complete circuit diagram of the modulator, providing up to 0.5 A peak through the diode, is given in Fig. 3(c).

Photomultiplier Head Amplifier: The photomultiplier head amplifier inverts the negative-going signal developed at the photomultiplier anode, and provides a standard level signal into a 75-Ω load (the input circuit of a display monitor). Once again a bootstrap follower has been used, this time as a voltage amplifier,[6] followed by an inverting stage and an emitter follower output stage. The circuit diagram is given in Fig. 4.

Optical System:—In any system employing a photoelectric transducer, the ultimate signal-to-noise ratio depends upon the primary signal photocurrent and hence upon the signal light flux collected. The polar diagram of the light emission from the gallium arsenide diode at the current density levels employed ($\approx 200\ A/cm^2$ tends to be omnidirectional, and no optimization of the diode geometry has been attempted. However, an increase of light output of about an order of magnitude occurs if the diode is cooled in liquid nitrogen (77° K) and provision had to be made for this facility. Two Schmidt optical systems of the type used in the 1950s for large screen domestic television (made by Philips of Eindhoven) were modified for use with the diode ("Transmitter") and the photomultiplier ("Rereceiver"). In the case of the transmitter the need for cooling the diode with liquid nitrogen made it difficult to site the diode within the Schmidt, both because access to the vacuum flask containing the liquid nitrogen would be required for "topping up" and also because of the possibility of the optics themselves frosting over. The difficulty was overcome by the use of an 8-mm diameter quartz light pipe, seen in Fig. 5 where the diode housing and light pipe are shown separate from the optics, which permitted the diode to be located outside the optics while introducing a virtual source at the required position within the Schmidt. An exploded view of the diode mount and light pipe is given in Fig. 6. The use of the light pipe also permitted an improvement in the aperture of the optics by causing minimum obstruction to the beam and using almost the whole area of the concave mirror. The "receiver" optics were used unmodified, the photomultiplier taking the place occupied by the cathode ray tube in the original television receiver application. The photomultiplier selected, the Mullard 150CVP, has a peak in its sensitivity at 8,000 Å,

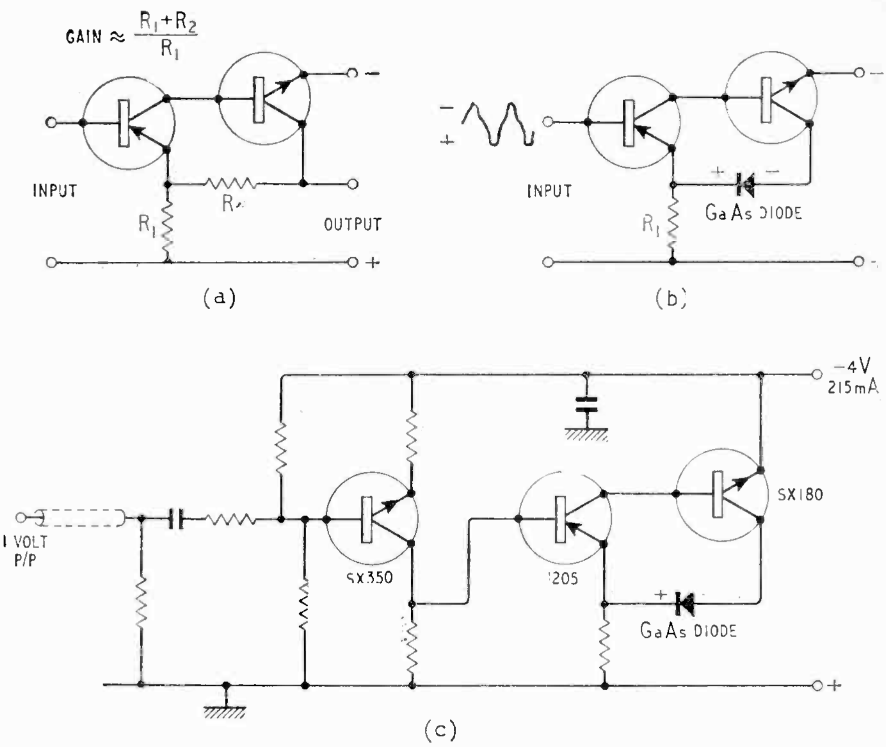

Fig. 3. Modulator circuit using the bootstrap follower.

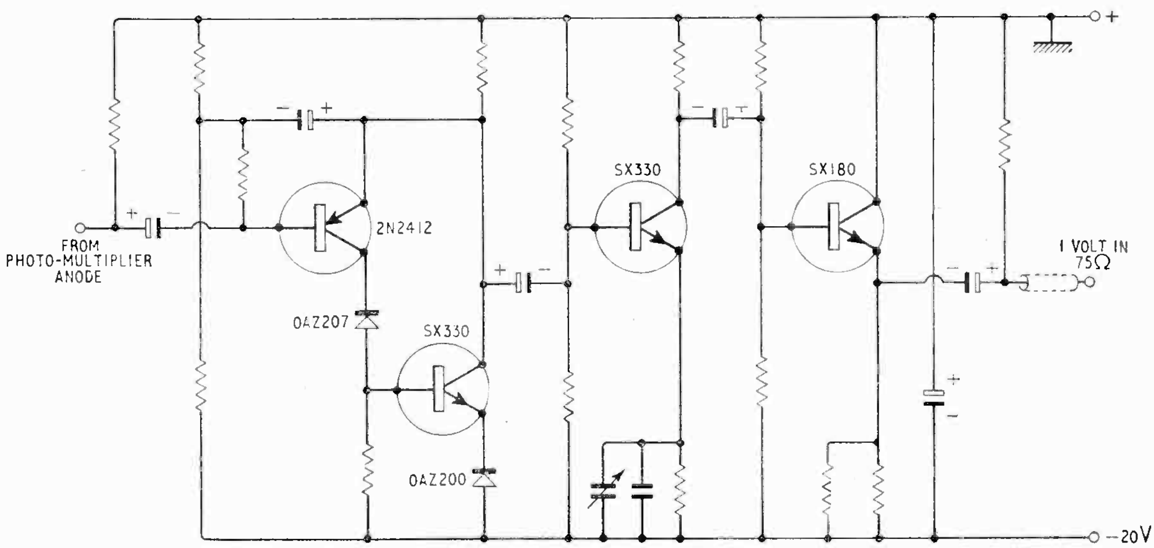

Fig. 4. Photomultiplier head amplifier.

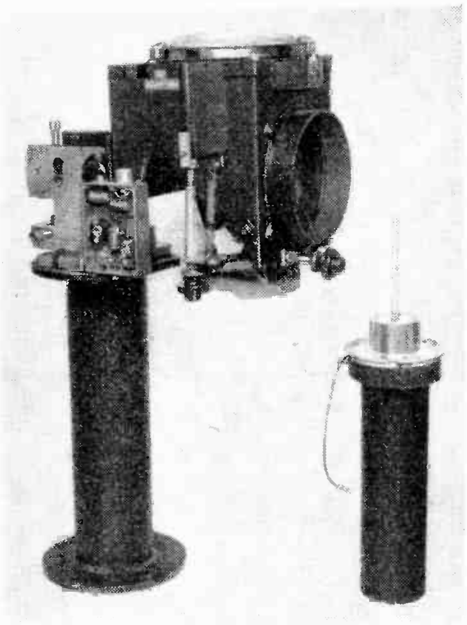

Fig. 5. Transmitter optics.

close to the peak in the diode's emission (≈8,300 A). Visible light picked up by the receiver Schmidt was excluded by a Wratten 87 filter covering the photocathode. It was also found advisable to screen the entrance pupil of the receiver Schmidt from scattered infra-red by a 3-foot-long matt-black tunnel.

System Performance

Electrical:—The two electronic links in the system, the modulator and the photomultiplier head amplifier, were set up to have approximately flat frequency responses (within ± 0.5 dB) to 8 Mc/s Above this frequency the head amplifier response dropped slowly to −6 dB at 20 Mc/s, while the modulator was 3 dB down at 12 Mc/s.

Time did not permit tailoring the response above 8 Mc/s, and it is possible that some of the high-frequency noise observed in the received picture might have been avoided if a controlled rate of cut off could have been introduced. However, as mentioned below, a more serious noise source made this noise relatively unimportant.

An important feature of the gallium arsenide diode, which contributes to its usefulness as a modulated light source, is its linear modulation characteristic which, in the television case, means that an additional gamma corrector is unnecessary.

Optical:—The original hope in using Schmidt optical systems was to collimate the infra-red beam over a distance of 40 feet, but this proved impracticable. The reason for this lay in the mechanical consideration which dictated the use of an 8-mm diameter light pipe. The magnification of the system made the generation of a circular beam equal to or smaller than the entrance pupil of the receiver Schmidt impossible at more than about 15 feet; beyond this the light collected by the receiver fell off inversely as the square of the distance.

The poor performance of the optical system in these circumstances also had the effect of making the exclusion of unwanted light an embarrassing problem; this in turn reduced the signal-to-noise ratio of the received picture, as was demonstrated by a marked improvement when the system was used in a darkened room. Had time permitted, the inclusion of an optical band pass filter centred around 8,300 Å would no doubt have improved matters; in the event only a Type 87 filter, which cuts off below 8,000 Å and passes longer wavelengths, was available for use. The signal-to-noise ratio of the received signal, measured in the laboratory in daylight, and with fluorescent overhead lighting was estimated to be 27 dB; this fell to 19 dB when the diode was operated at room temperature. The signal-to-noise ratio of the modulating signal was about 35 dB; stray light accounted for most of the S/N deterioration.

Subjective:—In the laboratory, with the pictures displayed on 14-inch monitors, the received and transmitted pictures were distinguishable only by the slightly increased noise content of the received picture; in other respects (sharpness and tone range), the difference between the two pictures was little more than could be accounted for by the differences between the two monitors. As a demonstration of feasibility, therefore, the experiment may be judged successful.

Summary

A use has been described and the feasibility demonstrated of a solid state light-emitting diode, modulated with an 8 Mc/s video signal, and used to transmit a television signal over a short distance. This experiment utilizes certain advantages of the

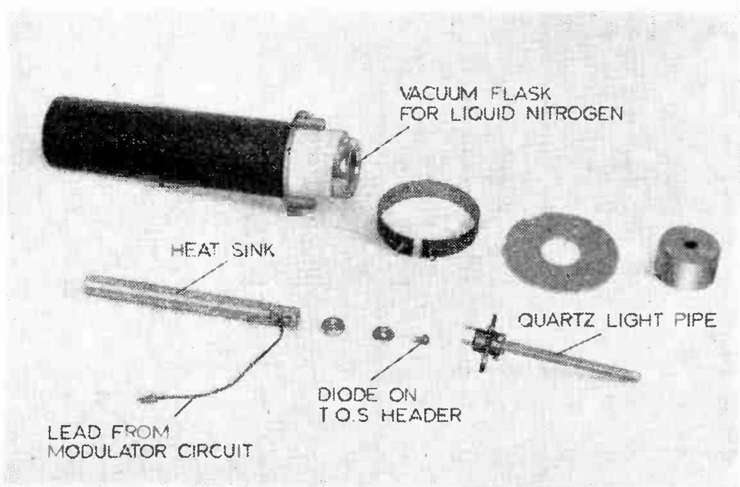

Fig. 6. Component parts of diode mount and light pipe.

light-emitting diode, which may be summarized as follows:

(1) Small device size.
(2) Well-defined region of light emission.
(3) Radiation detectable by photomultiplier or silicon photodetector.
(4) Linear modulation at high frequencies (up to 1 kMc/s may be possible).
(5) The diode is simple and cheap to make.

Certain disadvantages of the device must also be considered, namely:

(1) Light output is limited by heating.
(2) Low-temperature cooling is essential for high efficiency and good S/N ratio.
(3) The wavelength emitted varies with temperature.

It is clear, from the experiment which has been described, that the principal system limitation from the point of view of transmitting wide-band information is the goodness of the optical system. The light flux from the diode, even at the low peak drive employed (200 A/cm^2) is adequate to give an acceptable signal-to-noise ratio with the simple optical system demonstrated, but practical links over distances of miles will depend in the first instance on the success with which the light can be collimated and collected, without picking up extraneous radiation. The cost of such a system will therefore probably be related directly to the cost of the optical system, since the additional electronic equipment needed is simple and relatively cheap. An example of an experimental television link over a distance of 30 nautical miles is described in a recent paper[7]. The gallium arsenide diode, cooled to 77°K as in our experiment, was placed in the focal plane of a 5-inch reflecting telescope, and the receiving photomultiplier at the focal point of a 5-foot searchlight. The experiment, performed at night, gave a 10-dB signal-to-noise ratio under the best operating conditions.

The necessity of cooling the diode for best efficiency and S/N ratio is undoubtedly a disadvantage as far as the practical implementation of the system is concerned. Where a lower S/N ratio can be tolerated, however, or for lower bandwidth installations, it may be sufficient to cool the diode only to around 0°C by means, for example, of a semiconductor thermoelectric (Peltier effect) cooler.

Possible applications for the system include the transmission of information in enclosed premises, such as steel-works, power stations, coal mines, etc. where the use of coaxial cables would be difficult or impossible either because of potential damage to the cables or because of some other local hazard. Another application might be the transmission of television news from street level to roof level and thence by microwave link to a local transmitter. The system would of course be equally suitable for the transmission of radar information, either raw or in digital form.

Acknowledgement:—The authors acknowledge with grateful thanks the assistance given them by their colleagues in the Semiconductor Physics Group and especially by Mr. P. G. Ford, Mr. N. J. James and Mr. E. G. D. Youngs.

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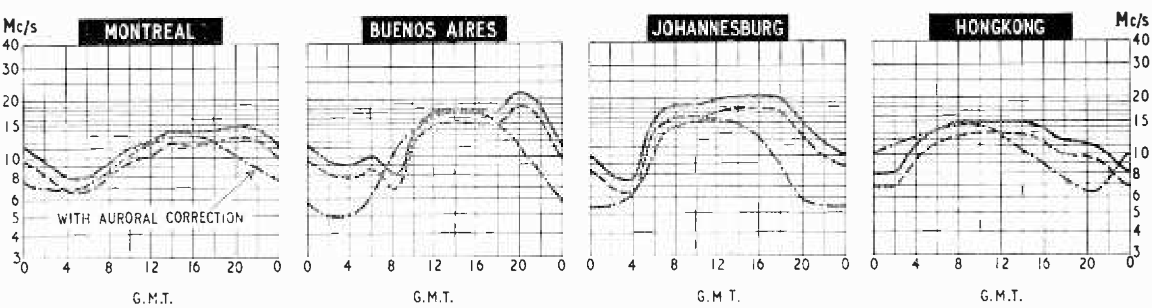
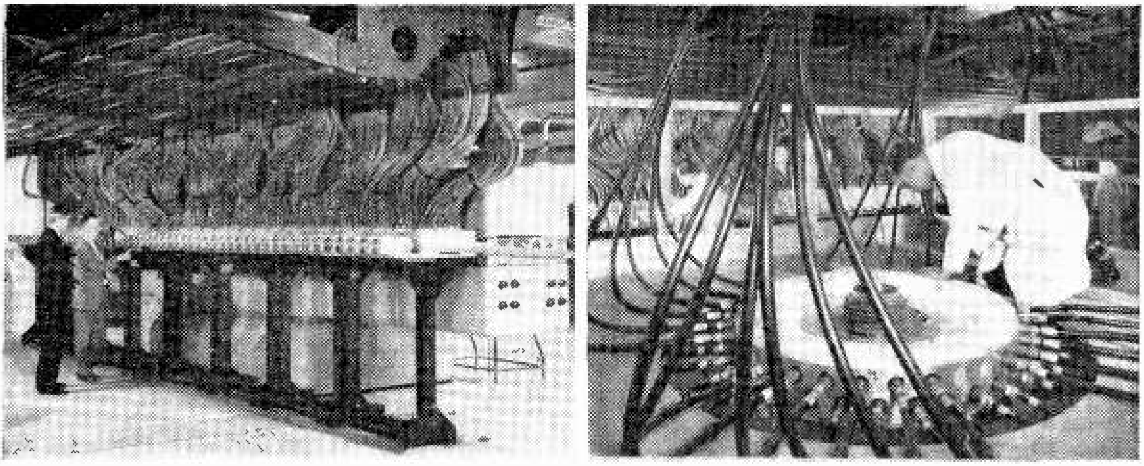
H. F. PREDICTIONS — AUGUST



MEDIAN STANDARD MUF
OPTIMUM TRAFFIC FREQUENCY
LOWEST USABLE HF

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

The MUF is, by definition, the frequency at which communication should be possible for 50% of the time. Satisfactory communication will, of course, be possible slightly above the MUF, but only for smaller percentages of time. The optimum traffic frequency is usually taken as 85% of the MUF.

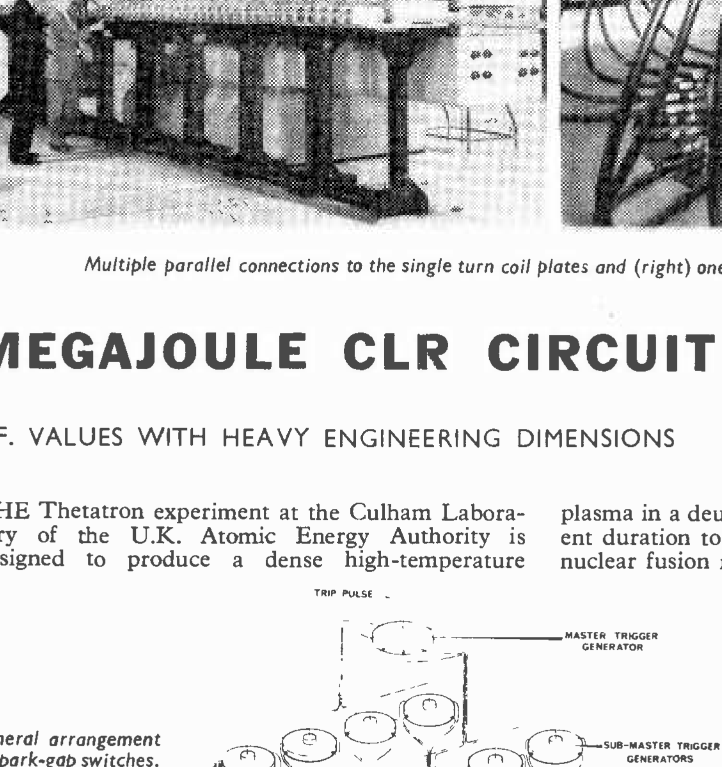


Multiple parallel connections to the single turn coil plates and (right) one of the trigger spark-gap rings.

MEGAJOULE CLR CIRCUIT

R.F. VALUES WITH HEAVY ENGINEERING DIMENSIONS

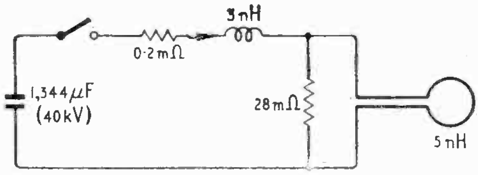
THE Thetatron experiment at the Culham Laboratory of the U.K. Atomic Energy Authority is designed to produce a dense high-temperature plasma in a deuterium-tritium gas mixture of sufficient duration to give a net yield of energy from the nuclear fusion reactions. Figures aimed at are 10^{17} particles/c.c. and a temperature of 10^8 degrees Kelvin for a millisecond, which is equivalent to a 10-fold increase in temperature and a 100-fold increase in time over previous experiments.



General arrangement of spark-gap switches.

Of special interest to readers of this journal is the design of the electrical circuits which calls for inductances of the order of nanohenries (10^{-9}H) in capacitor banks the size of a house with internal wiring totalling not far short of a mile of cabling.

The inductance of the single-turn current-sheet coil encircling the 2-metre long plasma tube is only 5 nH and it was important that the external circuit inductance should be as small as possible compared with this. By using 448 separate circuits each consisting of pairs of 1.5 μF capacitors (B.I.C.C.) designed for charging to 40 kV (1.07MJ) and connecting them in parallel on discharge, a measured bank inductance of 3 nH and series resistance of 0.2 milli-ohm were obtained. The discharge is oscillatory and the capacitors are designed for 80% voltage reversal. To suppress fast high-voltage transients superimposed on the main voltage waveform, a parallel resistance of 28 mΩ is con-



Equivalent circuit of Thetatron megajoule capacitor bank.

nected across the current collector plates leading to the Thetatron coil.

Parallel connection on discharge is effected by a cascade trigger system arranged to fire 448 main spark gaps within a period of 25 nanoseconds. One master gap provides simultaneous pulses to trigger eight sub-master gaps and these in turn trigger the main gaps.

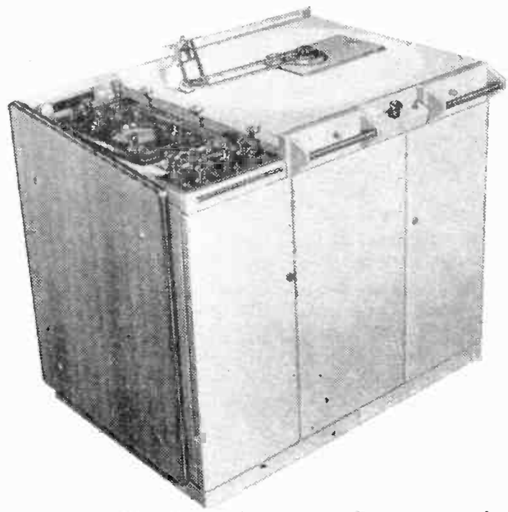
When the main bank has fired the current rises to 12 million amperes in 6 microseconds giving a magnetic field of 75 kilogauss.

PHOTOPLOT RADAR

THE Kelvin Hughes Photoplot marine display unit, which presents relative motion or true motion radar information to the operator in the form of a series of bright stable pictures on a flat paper-covered surface, suitable for plotting, is now available. It is designed for use with Kelvin Hughes marine radar installations, and the standard equipment (shown in the photograph) cannot be adapted for use with other makes of radar.

The 27-in diameter picture is produced by means of a rapid photographic processing system pioneered by Kelvin Hughes for military applications and subsequently developed for marine use. In the standard Photoplot unit, the radar information is first displayed in the normal way on a 3½in diameter cathode ray tube. This display is then photographed on special 16mm film, processed in a few seconds and then projected on the underside of a translucent screen. The time interval between successively projected pictures can be set, by simple adjustment, at 15 seconds, 3 minutes or 6 minutes, according to plotting requirements.

The original Kelvin Hughes marine Photoplot radar display was a custom built unit for the 45,000 ton P. & O. passenger liner *Canberra* and was installed for her maiden voyage three years ago. In 1963 a modified version of the *Canberra* installation was fitted to the 49,000 ton Shell tanker *Oscilla*. This was designed as



a self-contained unit and was the forerunner of the production model now introduced.

Electronics Expansion in the Navy

DIGITAL as well as analogue computers are now included in the very wide range of electronic equipment which sustains the navigational and fighting efficiency of ships of the Royal Navy. All this equipment is the responsibility of the Weapons and Radio Officer. His training is up to degree standard obtained either before entry or through the Navy's own "university," H.M.S. *Manadon* at Plymouth (which works to the London University syllabus); he may be also a graduate of the I.E.E. or I.E.R.E. He will be supported by specialist ratings who in the photograph are seen conducting a diagnostic and maintenance check on one of the latest Ferranti/Mullard "Poseidon" computers forming part of the new generation of ADA (Action Data Automation) equipment shortly to become operational in aircraft carriers (H.M.S. *Eagle* is already in commission). The capacity of the computers not only gives data processing of radar information but makes recommendations on the sequence of attack as well as on the problems of interception. A further advantage is that data transmission to other ships can be in digital form.

MANUFACTURERS' PRODUCTS

NEW ELECTRONIC EQUIPMENT AND ACCESSORIES

Instructional Modules

IN many educational establishments, the time spent by students and staff in assembling circuits for experimental use and then dismantling, is regarded as time wasted. The new electronic instructional modules manufactured by Physical and Electronic Laboratories, Palmers Green, London, N.13, have been devised to aid the student in obtaining a clear understanding of the principles involved in the experiments and to prevent waste of time in the preparation, wiring and testing of the circuitry. Each unit is $7 \times 4\frac{1}{2} \times 1\frac{3}{4}$in and is supplied complete with connecting wires and instruction sheet. The units available at present include an a.c. bridge unit, transistor amplifier unit, power unit and pulse circuit unit. The circuit diagram is printed on the front of each unit and a number of miniature sockets allow access to the circuit in a multiplicity of places. A number of experiments can be performed with each unit. A typical example is the pulse circuit unit Type 31. This can be used for practical work on monostable, bistable, multivibrator and Schmitt trigger circuits. The cost of this piece of apparatus is £7 5s.

11WW 301 for further details

Sweep Oscillator

UTILIZING a varactor sweep circuit and a non-contacting type tunable inductance, the Telonic Model VR-2M sweep oscillator designed as a plug-in unit for the Telonic SM-2000 sweep generator chassis, exhibits good stability over extended operating periods. Its stability after warm up is specified as 1 kc/s over short term and 10 kc/s over an hour's operation. Solid-state techniques are used throughout and a front-panel switch is used to select any one of three functional modes, namely, CW, narrow-band sweep or wide-band sweep. This dual-range, sweep-width control covers 100 c/s to 400 kc/s and 200 c/s to 10 Mc/s. The sweep is continuously variable within these frequency ranges. A frequency-marker system is provided and this is variable over the whole operating range. The sweep rate of this unit is variable from 1 sweep in 90 sec to 100 sweeps per sec. The output is 1 V r.m.s. The instrument is available in the U.K. from Livingston Laboratories.

11WW 302 for further details

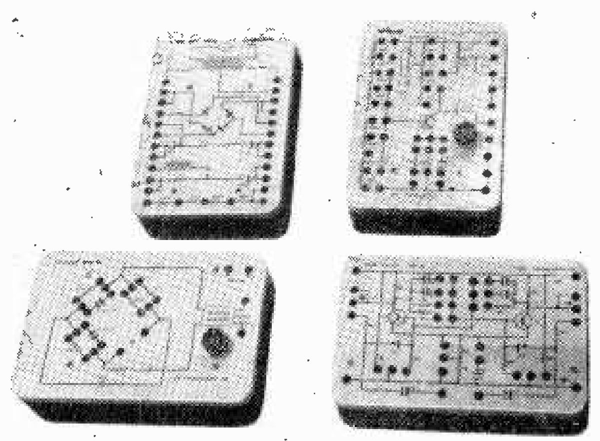
Mains Unit

MUCH transistor equipment now available only has provision for battery power. Those wishing to convert to mains-powered equipment may be interested in the "Osmabet" Type PM9 mains unit. This provides a 9 V output from a 200/240 alternating input. The current drawn should not exceed 150 mA. Measuring approximately $2 \times 2\frac{1}{2} \times 3$ in the unit is identical in size and appearance to many batteries used in recently-introduced equipment and fits into the battery housing provided. The cost of the unit is 45s.

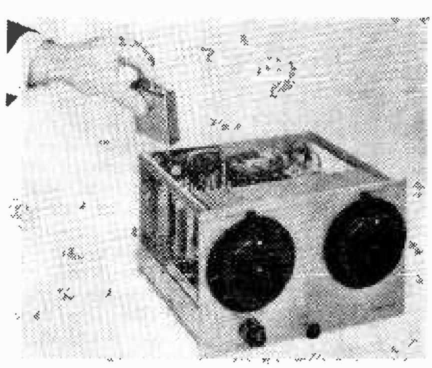
11WW 303 for further details

Pulse-height Analyser

A NEW automatic-scanning, single-channel, pulse-height analyser is available from Research Electronics, Cleckheaton, Yorkshire. Designated the Model 9050A, the equipment has been developed to provide most of the facilities required for gamma spectroscopy and pulse-height studies. The circuits employed are claimed to give a 20 to 1 improvement over formerly used circuits and the design of the discriminator completely eliminates drift from such causes as changing grid base. The



Electronic instruction modules manufactured by Physical and Electronic Laboratories.



Above: Osmabet Type PM9 mains unit.

Left: Telonic Model VR-2M sweep oscillator.

input can be d.c. restored and will cater for changes in mean value of pulse waveforms with changing pulse repetition rates. Manual, automatic or external scanning can be sèlected and the threshold level is variable from 2.5 to 100 V. The channel width is variable from 0.1 to 50 V.

11WW 304 for further details

Closed-circuit Television Camera

A NEW camera, the Type FA41 closed-circuit television camera, is announced by Visual Engineers, Aylesbury. Using semiconductor devices, the control circuitry is contained within the camera case. It will operate on 110 to 240 V, 50 to 60 c/s mains or 12 V battery. The output signal from the system is either video or r.f. with negative modulation. The system is 625 line, random interlace. The sensitivity control is fully automatic. Weighing less than 10lb the camera is only $11\frac{1}{2}\times5\frac{3}{4}\times5\frac{3}{4}$in in size. The cost of the camera is £238.

11WW 305 for further details

Paper Tape Dispenser

UP to 1,000 characters per second can be ensured without snatch or drag with the power-driven dispenser designed by Document Transports and available from Scientific Furnishings, Poynton, Cheshire. The unit, designated the Type 1,000 tape dispenser, was developed for feeding paper tape to high-speed punches and readers. Powered from a 230 V mains supply, the equipment is portable and caters for most sizes of paper tape without mechanical adjustment.

11WW 306 for further details

Capacitance Bridge

A BATTERY-POWERED, transformer-arm bridge Type 976 manufactured by Electro Scientific Industries is now available in the U.K. from Livingston Laboratories. Two- and three-terminal measurements may be made over a range of 1,200 pF to $1{\cdot}2\,\mu$F, the resolution on the lowest range being 0·1 pF. The 1 kc/s oscillator and detector are included in the instrument and transistors are used throughout. Balance may be observed on a built-in meter. Alternatively, provision is made for audible nulling using headphones. The bridge costs £226 excluding duty.

11WW 307 for further details

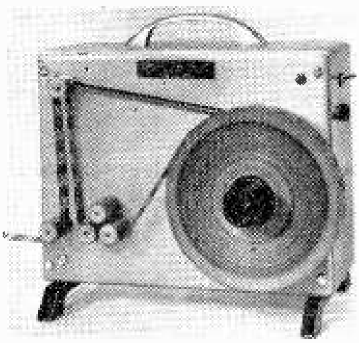
Component Storage Bins

A NEW component-storage system is announced by Savage and Parsons, Watford, Hertfordshire. Essentially an extension of the Spur Plastibac range, eight sizes of bins are available and these can be intermixed during stacking The bins are moulded from coloured high-impact polystyrene, the colours available being red, blue, green, industrial green and yellow. When assembled into racks the contents of each bin can easily be seen, but a slot is provided on the front of each bin for descriptive labels.

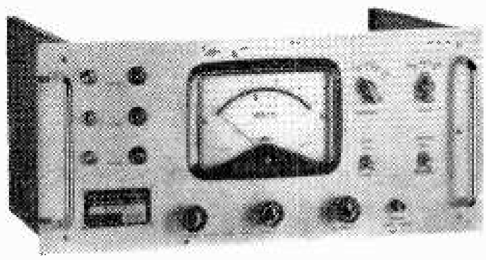
11WW 308 for further details

Digital-logic Modules

PLUGGING into a B9A valveholder, modules recently introduced by Sidien Products, Birchwood Court,

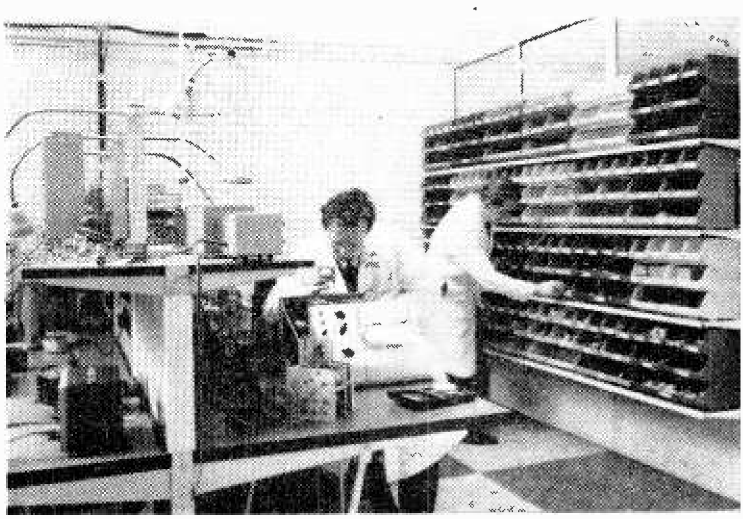


Paper-tape dispenser designed by Document Transports.



Research Electronics Model 9050A pulse-height analyser.

Type 976 capacitance bridge (Electro Scientific Instruments).



Storage system using Spur Plastibac components.

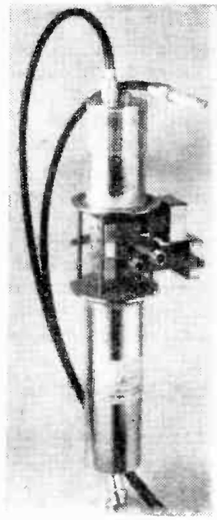
Edgware, Middlesex, provide an inexpensive method of constructing digital computer and control systems. Each module has a diameter of $1\frac{3}{16}$ in and a height of $1\frac{3}{16}$ in. The coloured plastic dust-covers provide a means of identifying each unit in the series. The dust-covers are easily removable for component replacement or for educational demonstration purposes. If required, the modules can be supplied sealed in silicone rubber. Units available include shift registers, 2- and 3-input and/or gates, Schmidt triggers and monostable and bistable units.

11WW 309 for further details

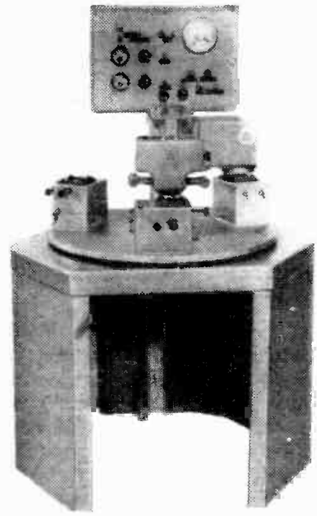
X-band Klystron

A HIGH-POWER klystron Type X850 manufactured by Eimac is now available from Walmore Electronics, Drury Lane, London, W.C.2. The valve is capable of delivering c.w. power of 20 kW at frequencies between 7.125 and 8.5 Gc/s. The electron gun assembly utilizes a highly convergent, confined flow field. This is said to give a very low cathode current density resulting in long life expectancy, good bandwidth (35 Mc/s minimum), low-beam voltage and the focusing arrangements are non-critical thus producing a stable electron beam.

11WW 310 for further details



High-power, X-band Klystron Type X850 manufactured by Eimac.



Vacwell Engineering mask-alignment unit Model PR60a.

Laser

A MEDIUM-POWER, solid-state laser has been announced by M.E.L., Kings Cross Road, London, W.C.1. The device, complete with charging and control unit, is available as a standard catalogue item. The laser head can be adapted to accommodate flash tubes of different types and to accept plain or chisel-ended laser rods. Also, rods of different diameters or different materials can be used with suitable adaptors and there is provision for outlet ports at both ends of the laser head. There are also facilities for attaching lenses and filters.

The rod normally fitted is of neodymium-doped glass and is ½ in in diameter and 6 in long. The pumping source is a 5,000-joule, linear flash tube and the coherent light output is nominally 5 joules. The pulse length is 0.4 to 0.8 msec but with the Q-switching attachments this is reduced to 0.1 to 10 μsec and the peak power is increased approximately 100 times. The standard laser rods have plane parallel ends with dielectric coatings having nominal reflectivities of 58% for one end and 97% for the other. Rods can also be supplied with one end totally internally reflecting and the other end uncoated, or with plane parallel ends uncoated for use with external reflectors. The flash tube has a life expectancy in excess of 7,000 flashes at 5,000 joules. Consistency of performance is assured by the use of oil-filled metallized paper capacitors.

11WW 311 for further details

Semiconductor Manufacture

THE precise positioning of glass masks and wafers during semiconductor and microcircuit manufacture can be facilitated by the Vacwell Engineering Model PR60a mask-alignment unit. This apparatus, intended for production purposes, features a high-resolution microscope of the dual image type, permitting the viewing of two surfaces at opposite ends of the wafer. The two images can be viewed simultaneously and will be superimposed when aligned. The mask-alignment jig gives precise adjustments in *x*, *y* and *z* directions and a self-aligning, ensuring perfect parallelism of the mask and slice. Three jigs are mounted on a rotary indexing table. With two operators, one for loading and the other for aligning and exposure, production rates can be appreciably stepped up.

11WW 312 for further details

Variable Transformers

SEVERAL new features have been incorporated in the Series 120 range of "Regavolt" variable transformers manufactured by The British Electric Resistance Company. This new range is characterized by a 25A rating. All models are fitted with an easily accessible H.R.C. fuse link connected in the output circuit. Six brushes, mounted vertically, are em-

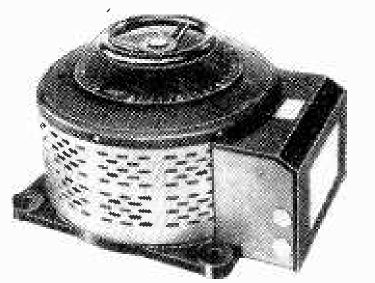
INFORMATION SERVICE FOR PROFESSIONAL READERS

To expedite requests for further information on products appearing in the editorial and advertisement pages of *Wireless World* each month, a sheet of reader service cards is included in this issue. The cards will be found between advertisement pages 40 and 43.

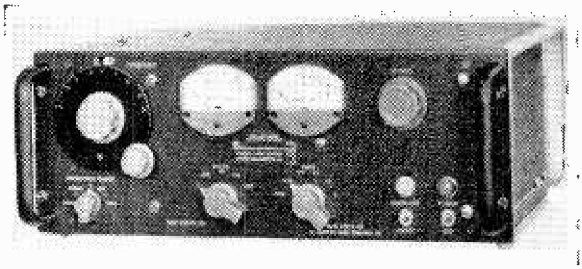
We invite readers to make use of these cards for all inquiries dealing with specific products. Many editorial items and all advertisements are coded with a number, prefixed by 11WW, and it is then necessary only to enter the number(s) on the card.

Readers will appreciate the advantage of being able to fold out the sheet of cards, enabling them to make entries while studying the editorial and advertisement pages.

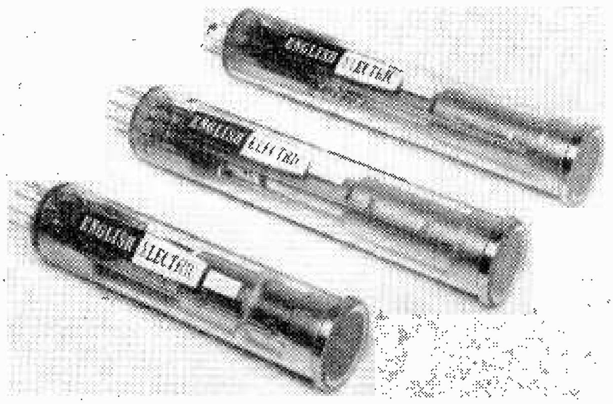
Postage is free in the U.K., but cards must be stamped if posted overseas. This service will enable professional readers to obtain the additional information they require quickly and easily.



Component from the 25A series of "Regavolt" variable transformers.



Type 1308-A variable-frequency power supply (General Radio).



Separate-mesh vidicon television camera tube (English Electric Valve Company).

Size 18 Encoder manufactured by Moore, Reed and Company.

ployed and these pass over parallel turns. The core and windings of the transformers are clamped to an aluminium base-plate which acts as a heat sink. Holes are provided in this plate so that ganging of two or more transformers is easily attained for 3-phase applications, etc.

11WW 313 for further details

Lead-through Capacitors

NEW feed-through capacitors are announced by Oxley Developments Company, Ulverston, Lancs. Three values are available at present, being 47, 470 and 1,000 pF. The tolerances available are −10% +80% or ±20%. The working voltage rating on all types is 350 V (direct). The body of the component has a 2B.A. thread. The ceramic tube is sealed into the body, under vacuum, with a resinous material.

11WW 314 for further details

High-power Audio Oscillator

THE Type 1308-A audio oscillator and power amplifier manufactured by General Radio Company and available in the U.K. from Claude Lyons, Hoddesdon, Hertfordshire, is capable of delivering 200 W from 20 c/s to 1 kc/s with reduced output up to 20 kc/s. The equipment is thus ideally suited as a variable frequency power supply. The maximum output voltage availabe is 400 V and the maximum output current is 5 A. Both voltage and current are continuously indicated on front-panel meters.

The harmonic distortion is less than 1% from 100 c/s to 10 kc/s and less than 2% from 50 to 100 c/s. Rack-mounted or bench versions are available.

11WW 315 for further details

Separate-mesh Vidicon

THE English Electric Valve Company have increased their range of television-camera tubes by the addition of three high-resolution, 1-inch vidicons Types P831, P841 and P842. A feature of the new components is that separate mesh construction is used, which, combined with an improved photo-conductive layer, provides high sensitivity coupled with low signal and low dark-current shading effects. Limiting resolutions up to 1000 lines may be obtained at the centre of the picture when these tubes are operated with high voltages on grid 3 and the mesh. Under these conditions optimum resolution is achieved when g3 voltage is 0.6 to 0.7 of the mesh voltage. Two of the tubes Types P831 and P842 have the additional feature of low-power (0.6 W) heaters. Thus they are particularly suited for installation in battery-powered cameras.

11WW 316 for further details

Encoder

THE size 18 encoder available from Moore, Reed and Company, Durnsford Road, London, S.W.19, gives a total count of 524,288 in natural binary (2^{19}). Three binary discs are employed with a gear ratio of 64:1 between them. The highspeed disc rotates directly with the input shaft, the intermediate disc makes one revolution when the input shaft has rotated through 64 complete revolutions and the low-speed disc completes one revolution when the input shaft has turned through 4,096 revolutions. "V Scan" brush disposition is employed on all discs to avoid ambiguity of readout and buffer diodes are incorporated on each brush. Connections are by header pin and the design is arranged with a crimped joint between the diode termination and the pin so that soldering to the pin can be carried out without danger to continuity within the unit.

11WW 317 for further details

Rack and Panel System

THE L.E.D. "Uniframe" rack and panel system is designed as a lightweight kit of parts that can be quickly assembled into a variety of cabinet sizes and styles. Racks and cabinets so made can quickly be dismantled. The system permits the rapid interchange of side and rear panels and corner trimmings which are available in a variety of colours. The panels are constructed from p.v.c.-covered sheet steel. All exposed steel parts are zinc plated. The basic framework can be extended to 6 ft in height and to any width. In addition to the basic kits, the manufacturers, Lancier Electronic Development Co., Belsize Park, London, N.W.3, can supply special parts as cable-form supports, plinths and blower and ventilation units.

11WW 318 for further details

Electronic Thermometer

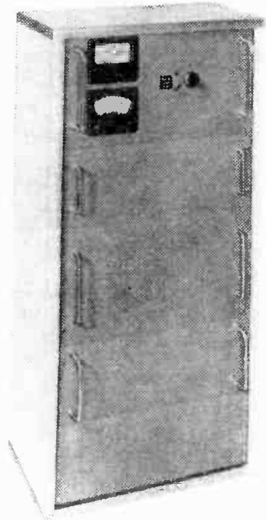
A POCKET - SIZE instrument, measuring only $4\frac{1}{2} \times 2\frac{1}{2} \times 1\frac{1}{2}$ in and utilizing a $2\frac{1}{2}$in dial, the Dependatherm electronic thermometer permits temperature measurements over the range 0 to 200°C. A number of probes are available to enable the instruments to be used in a large number of applications. Leads between probe and the instrument may be up to 50 ft long. Stabilization circuits are employed and pre-measurement balancing is not necessary. The equipment is powered by a 9 V dry battery. The low thermal capacity and rapid response of the instrument to temperature fluctuations greatly facilitates measurements such as hot-spot locations and temperature gradient displays, etc. The equipment is manufactured by Dependable Relay Company and distributed by Kane-May, Upper Street, London, N.1.

11WW 319 for further details

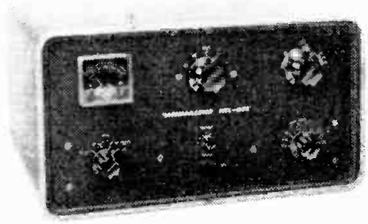
Power Amplifier

THE Hammarlund Manufacturing Company, New York, recently introduced the Type HXL-1 linear amplifier rated at 1,500 W p.e.p. requiring only 50 to 60 W driving power for full output. Although designed primarily as a companion unit to the HX-50 single sideband transmitter, the control circuitry is such that the equipment is compatible with most transmitters and transceivers currently available. Coverage is from 80 to 10 metres and a meter provides constant visual indication of correct amplifier adjustment. The unit measures $17\frac{1}{2} \times 9\frac{1}{2} \times 9\frac{1}{8}$ in and requires a 115 V or 230 V alternating power supply.

11WW 320 for further details



Typical cabinet assembly constructed from L.E.D. Uniframe system.



Power amplifier Type HXL-1 manufactured by Hammarlund.

Heat Sinks

INSULATED heat sinks suitable for TO5- and TO18-type transistors are available from Jermyn Industries, Sevenoaks, Kent. Insulation is achieved by hard anodizing on aluminium and measurements of better than 3000 MΩ at 85 V have been made. The finish is claimed to have a thermal resistance about five times lower than that of mica.

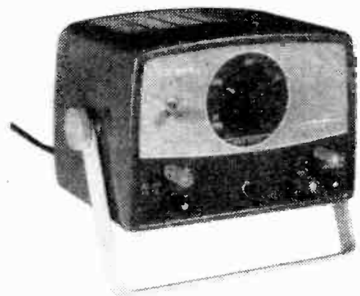
11WW 321 for further details

A.C./D.C. Converter

A NEW converter designed primarily for use with the Digitec range of d.v. voltmeters, enables alternating voltages to be measured on most instruments requiring an input of 1 V (d.c.). The equipment, the Wayne Kerr-Digitec a.c./d.c. converter Model 1900, operates over the frequency range 50 c/s to 25 kc/s with a linearity of ±0.5% full scale. Four input ranges are provided 0 to 1, 10, 100 and 500 V r.m.s. The input impedance is 1 MΩ (100 kΩ in the 1 V range). The d.c. output of the equipment is available at an impedance of 10 kΩ. The unit is available either in a portable case or for rack mounting. The cost is £124.

11WW 322 for further details

Dependatherm electronic thermometer.



Wayne Kerr-Digitec a.c.-d.c. converter Type 1900.

Miniature Fuseholders

A NEW range of robust miniature fuseholders has been introduced by Belling and Lee. Intended for panel mounting, two types are available so that British $\frac{5}{8} \times 3\frac{3}{16}$ in and continental 20×5 mm fuses are catered for. The new fuseholders are claimed to have a better mechanical strength than the Type L575 components which they are to supersede. The fixing nut for the new fuseholders is located at the

New miniature panel-mounting fuse-holders manufactured by Belling and Lee.

rear of the panel and the length of the threaded portion has been increased to accommodate panels up to $\frac{1}{8}$in thick. Other features include automatic isolation and withdrawal of the fuse link from the front, internal spring to compensate for fuse-link length variation, probe hole in the lid and a very small volume and panel coverage.

11WW 323 for further details

Multirange Measuring Instruments

TWO versions of a new measuring instrument are available from the Industrial Division of Smiths, Wembley, Middlesex. Voltage, current, resistance and capacitance measurements may be made. The meter movements are shock-resistant and ease of operation is ensured by a single selector knob. Electrical cut-out protection is provided which acts in under 0.01 sec and the meters are fused against high-current overloads. The instruments will measure superimposed a.c. or d.c. signals and current transformer, isolating capacitor and diode rectifiers are included within the main case. The two versions differ only in the ranges available. In the case of the Type 4S, the sensitivity is 100,000 Ω/V on d.c. ranges and 20,000 Ω/V on the a.c. ranges, the ranges being 0 to 100 mV to 0 to 5,000 V d.c. and 0 to 10 V to 0 to 1,000 V a.c. Current measurements are possible from 0 to 1 A d.c. (the lowest range being 0 to 10 μA). Resistance may be measured up to 500 MΩ and capacitance from 2,000 pF to 5 μF. The alternating ranges of the instrument can be used up to 20 kc/s. The other version, Type 3S, has a sensitivity of 25,000 Ω/V on the d.c. ranges and 2,000 Ω/V on the a.c. ranges. The ranges available are limited compared to the Type 4S, the limits being 5,000 V (a.c. and d.c.), 5 A (a.c. and d.c.), 0 to 50 MΩ, and 100 to 20,000 pF.

The weight of both types is 3 lb and a number of current transformers, shunts and voltage multipliers are available.

11WW 324 for further details

Piezo-electric Carbon Elements

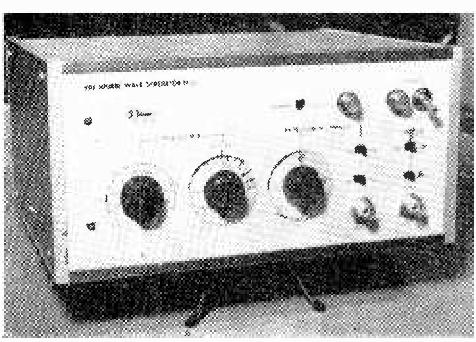
IN the search for a small, robust and cheap pressure-sensitive element, Plessey-UK have evolved a material composed of carbon black particles moulded in a phenolic resin matrix. Elements made of this material exhibit a change of resistance with pressure which is almost constant over the range 0-8,000 lb/in^2, the slope being 1.33% for 1,000 lb/in^2 change. Voltage up to 5 V applied to the element has no effect on pressure sensitivity. The variation of resistance with temperature is 0.750 parts per million per degree centigrade.

11WW 325 for further details

Square-wave Generator

A SQUARE-WAVE generator Type SG21 has been announced by Advance Electronics, Hainault, Essex. Two outputs are available (both at the same frequency) which extends from 9 kc/s to 100 Mc/s in 8 ranges. The main output provides pulses variable in amplitude from 20 mV to 1 V (50 Ω) or up to 2 V open circuit. Pulses from the auxiliary output are switchable in steps of 0.2 V, 0.4 V, 1 V and 2 V into 50 Ω (4 V open circuit). The rise-time is dependent on amplitude and output current. In the case of pulses provided by the main output the minimum rise-time is 0.5 nsec (50 Ω load, 20 to 500 mV range). The dimensions of the instrument are $11 \times 5\frac{3}{4} \times 9\frac{1}{4}$ in, the weight being 7 lb. The power requirements are 90 to 125 V, 180 to 250 V, 40 to 60 c/s, 20 W. The provisional price is £150.

11WW 326 for further details



Square-wave generator Type SG21 (Advance Electronics).

Integrated Wideband Linear Amplifiers

TWO new amplifiers are available in the Ferranti "Microlin" series of integrated amplifiers. The new units are designated Types ZLA10 and ZLA15 and are planar, epitaxial silicon integrated circuits, hermetically sealed and encapsulated in 8-lead, TO-5 cans. Both types can be used as wideband video amplifiers, intermediate frequency amplifiers and fast rise-time pulse amplifiers. The ZLA10 circuits have a typical current gain of 8 and, dependent on load, a bandwidth of up to 120 Mc/s. Four amplifiers connected in cascade provide a voltage gain of over 70 dB with a bandwidth of 86 Mc/s.

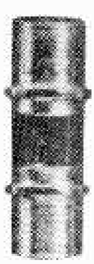
The ZLA15 amplifier, with a typical current gain of 30 and a bandwidth of 20 Mc/s, offer a high gain per stage when a very high frequency limit is not required. It has a rise-time of 15 nsec and meets the requirements for use in a 10 to 15 Mc/s i.f. amplifier.

11WW 327 for further details

Varactor Diodes

GALLIUM arsenide point-contact varactor diodes manufactured by Varad, and available in the U.K. through Claude Lyons have cut-off frequencies from 50 to 500 Gc/s These high cut-off frequencies are said to be due to the low capacitance of a point contact combined with the high electron mobility, high energy gap and low dielectric constant of gallium arsenide. All the types available in this series can be used over a temperature range of −196°C to +100°C. The minimum reverse-breakdown voltages range from 4 to 18 V and the zero bias capacitances extend from 0.05 to 1 pF. The maximum power dissipation is 100 mW, maximum forward current 5 mA and maximum reverse current 10 μA. All the diodes are constructed in a fused-quartz dielectric cylinder sealed with gold-plated steel end caps.

11WW 328 for further details



Varad varactor diode. The largest component is $\frac{1}{4}$ in long.

SINE WAVES

WHY DO WE USE THEM?

By THOMAS RODDAM

THE other day I was talking to someone connected with one of the high buildings which still do not make London look like New York. Most of the building time, from his account, went into the digging of a large hole, the driving of piles and the pouring of the foundation raft. Once the builders set off upwards the structure was complete in, as they say, no time at all. In parentheses, without actually using them, I am reminded that I was proud to see British methods being used on a very large pile driver in Rotterdam recently. The skilled technician responsible for the equipment climbed steadily up the framework until, some 40 feet up, he could deliver a few sharp blows with a wrench on the delicate mechanism. It worked.

We tend to take the earlier stages of any process for granted. The housewife planning to re-paint a bedroom assumes that the roof will not blow off: the man working on the roof assumes that the walls will not collapse. We shall be wise if, from time to time, we look back at the things we are taking for granted. Most of what we learned at school is so riddled with simplifications that our actual knowledge of it is based on the rule " What I tell you three times is true."

Why do we use sine waves for nearly all our theory and our experiments? I looked in one or two textbooks and was not surprised but astonished to learn, from a university-level text which was otherwise quite good, that it is because rotating generators produce sine waves. It may be that there are still Alexanderson alternators in service, spinning at ever higher speeds. Perhaps in some back rooms at exhibitions the new models are revealed to favoured customers: I thought I was favoured because they showed me the gin bottle. It seems rather unlikely to me that we use sine waves just because there are generators spinning round at Battersea: the power station and the dog's home are equally irrelevant.

In order to examine this whole question we must go back to the simplest ideas of circuit theory. To keep the discussion within bounds I shall forget about transformers and gyrators and will not consider active devices at all. This does not mean that the results are limited, but merely that we are leaving out a few sections of the study. After all, gyrators are quite rare, while transformers and linear amplifiers are simply scale changers, even though we can get a negative sign by using them.

We can say that most of our circuit theory is concerned with combinations of resistance, inductance and capacitance. For the resistance elements we can write, at any instant, Ohm's Law. The words, at any instant, are central to our whole theme, since we are not assuming any particular kind of signal.

Capacitance is the charge-storing ability of a circuit element and is defined by the equation $C = Q/V$. Here, of course, Q is the charge and V the terminal voltage. Since capacitance is usually the property of a component, the value of C will generally be constant. If C varies with time our equations will give us more trouble because they become more complicated. if C depends on the voltage we are moving outside the rules of linear circuit theory, since $Q = CV$ is no longer a first-order function of the voltage. The defining equation, as it stands, is not very useful, for charge is not a variable which we observe as such. We do observe the movement of charge, the current, and we can write either

$$CV = \int I dt$$

$$\text{or } \frac{I}{C} = \frac{dV}{dt}$$

The first of these equations is an expression of the statement that the terminal voltage of a capacitance depends on the whole past history of the current. The second equation describes how the way the voltage changes now depends on the instantaneous value of the current. The way in which these equations must be written if C is a function of time is left to the reader to decide.

We ought really to consider the electric field between the plates of our capacitor and then move on to consider the magnetic field of an inductor. It is not our business how the component maker produces his effects, however, and so as a first step let us say simply that a capacitance will store up past current, or will require current to produce a voltage change. The dual of this is a device which stores past voltage, or demands an applied voltage if the current is to change. Such a dual will satisfy the equations

$$LI = \int V dt$$

$$\text{and } \frac{V}{L} = \frac{dI}{dt}$$

These equations are immediately identified as those for an inductance, as equations which correspond to a circuit element which can be realized, albeit approximately. It can be proved that the set of three kinds of elements is a complete set, although nowadays it is more usual to include the two four-terminal elements and to show that the full set of five is complete. The condition that a system should be linear and passive makes other types of element impossible.

Let us consider the familiar circuit shown in Fig. 1. In the usual way of getting a simple treatment we assume that the capacitance is initially unchanged

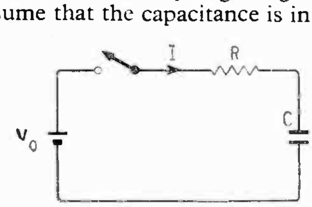


Fig 1

and that at some instant $t = 0$ the switch is closed. We then write $V = 0$ for $t<0$. For $t>0$ we know that the voltage across the resistance is (V_0-V), so that the current must be $I = (V_0-V)/R$. The definition of C is that $I = C\, dV/dt$ and so $CR\, dV/dt = (V_o-V)$.

Here we leave the usual treatment and we consider the basic mathematics of the situation. We *define* a function $\log x$ as

$$\log x = \int_1^x dt/t$$

The reason we introduce this function is that we cannot solve our equation without it. This is a fundamental step which most of us have forgotten we ever had to study. We usually, at school, creep round the back of the problem, because we learn to "use logs" for doing sums before we get into the theory. The effect is to postpone the awkward problem which appears if x is a complex number.

On the basis of this definition we can show that

$$\log x = \int_1^x dt/t = -\int_1^{1/x} \frac{du}{u}\ (u=1/t) = -\log\left(\frac{1}{x}\right)$$

and writing $t = y\,u$

$$\log xy = \int_1^{xy} \frac{dt}{t} = \int_{1/y}^{x} \frac{du}{u} = \int_1^{x} \frac{du}{u} - \int_1^{1/y} \frac{du}{u}$$

$$= \log x - \log(1/y) = \log x + \log y$$

Because of this basic mathematical result we can use log tables as we do, and because they can be used, they exist. But the definition of $\log x$ is still the integral. Another useful definition is the number e, defined by the equation, $1 = \int_1^e dt/t$. From the form for $\log xy$, we arrive at $\log e^n = n \log e = n$.

With this formulation we can get the familiar solution, in a slightly unfamiliar form,

$$t = CR \log V_o/(V_o-V),$$

$$\text{or } V = V_o(1-e^{-t/CR})$$

We know that if we consider the current in this circuit, or the current and voltage in a simple LR circuit, we shall again get a term of the form $e^{-t/\tau}$ cropping up. This is, as it were, the natural waveform of this kind of circuit. When we construct a chain of similar circuits, however, the waveform, although still based on this exponential function, becomes what I am tempted to call messy. Functions called the Laguerre polynomials creep in, and at this stage, of course, any analysis would be made extra hard by the need to watch that we were not letting the idea of frequency in by the back door. Let us therefore try something else.

The circuit shown in Fig. 2 is also very familiar. For this circuit we may write:

$$\frac{dV}{dt} = \frac{1}{C}\cdot I$$

$$\text{and } V_o - V = L\frac{dI}{dt}$$

If we differentiate the first equation we get

$$\frac{dI}{dt} = C\frac{d^2V}{dt^2}$$

$$\text{and thus } LC\frac{d^2V}{dt^2} + V = V_o$$

There are several ways in which we can solve this. One way is to guess that it will have a solution of the e^{kt} kind, to try this solution and to find the value which k must have to make the solution apply. The result involves us in imaginary values of k, which do not seem to be in our tables, and the expressions are rather long-winded. They are, however, very

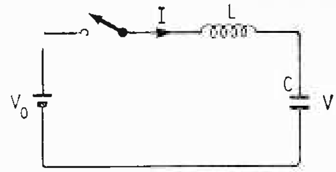


Fig. 2

important. There is something else we must do, in any case. Let us *define* a brand new function, having no necessary connection with any other function of the same name,

$$y(x) = \text{arc tan}\, x = \int_0^x \frac{dt}{1+t^2}$$

A detailed study of this reveals that there will exist a continuous function $x = \tan y$

We now *define* two more functions,

$$\cos y = \frac{1}{\sqrt{1+x^2}} \text{ and } \sin y = \frac{x}{\sqrt{1+x^2}}$$

and proceed to prove that these functions have, in fact, the properties with which we are already familiar from the trigonometry class studies of functions of the same name. In particular

$$\frac{d \cos y}{dy} = \frac{d}{dx}\left(\frac{1}{\sqrt{1+x^2}}\right)\frac{dx}{dy} \ldots\ldots = -\sin y$$

$$\text{and } \frac{d \sin y}{dy} = \cos x$$

$$\text{so that } \frac{d^2 \sin y}{dy^2} = -\sin y$$

This is just the form we need for solving the basic equation which describes the steady-state behaviour of our LC circuit.

$$\frac{d^2V}{dt^2} + \frac{V}{LC} = 0$$

and gives us,

$$V = A \sin(t/\sqrt{LC})$$

There is another integration constant to put into this somewhere, but we need not worry about that. There is also an "effect of switch" term to be included, but we know that this will be a dying-away effect. The full solution is so well known that I feel no shame in leaving out the more conventional aspects.

It must be repeated that this $\sin(t/\sqrt{LC})$ function is completely refined by the integral and the equation above, together with a set of equations of the type $\sin(y + \pi) = -\sin y$, in which π is defined by the equation $\sin \pi/2 = 1$. In other words, a sine wave is *defined* as the waveform produced by an LC circuit once the starting shock is over. It might have been better, indeed, to do the analysis in terms of a function with an unfamiliar name, like bong (x), and then, at the very end, to have revealed that bong (x) is $\sin x$.

Turning, though I do not propose to turn very far, to the circuit using all our elements, the LCR circuit, we find that the solution of the equations is either two terms of the exponential kind, or the product of an exponential term and a sinusoidal term. All this, together with an explanation of what happens at the transition point, is in the books. When the resistance is negative, whatever that means, the exponential term gives a growing amplitude: the ordinary positive value of R which we must have in a passive network gives us a decaying amplitude. Is this, then, the right natural waveform to use for circuit study?

Let us apply the damped sinusoidal waveform to an arbitrary network of inductances, capacitances and resistances. At some other point in the circuit we shall observe that we get a sinusoidal waveform with a new envelope, an envelope which is a combination of exponentials and which varies from network to network. On the other hand, if we have applied, at some time sufficiently past for the transients to die away, a constant-amplitude sinusoidal wave, we find that the signal at any other point in the network is of the same form. The transmission of the network for such a signal is characterized by a size parameter and a time delay.

Our measurements then consist of a comparison of like with like, which is simple, rather than the extraction of a bunch of mixed exponents from a rather complicated waveform. The sine wave owes its great importance in circuit theory to the simple fact that in a linear passive system, once a sine wave, always a sine wave. In most active systems, too, the same is true, provided that linearity is maintained.

In this derivation of the sinusoidal signal, you will observe, there has been no mention of machines spinning round, nor of jolly Egyptians out measuring pyramids, the purpose for which trigonometry was apparently invented. The sine wave is used for studying circuits because circuits produce sine waves. This, not surprisingly is the key to the way we make our signal sources: we contrive, by using active devices, to cancel out the resistance in a circuit made up of a practical inductor and a practical capacitor and thus to maintain the circuit operating as an analogue solver of the equation $LC\,d^2V/dt^2 + V = 0$, with a particular integration constant. Of course there are other methods, the beat-frequency oscillator, the RC oscillator, the waveform synthesizer, but the LC, infinite-Q circuit is the really fundamental signal source.

One textbook states that we use sine waves because we can resolve any waveform into, well, into a Fourier series. This is a useful feature of the sine function, but it is a feature shared by a whole range of what are called orthogonal functions. We might choose to express our arbitrary waveform as the sum of a series of Bessel functions, for example. The uniqueness of the sine function is that it is what simple oscillators produce.

I should like to sketch out the way the purely mathematical approach continues. This is not the full formal treatment, but a description of the path followed in a formal study of these functions. The first step is to show that $e^{\alpha+j\beta} = e^{\alpha}(\cos\beta + j\sin\beta)$ and then, by taking $\alpha = 0$ and the forms for β and $-\beta$, that $\sin\beta = -j/2\,(e^{j\beta} - e^{-j\beta})$

We use this result, of course, in the normal heuristic method of solving the differential equation for the LC circuit. We guess the answer e^{kt} and then find that we have $k = \pm jn$, where n is some constant depending on L and C. So far, sin x has been defined only for real values of x, but e^x, or more strictly exp x, can be defined for complex values of x, such as the $(\alpha + j\beta)$ we have just been using. We can now *define*

$$\sin x = -j/2\,(e^{jx} - e^{-jx})$$

for all values, real or complex, of x.

I should like to recapitulate here the whole basic chain. The first definition is a definition of the general logarithm, Log λ, by an integral

$$\mathrm{Log}\ \lambda = \int \frac{dz}{z},$$

in which the integral is along a curve C which starts at 1 and goes to λ without passing through the origin. If the curve encircles the origin we get terms of the form $2n\pi$ appearing.

Next we define

$$\lambda = \exp\nu \qquad \text{if } \nu = \log\lambda$$

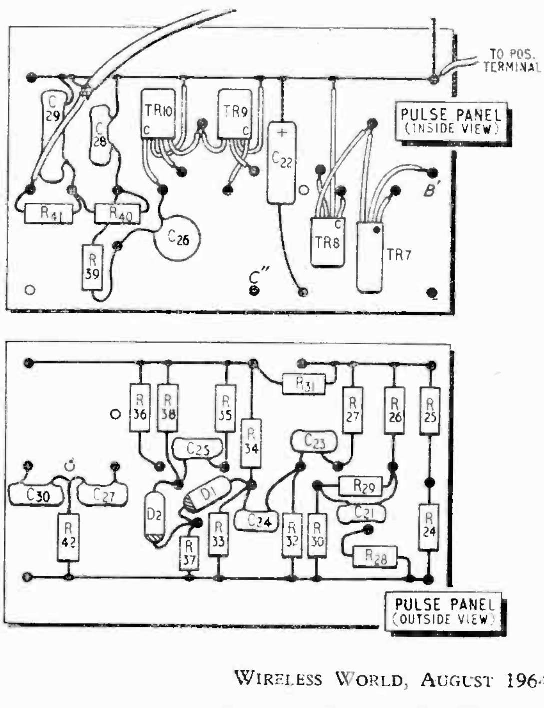
Finally we have the definition of sin x given above, and the companion definition of cos x.

Without this formal background we cannot properly solve the problem of the simple LCR circuit. With it we can plug away, substituting e^{kt} in the second-order differential equation and arriving at the well-known answer $e^{\alpha t}\sin\beta t$. Now, however, we find that the answer may take a slightly different form. The use of the more general forms for the sin and cos function lead us on to the more general idea of frequency. We decide that we should plot the roots of the equation in the complex plane and, having plotted $-\alpha + j\omega$ and $-\alpha - j\omega$ it is only a short step to seeing $(\omega - j\alpha)$ as the complex frequency.

This outline for an analysis shows how the question in the title is answered. It also shows that without some fairly rigorous treatment along these lines, or along some equivalent path, since we may define our functions in other ways, we have no real foundation on which we may build our circuit theory. Trace back what you think you know about sines and cosines and you find that it is all based on what Mr. Trig the maths master told you ten, twenty, thirty years ago. "The essence of our whole field of work deserves a sounder basis," that's what Sir said.

"W.W." F.M. Tuner

The drawing below replaces the bottom part of Fig. 10 (p. 331 of the previous issue) in which it is regretted that component numbering differed from the circuit diagram. H.t. required is 9V at 14mA and the expression for crystal frequency on p. 333 should read (89.1 − 0.13)/3 = 29.657.



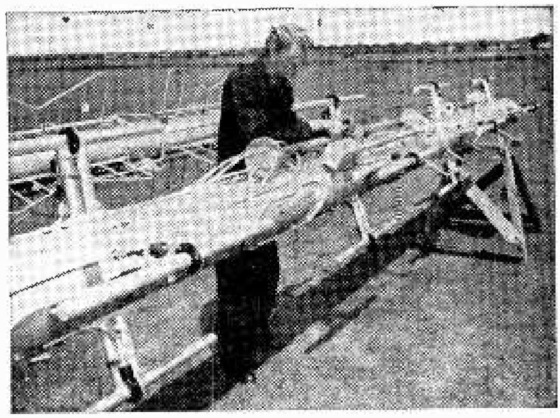
WORLD OF WIRELESS

Synchronous Satellites

A TRULY equatorial orbit is planned for Syncom III which is due to be launched by N.A.S.A. for Hughes Aircraft Company on August 8th. This is the third in the series of experimental synchronous satellites built by Hughes. Contact with the first was "lost" after it had reached its synchronous orbit but the second was successfully launched in July last year and is still operating although power from the solar cells has diminished slightly.

Syncom III will transmit on two 25-Mc/s channels centred on 4081 Mc/s for the U.S.A. and 4161 Mc/s for Europe. Frequencies for transmission to the satellite will be 6301 and 6390 Mc/s.

The first *commercial* synchronous satellite, which has been ordered by the Communications Satellite Corporation (Comsat) and is to be known as Eary Bird, is a more sophisticated version of Syncom. The Early Bird $8M contract awarded to Hughes calls for two satellites for next April. The solar cell surface on Early Bird will be considerably larger than on its predecessors and will have a capacity of 50 watts compared with 30 W in Syncom and a transmitter power of 6 W compared with two. It is to be stationed over the Atlantic and will be capable of handling 240 two-way telephone calls simultaneously.



Spare Aerial.—To reduce to a minimum the time that an I.T.V. programme would be off the air should a transmitting aerial be seriously damaged, the Independent Television Authority has placed a contract with EMI Electronics Ltd. to supply a reserve 250 ft. mast and two aerials; one vertically and one horizontally polarized. The mast can be erected in eight hours by a team of seven men, ready for the appropriate aerial to be fitted and powered, which can take as long again.

"Technician Engineers"

IN last month's Editorial Comment on the formation of the Society of Electronic and Radio Technicians, reference was made to the proposal of the Association of Supervising Electrical Engineers for a society for "technician engineers" in the electrical and electronics industries. The Association has now decided (on July 8th) to promote the formation of a new organization which will be known as the Institution of Electrical and Electronics Technician Engineers. This will have a two-fold function; to serve as a qualifying body and to arrange a programme of technical meetings and publications. There will be a graded membership structure, which will take into account the extent of the candidate's industrial experience. Qualifications for graduateship will include the Higher National Certificate and certain final certificates of the City and Guilds of London Institute.

The proposed new body has the warm support of the Institution of Electrical Engineers. It will be administered by the Secretariat of the A.S.E.E., 26 Bloomsbury Square, London, W.C.1.

Amateur Licensing Changes

A NEW amateur sound licence, authorizing the use of telephony only and of frequencies above 420 Mc/s, has been introduced by the Postmaster General. It is designated Amateur (Sound) Licence B to distinguish it from the standard sound licence permitting transmission of morse or 'phone in any amateur band. Applicants for Licence B will have to pass the Radio Amateur Examination but will not have to undergo the morse test laid down for Licence A. Holders of the new telephony licence will be allocated call-signs with the prefix G8 (or GM8-Scotland, GW8-Wales, etc.).

It is also announced that the 70 Mc/s amateur band has now been extended from 70.2-70.4 to 70.1-70.7.

Another change is that in future all amateur television transmitters will have call-signs with the prefix G6 and the suffix "/T."

Semiconductor Research Grant.—A three-year project to seek experimental confirmation of recent theory of the electrical conduction characteristics of certain materials which lie between insulators and semiconductors, is to be carried out by the Electrical Research Association with the support of a D.S.I.R. "earmarked" grant of up to £17,400. The £3,000 balance of the total estimated cost for the project will be provided from the Association's research funds. Although the work to be done is of a speculative nature it may lead to advances in controlling semiconductor devices, such as transistors, capacitors and thermocouples at high temperatures. The work proposed in the present project will start from the basis of theoretical work done at Liverpool University, which has yet to be confirmed experimentally.

Valves and Semiconductors: Who Makes What.—A guide to the structure of the British valve and semiconductor industry, first published in booklet form two years ago, has been revised and is available free from the secretary of the B.V.A., Mappin House, 156 Oxford Street, London, W.1. This second edition of "British Valve & Semiconductor Industry" broadly classifies 62 types of valves, tubes and semiconductor devices (compared with 48 in the first edition) and lists the names and addresses (with telephone numbers) of the firms making each type mentioned. The book is published by the British Radio Valve Manufacturers' Association (B.V.A.) and the Electronic Valve and Semiconductor Manufacturers' Association (V.A.S.C.A.).

The **International Exhibition of Industrial Electronics** (INEL), which was held in Basle for the first time last September, is to be a biennial event. It has been decided that the next INEL will be held in Basle from 7th to 11th September, 1965.

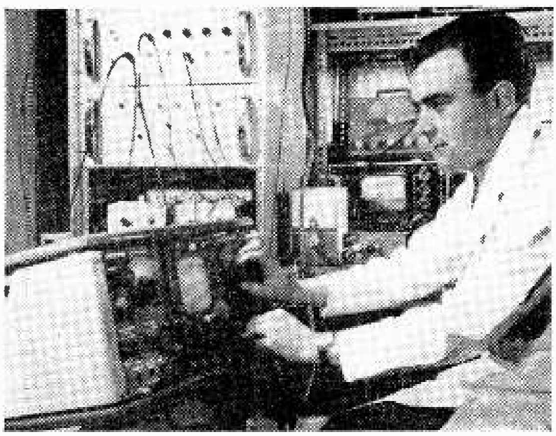
The annual report of the **Radio Industries Club** records that the membership of the parent organization and the eight provincial clubs now totals 2,039. The London total is 850.

The 1965 **Automatic Control Convention** is to be held in the University of Nottingham from 6th to 9th April. The Convention, under the aegis of the United Kingdom Automation Council, is being organized by the Institution of Mechanical Engineers on behalf of a consortium of Institutions, which includes the I.E.E. and the I.E.R.E. Further details are available from the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1.

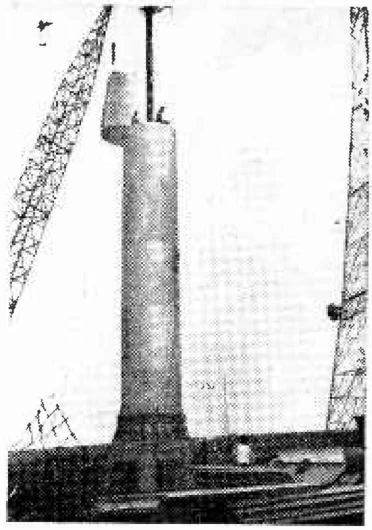
Belize, British Honduras, is the location of a new h.f. station Cable and Wireless Ltd. propose to complete during the next eighteen months. The station, which will be built on a site at Pine Ridge, will contain four 1kW transmitters and five receivers, and will be connected to the Central Telegraph Office in Cattouse Building, Belize, by a multi-channel v.h.f. link. It will be used to provide telegraph links to Jamaica, Mexico and Miami, and telephone links to Jamaica, Guatemala and Honduras Republic.

Television Society Premiums have been awarded to the following for papers read before the society during the past year: G. B. Townsend (Rank Cintel) receives the Mullard premium for "New developments in SECAM"; Dr. P. Schagen (Mullard Research Labs.) the *Wireless World* premium for "Electronic aids to night vision"; A. C. Dawe (E.M.I. Electronics) the *Electronic Engineering* premium for "Characteristics of special vidicon camera tubes and their applications"; K. Fawdry (B.B.C.) the Pye premium for "Education by television"; and C. F. Whitbread (Associated Aerials) the T.C.C. premium for "Receiving aerials for u.h.f. television".

Navy Days.—The Royal Naval Amateur Radio Society will operate a special exhibition station, under the call-sign of GB3RN, from H.M. Dockyard, Portsmouth, during the period August 1st-3rd. The station will be operating on all amateur bands from 1.8 to 145 Mc/s.



***British Entrant.**—Roger Munt, a twenty-year old student technician apprentice with the M.E.L. Equipment Company, has been selected to represent Britain in the "Radio & Television Servicing & Repair" section of the International Apprentice Competition, which is to be held in Lisbon during August. Mr. Munt was selected after a two-day test during which each entrant had to build, test and calibrate an a.m./f.m. receiver. Next year's Competition is to be held in this country and selection tests for the team to represent the United Kingdom will be held during the coming autumn. Full details are available from the director (IAC), City and Guilds of London Institute, 76 Portland Place, London, W.1.*



***I.T.A./B.B.C. Mast.**—Constructing the 1,000ft steel mast at the I.T.A. station at Winter Hill, Lancs. in preparation for the co-siting of B.B.C. and I.T.A. transmitters. The mast, which will replace the existing 450ft tower, will be capable of carrying four u.h.f. and two v.h.f. television aerials and a Band II aerial. It will consist of a 9ft diameter steel tube of 650ft with a 350ft open lattice steel topmast.*

Reciprocal Amateur Licensing.—The United States House of Representatives and the Senate have passed the Amateur Radio Reciprocal Operating Bill which permits the U.S. government to enter into agreements with other governments whereby each would allow the radio amateurs of the other country to operate a transmitting station while on a visit. The passing of this Bill could result in a change of outlook by the Post Office in this country insofar as U.S. amateurs are concerned, for at present, no "foreign" amateur is permitted to operate while visiting this country. In a few Continental countries U.K. amateurs are able to obtain short-term licences for mobile rallies, etc., although this is not reciprocated by this country.

BBC-2.—The erection of a temporary aerial on a 150ft mast at the B.B.C.'s Sutton Coldfield station will enable the BBC-2 television service to be extended to the Midlands by the end of this year—eight or nine months earlier than expected. It will also be necessary for the B.B.C. to provide temporary radio links to carry the programme from London until the permanent Post Office circuits are ready. The station will operate in channel 40 (vision 623.25 Mc/s, sound 629.25 Mc/s) with horizontal polarization but with an e.r.p. of about one-tenth of the final 1,000 kW.

Code of Practice.—British Standards Code of Practice CP 327, entitled "Telecommunication facilities in buildings," is being revised and work has now been completed on Part 3 which covers "Sound distribution systems". This part deals with sound distribution systems in buildings which are not designed primarily for sound reproduction. Some guidance is also given on installation in open spaces. Copies of this 70-page publication may be obtained, price £1 each, from the B.S.I. Sales Branch, 2 Park Street, London, W.1.

Tunnel Diodes.—The British Standards Institution has issued an amendment to Part 1 "Essential ratings and characteristics" of B.S. 3494 "Memorandum on light-current semiconductor devices". Copies of this amendment, which lays down the minimum data which should be provided by a manufacturer when describing his product for general sale, may be obtained, price 2s 6d each, from the B.S.I. Sales Branch, 2 Park Street, London, W.1. (Postage will be charged extra to non-subscribers.)

Correction.—The correct price of the "Contessa" transistor receiver kit advertised by Radio Clearance Ltd. in last month's issue is £7 19s 6d.

I.E.E. Membership.—During the year ended last March the membership of the Institution of Electrical Engineers increased by the record number of 1,741 bringing the total to 52,125. Reference is made in the report to the proposed introduction of a new class of membership. The new class would be open to "persons not being eligible for Corporate or Graduate membership of the Institution who, by their connection with engineering, science, or the arts, or otherwise, are interested in, and capable of rendering service to, or advancing knowledge in, electrical engineering."

"The Transistor"—A revised and extended version of the Mullard colour film entitled The Transistor—Its Principles and Equivalent Circuit (UK 2248), is obtainable on free loan from the Central Film Library, Industrial Section, Government Building, Bromyard Avenue, Acton, London, W.3. It is split into three parts: how the transistor works (8 min); the small signal equivalent circuit (17 min); and the large signal pulse equivalent circuit (22 min).

Components & Materials.—A conference on components and materials used in electronics engineering is to be held at the I.E.E. from 17th to 21st May next year. This will be concurrent with the Radio and Electronic Component Show at Olympia (18th to 21st May). Further information and registration forms will be available in due course from the I.E.E., Savoy Place, W.C.2.

Solderability.—"A guide to a method of measuring the solderability of round wires and component termination wires" is the title of a recent publication from the Electronic Engineering Association. This is the final report of a working party, set up in 1962, to study this problem and is available, free of charge, from the Association, 61 Green Street, Mayfair, London, W.1.

Audio Signal Generator.—Reprints of the constructional article, which appeared in the November and December issues of last year, describing the *Wireless World* designed transistor audio signal generator are now available, price 3s.

PERSONALITIES

Kurt Hoselitz, Ph.D., F.Inst.P., F.I.M., has been appointed deputy director of Mullard Research Laboratories. Dr. Hoselitz was educated at the Universities of Vienna and Bristol. He received his Ph.D. at Bristol in 1942 and subsequently became a research scientist with the Permanent Magnet Association. He

Dr. K. Hoselitz

was promoted director of the Association's Central Research Laboratories in 1947 and five years later he joined the Mullard Research Laboratories to establish the solid-state physics division. Dr. Hoselitz, who is 47, will continue as head of the division.

P. G. Wilkins, A.M.I.E.E., A.M.I.E.R.E., has been appointed engineer-in-charge of the B.B.C.'s Rosemarkie television and v.h.f. sound transmitting station. Mr. Wilkins, who joined the Corporation in 1947 and became a senior maintenance engineer in 1953, was appointed assistant e.-in-c. at Burghead in 1955.

Edward E. Rosen, while retaining the chairmanship of Ultra Electric (Holdings) Ltd., has relinquished his full-time executive responsibilities. After serving with the Royal Flying Corps in the first world war, Mr. Rosen started his own company (Edward E. Rosen & Co.) for the manufacture of headphones and loudspeakers. Three years later the company's name was changed to Ultra Electric Ltd. Following this announcement, **F. W. Stoneman,** M.B.E., T.D., Ph.D., B.Sc.(Eng.), A.M.I.E.E., who joined Ultra from Smiths Aircraft Instruments in 1959, has been appointed to the board of the subsidiary, Ultra Electronics Ltd., and becomes joint managing director with **A. V. Edwards,** who has been appointed managing director of Ultra Electric (Holdings) Ltd. As the senior director of the electronics company, Mr. Edwards retains responsibility to the parent board for the operations of that company.

F. W. Chignall, Assoc.I.E.E., engineer-in-charge of the B.B.C.'s Transcription Service, Maida Vale, since 1946, has retired. Mr. Chignall joined the B.B.C. in 1929 as an assistant maintenance engineer at Liverpool and moved to London to join the technical recording section in 1936. In 1941 he went to the Middle East and served as a war correspondent with the Army in the Western Desert until he was appointed e.-in-c. of the B.B.C.'s first overseas office, in Cairo, in 1943. He held this post for three years. For the time being, responsibility for the engineering aspects of the Transcription Service has been assumed by **R. C. Patrick,** Assoc.I.E.E., of the headquarters staff of External Broadcasting.

P. S. Carnt, B.Sc.(Eng.), A.C.G.I., M.I.E.E., joint author with G. B. Townsend of the book "Colour Television," has left the G.E.C. Hirst Research Centre to join R.C.A. Laboratories Ltd. in Zurich. Mr. Carnt graduated at Imperial College (City and Guilds College) in 1944, and went to the G.E.C. Research

P. S. Carnt

Laboratories in 1946 after two years at the Admiralty Signals Establishment, Haslemere.

R. Aspinall, M.A., who for the past year has been assistant director of guided weapons (guidance and control) in the Ministry of Aviation, has been appointed director of guided weapons research and development (common services). Mr. Aspinall, who is 47 and graduated at Oxford, joined the scientific civil service in 1940 and initially worked on aerials research at the Air Ministry Research Establishment at Swanage, Dorset. In 1943 he was posted to the British Air Commission in the United States and returned in 1945 to continue his research at the Telecommunications Research Establishment, Malvern. He later transferred to guided missile research and became group leader responsible for the development of guidance control and telemetering for beam riding and other guided weapons. In 1954 Mr. Aspinall was appointed superintendent of the long-range guided weapons division at Malvern and two years later became superintendent of the defensive radar division.

L. G. Brazier, Ph.D., B.Sc., M.I.E.E., F.Inst.P., director of research of British Insulated Callender's Cables Ltd., retires from the company at the end of August after 39 years' service and has recently accepted an invitation to join the board of Metal Industries Ltd. on 1st September. He has been a director for the past 14 years and is succeeded, as director of research, by **A. L. Williams,** Ph.D., M.Sc., D.I.C., A.Inst.P., M.I.E.E., formerly the company's research manager. Having also reached the age of 65 at the end of August, **W. C. Handley,** B.Sc., M.I.E.E., will relinquish his position as joint managing director, but will remain on the board. **R. M. Fairfield,** B.Sc., M.I.E.E., M.I.Mech.E., who has been joint managing director since January 1962, becomes deputy chairman and managing director of the company.

B. Wilkinson, who joined Standard Telephones and Cables Ltd. as assistant to the manager of the Transmission Systems Group in

B. Wilkinson

1960 and became manager of the submerged repeater division in the following year, has been appointed marketing manager of the Transmission Systems Group, which includes the land lines, submerged repeater, microwave systems and installation divisions. Prior to joining S.T.C., Mr. Wilkinson spent 17 years with Amalgamated Wireless (Australasia) Ltd., and ten years with E.M.I. He is succeeded as manager of the submerged repeater division by **B. D. Mills,** B.Sc., B.E., A.M.I.E.E., who for the past two years has been chief engineer of S.T.C.'s transistor division at Footscray. Mr. Mills, who is 35, joined

B. D. Mills

the company in 1951 as a development engineer specializing in high-reliability receiving valves. He is a graduate of the University of Queensland.

L. F. Lewis has been appointed engineer-in-charge of the B.B.C.'s sound outside broadcasts in succession to **R. H. Wood** who, as announced in our June issue, has retired. Mr. Lewis joined the B.B.C. in 1932 as an assistant maintenance engineer in the London Control Room and three years later transferred to the recording department where he served as a senior recording engineer in the technical recording section and in the London recording unit. In 1957 he became an assistant to the superintendent engineer, sound broadcasting.

R. L. Ferrari, B.Sc., A.R.C.S., D.I.C., has been granted leave of absence for a year from the research laboratories of the M-O Valve Company at the Hirst Research Centre, to undertake electron beam plasma research at Cornell University, Ithaca, New York. Mr. Ferrari is a member of the principal scientific staff of the laboratories where he has worked for nine years on semiconductor and electron beam research. Recently he has been particularly concerned with new microwave and plasma devices.

OUR AUTHORS

A. J. Goss, B.Sc., Ph.D., F.Inst.P., one of the authors of the article on the light-emitting diode in this issue, has been in charge of the semiconductor materials research laboratory at the Marconi Research Laboratories, Great Baddow, Essex, since 1955. Dr. Goss obtained his doctorate after doing post-graduate research in crystal growing at the University of Southampton from 1949-1952 and then spent three years on research in semiconductors at the Bell Telephone Laboratories, Murray Hill, New Jersey. His co-author, **A. E. Sarson,** B.Sc., A.Inst.P., has been at the Marconi Labs. since 1949 initially on television research and since 1958 as chief of the semiconductor physics group in the measurement laboratory. Mr. Sarson was in the G.E.C. Research Laboratories from 1932 until 1946 when he joined Cinema Television Limited as a research engineer and was concerned with work on colour television systems and television recording on film.

P. Visontai, Dipl.Ing., A.M.I.E.R.E., author of the article on page 408, studied electronic engineering at the Technical University of Budapest, Hungary, before joining the staff of the Hungarian broadcasting organization where he was concerned with the design and development of television studio equipment. He left Hungary in 1958 and after working as a television development engineer with Nordmende Rundfunk KG, of west Germany, came to this country in 1960. He was with Radio and Allied Industries until recently joining Rediffusion Vision Service, Ltd.

C. E. Goodison, contributor of the article in this issue on meteorological satellites, is an experimental officer in the Instrument Development Branch of the Meteorological Office headquarters at Bracknell, Berks. For the past three years he has been mainly concerned with the electronics side of such projects as unmanned automatic weather stations. After leaving school in 1945 he served in the Royal Navy as a petty officer radio mechanic and joined the Meteorological Office on demobilzation in 1948.

OBITUARY

Hugh D. Law, engineer-in-charge of the B.B.C. West Region transmitter at Start Point from 1951 until his retirement in 1962, died in Newcastle-upon-Tyne on June 22nd, aged 65. Mr. Law joined the B.B.C. at Dundee in 1925.

Harry C. (John) Willson, founder of Reproducers & Amplifiers Ltd., of Wolverhampton, died on July 8th. Mr. Willson was chairman and managing director of the R. & A. from the formation of the company in 1930 until he retired two years ago.

LETTERS TO THE EDITOR

The Editor does not necessarily endorse opinions expressed by his correspondents

Black-level Correction Circuits

AS Mr. Mothersole (July issue, p. 357) raised many points concerning the difficulties of fitting my circuit to an average receiver, I should like to take this opportunity of replying to the points in the order that they were raised.

I went to pains to discuss how my Fig. 2 was unnecessarily extravagant for a commercial receiver and suggested that it could be reduced to just V3 with its eleven resistors, four capacitors, four diodes and a voltage dependent resistor. While this compares unfavourably in cost with Mr. Mothersole's pentode, three resistors and three capacitors, it has the advantage of not only retaining the black level, but also of maintaining the peak white amplitude at the correct level. This can hardly be described as a "difficult" circuit and it certainly requires no "critical adjustment of preset potentiometers" or "system switching" which were the points that I originally contested.

As I have only spent some 30-40 hours on the circuit development, and that in my living-room, I cannot claim that the circuit as it stands is ready for mass production, but in view of the fact that it contains no accurate components, presets or switching, I think it offers considerable promise. In order to protect the c.r.t. from excessive beam current, it would probably be best to limit the range of the contrast and brilliance controls or to preset them altogether to completely prevent maladjustment.

While I have not toured the country with this modified receiver, I have tried input signals up to 40 dB above a.g.c. action on Band I and III and to 25 dB above a.g.c. action on Band IV giving the performance as stated in my first letter. Additionally, by using an inferior indoor aerial, I tried the circuit on signals containing several strong variable echoes and much electrical interference and the receiver showed no special defects over other a.g.c. systems.

Mr. Mothersole's point concerning "blocking" is completely irrelevant as, as he indicated towards the end of the paragraph in question, a mean level a.g.c. system is just as susceptible to this effect and the standard methods of eliminating this effect are just as appropriate. Some set manufacturers use a time-constant in an i.f. valve grid to off-set blocking on the 405 line system. Had I suffered from this effect I would have preferred to take delayed a.g.c. from the sound i.f. detector stage and applied that to the vision a.g.c. line as, in my opinion, this offers a more positive solution to the problem.

It is a very debatable point as to whether the small minority of viewers who suffer from aircraft flutter would consider it less desirable to have the wanted image luminance levels fixed while the delayed reflected image from an aircraft varies cyclically in brightness than to have both images varying such that the combined brightness is constant. Anyway, at flutter frequencies in excess of 2 c/s, both a.g.c. systems will behave in the same manner due to the long time-constant necessary on the a.g.c. line in the mean level system. Here at Cuffley, I live on one of the principal traffic routes into London Airport and am not troubled by this effect as I have an adequate aerial array. Due to the 10 msec time-constant in the keyed clamp and the 30 msec time constant on the a.g.c. line, no discernible streaking in the black level occurs after interference bursts.

Mr. Mothersole's last three paragraphs say that the black level shift is the worst effect of mean level a.g.c., but that if you want to see the picture in a well-lit room you have to put up with this because of poor e.h.t. regulation, but to obtain maximum contrast on dark scenes you must stabilize the black level and that the typical television receivers of today approach the ideal. I find it hard to comment on these points.

I would very much like to discuss all the minor problems I encountered when fitting this additional circuit to the receiver, but it would run to greater length than the Editor is likely to tolerate.

Finally, one other advantage of this circuit over mean level a.g.c. is that the a.g.c. time-constant can be reduced from about 1 sec to 30 msec. This not only responds to channel changing immediately, but also eliminates signal flutter due to the aerial array and downlead swaying in high winds.

Cuffley, Herts. J. D. MIDDLETON

The author replies:

The d.c. component and mean-level a.g.c. are subjects that have been, and I am sure will be, argued about for as long as we are blessed with television! Unfortunately, in such debates some people take Mr. Middleton's uncompromising point of view and grossly overestimate the ease of retaining the d.c. component in a domestic receiver. Further discussion of the subject invariably shows that, as in this case, the opinion is based on very limited field experience or laboratory study.

Mr. Middleton disagrees with my findings that variations in the displayed picture black-level are more objectionable than variations of video drive. This conclusion was, however, established by extensive subjective laboratory tests and has been confirmed by several other workers, notably the Hazeltine Laboratories (U.S.A.).

It is an established fact that the average non-technical viewer finds some difficulty in correctly setting the brightness and contrast controls of a normal receiver. This is largely due to the interaction of these controls and is virtually independent of the a.g.c. system. This is the effect I was, in fact, referring to in my original article and is one reason why the d.c. component is reduced or removed even in receivers that have a true signal level a.g.c. system and in which one might expect, therefore, the retention of the d.c. component in the displayed picture.

It is my opinion that the term "Brightness Control" is also a contributory factor to the difficulty since the name encourages the user to look at the "bright" parts of the picture while adjustment is made when, in fact, he should be looking at the dark areas. The situation might be helped by changing the name to "Blackness Control," for example, and if a simple stabilization or clamp circuit is used to make these controls less interdependent, and hence simplify the operation of the receiver, we may have made a start in removing some of the problems of retaining the d.c. component in the displayed picture.

The outstanding question then is "How does one sell the improvement to a normal viewer"?

P. L. MOTHERSOLE

I HAVE followed with interest the renewed controversy on picture presentation *vis-à-vis* black level retention *versus* mean level a.g.c. with brightness correction. It is certainly true that an excellent correction of picture background information is obtainable with Mr. Mothersole's invention. It does, however, suffer from the usual defect of all mean level systems inasmuch as low key pictures result in a drop in a.g.c. with a resultant rise in i.f. sensitivity with its concomitant increase in "noise". This, of course, is more apparent on a dark picture. One of the major drawbacks of mean-level a.g.c. coupled with long time-constant in the c.r.t. cathode degenerative network is apparent where a bright sky scene occupies the top of the picture with picture detail in the grey-black at the bottom. With mean level the high-level whites bias back the i.f. amplifies so that with the usual slow recovery the detail at the bottom is lost as a result of the greys being crushed into the black.

Keyed a.g.c. systems are an answer but are obviously more expensive, although if the field synchronizing period is used, rather than the back porch of the line pulses a cheaper and more reliable result can be achieved on dual-standard receivers. Its disadvantage is the long time-constant required in the filters, which gives little protection against aeroplane flutter.

A still cheaper and reasonably effective a.g.c. system can be derived from the sound channel. On either system the level of the sound carrier is constant. However, if v.a.g.c. is wholly derived from this, variations due to local differences in the sound/picture ratio, selective fading and tuner oscillator drift may give rise to unrealistic results between different channels.

However, in the majority of modern designs a high-gain class A sound i.f. amplifier follows a stage or stages which are controlled by a.g.c. derived from the picture with either system. It will be apparent that a secondary a.g.c. can be derived from the sound i.f. amplifier. It is not difficult to arrange an a.g.c. feed network which supplies bias to the controlled stages both from the sound amplifier (which should not itself be a.g.c.-controlled) and from the mean level of the video signal. The mechanism is as follows. An increase in picture background results in increased a.g.c. to the common controlled stage(s), the level of a.g.c. voltage taken from the sound i.f. amplifier is thereby reduced. Since this voltage is also applied to the controlled stages the net value of a.g.c. variations is reduced, the sound a.g.c. drop tending towards a return to the *status quo*. Experiments have indicated an improvement of at least 50% in picture information display by this means. A low-drift oscillator in the tuner is an essential, particularly on 405.

Brighouse, Yorks. F. H. BEAUMONT
Beaumont (Television) Limited.

I HAVE been very interested to read of Mr. J. D. Middleton's black level clamp and gated a.g.c. circuit, and Mr. P. L. Mothersole's reaction to it. Referring to his circuit diagram Fig. 2, Mr. Middleton states "In fact it may prove entirely satisfactory to include just V3 the high-level a.g.c. valve. . . ." At this point I should like to draw his attention to my article "Gated A.G.C." published in the October 1963 issue of "W.W." which to my mind typifies some of the simplification possible with this kind of circuit. My Fig. 2 includes the environmental circuit associated with the basic system. V4 forms a long-tailed pair comparator of the kind described by Mr. Middleton, in this case d.c.-coupled to the video amplifier. The mode of connection enables the triode part of V4 to be regarded as a cathode follower conveniently available to drive the c.r.t. cathode and sync. circuits. By applying both a gating pulse of stable amplitude and a d.c. "contrast" control bias to V4 pentode grid, the gating action is achieved. The pentode anode pulses are rectified to produce a.g.c. bias.

Voltage stabilized supplies have proved unnecessary as the cathode potentials of V4 (and hence the c.r.t. cathode), the contrast control line and brilliance network are of the same order.

Relative voltage changes between the various points are small enough to have negligible effect on normal operation.

The addition of black-level clamping circuitry would naturally provide independent operation of contrast and brilliance controls, but over five years' operation of the system contrast adjustments have been very infrequent. Bearing this in mind I doubt whether the complexity of the black-level clamp is justified where a black-level-conscious a.g.c. system is employed. While Mr. Mothersole's clamp is undoubtedly better than no form of black-level stabilization, I cannot help feeling that when used in conjunction with mean level a.g.c. it simply attempts to "bolt the door after the horse has gone." The subjective effect on the viewer is obviously better, but contrast expansion occurs on low key scenes and consequently the picture is still not displayed as transmitted.

I do, however, sympathize with Mr. Mothersole's remarks to some degree. The problems of ghosting, interference and blocking must not be neglected. Blocking or "lock-out" was one of the problems associated with my circuit, and was simply cured by the addition of two components. In the event of the system's use on a negatively-modulated signal, d.c. restoration would need to be employed at the video amplifier grid, with a.c. coupling from the detector. An a.g.c. override could then be arranged from the detector itself to prevent blocking,

The question of ghosting is more complex and obviously depends to a great extent on what the general viewing public is prepared to tolerate. In my experience the public appears to be over-indulgent towards indifferent pictures; the TV magic is all-powerful and criticism taboo.

The mean-level a.g.c. system can obviously cope better with aircraft flutter and some forms of ghosting than the gated system—but how much better and at what cost to the accuracy of video presentation?

Aircraft flying in the vicinity of my home give rise to video flutter. It is probable that the gated a.g.c. does not cope so adequately as would a mean-level system, but I prefer to watch a correctly presented picture for the majority of the time compared with a mean-level system, with possibly improved interference and ghosting immunity.

The whole discussion appears to boil down to the fundamental philosophy of whether it is preferable to provide a receiver capable of reproducing correct black level and tonal gradation, or not. Acceptance of mean-level a.g.c. denies the viewing public the possibility of seeing correctly-reproduced pictures.

While interference etc. has been considered I am sure that cost comes into the picture as well, to a degree that no manufacturer seems prepared to admit.

I have the impression that perhaps one manufacturer cut his costs initially by adopting mean-level a.g.c., and when his competitors saw him getting away with it they followed suit in order to compete. "All we like sheep have gone astray . . ."! The tolerant public simply put up with the situation. Perhaps they didn't even notice in some cases. As a result, mean level a.g.c. is now firmly entrenched and we must be grateful to Mr. Mothersole for producing a particularly neat solution to one of its disadvantages. He still adds a valve though, and deep down I feel that perhaps it should have been an a.g.c. gate. Perhaps Mr. Middleton and others feel the same way.

Southampton. KEITH CUMMINS

Intermodulation Distortion Measurement

IN spite of Mr. Waddington's conclusion (June 1964 issue) that there is no simple method of making distortion measurements, perhaps he has not seen the method described by Richards and myself in your journal only fourteen months ago? In April 1963, we dealt with single- and two-tone tests and went on to show that there is a simple method which gives a unique figure for relative merit which can be carried out on any amplifier at any level and which gives the unwanted distortion power for programme type signals without ambiguity of any kind.

The fact that there is no commercially available test equipment so far should not prevent the discussion of this slotted white noise method in any paper bearing the title which Mr. Waddington has chosen.

Engineers who have read both papers may take comfort from the fact that the measurements by the three methods used by Mr. Waddington, confirm our statement that the interpretation of "tone" type tests is extremely difficult and laborious and still gives no unique figures of merit. The wider this knowledge spreads the better. It will only hasten the day when the slotted white noise method comes into its own.

London, N.W.2. J. SOMERSET MURRAY

The author replies:

Mr. J. Somerset Murray has obviously misread my statement that there is no simple *rule* for making distortion measurements. There are simple *methods* and I have described three of these in my article.

I read the article referred to, together with the correspondence, with considerable interest at the time of writing my own article and I came to the conclusion that the white noise method of measurement should be omitted for the following reasons:—

1. While the white noise method could give a "figure of merit", provided that the test specification were well defined, this would only be useful as an end product in a production test.
2. This test gives no indication as to whether the distortion is of even or odd order.
3. There is no convenient method of finding out whether the distortion is occurring at the high or low frequency end of the pass band of the amplifier under test.
4. As white noise is not a coherent signal, it is necessary to run the test at a level such that the output power is at least 8 dB below the full power output in order to ensure that overloading does not occur for more that 1% of the time (see for example "Reference Data for Radio Engineers", 4th edn. International Telephone and Telegraph Corp., p. 874). Hence, if the distortion were occurring mainly at the crossover point of the transfer characteristic, the distortion as measured by this method would be pessimistic, while if it occurred mainly at the overload point the result would be optimistic.

D. E. O'N. WADDINGTON

Loudspeaker Polarity

I UNDERSTAND from my brother (G. F. Johnson, of Malvern) that he has written to you in connection with the unbalanced effect in hearing described in your (June) letter from Messrs. Wooller, Thorley and Boys. At the time of writing I have not seen the text or heard even an outline of what he wrote but I am wondering whether it concerns an interesting effect that he and I observed soon after the war.

For general use in our "lab" at home he built a capacitor bridge of the simplest type which we calibrated by the simple method of measuring every marked capacitor we could find and plotting the results on a "standard" graph! A pair of ancient (*circa* 1930) headphones—probably S. G. Brown's Type F if I remember—were used for detecting the balance and we found that adjustment was very easy and reproducible.

After several months one of us mentioned that he was balancing not for the minimum sound but for the residual sound *coming from directly in front!* On saying this the other said yes, that was what he did too, but nothing had been said as it seemed so silly! As one turned through balance the sound went quite distinctly from one side to the other as it went through the minimum. Such an arrangement could, of course, have been designed using separately connected earpieces, but we obtained it with the standard series arrangement on a single circuit.

As you will have guessed the drive was a primitive transformer-coupled arrangement which we thought was oscillating at about 1 kc/s. When we got an oscilloscope, in due course, we found that actually it was blocking hard and making an output of virtually a single spike about $\frac{1}{2}$ msec wide at a repetition rate of perhaps 100 c/s or even less! The bridge was, of course, not frequency-sensitive so that the signal at the 'phones would pass through zero if the balance were perfect and would in any case go through a "symmetrical" (by any definition) state close to balance.

I have always assumed that the simple "moving Stalloy" earphones were providing the non-linearity and that the one with the diaphragm moving in (they must in any case have been connected in opposite phases) could be expected to make a louder sound, which is all that is said to be needed to give a sense of direction at low frequencies. However, I found it hard to credit that even such earphones could be appreciably non-linear at a signal level at least one, if not two, orders of magnitude lower than that which they could still handle without serious overloading. The out-of-phase signal at balance wasn't very large and the "effect" was quite usable at fairly low drive levels.

Now the letter from Messrs. Wooller *et al.* suggests that perhaps the required sense of direction is obtained within the ear itself. Is it possible that if a "push" pulse of this type is sent to one ear and an *exactly equal* "pull" arrives simultaneously at the other ear then the brain receives an impression that an event occurred at one side (clearly there is evidence that the sound cannot have come from in front!) and from experience the brain may assume that it came from the "push" side when there is no time delay evidence to go by?

This is not precisely the "Wooller Effect," but his observation suggests that the ear has this property of distinguishing the polarity of an unsymmetrical waveform. He also implies that the effect is not due simply to non-linearity, since if it were it would only be appreciable for very loud sounds, and he doesn't mention any such requirement. It may then be due to an ability for the brain to make phase comparisons, independently of the amplitude, between the various Fourier components of a single incoming waveform. If this ability does in fact exist, and remember phase comparisons between one ear and the other appear to be essential to the sense of direction at high frequencies, then it is but a short step for it also to be developed for use as a direction finding technique, since a great many practical sounds have the property of asymmetry whereas very few are symmetrical.

There would seem to be a wide field for experiment here. What does a wild animal do if you play a recording of its natural foe reversed? Does it just not show alarm, or is it confused in direction, or does it act normally? I can see Messrs. Wooller *et al*, causing confusion not only in the world of recorded music but also, for instance, amongst the bird-song enthusiasts!

Finally, Mr. Wooller's implication that "polarity" should be standardized would be difficult to adopt in a recording studio unless pressure sensitive microphones (rather than velocity) could be developed. Pressure loudspeakers would then be wanted.

Cheadle. K. C. JOHNSON

IF THE preservation of correct sign in the reproduced sound does prove to be an important factor in preserving realism, then the effects on microphone technique will be far-reaching and may even rule out completely the ribbon microphone—or others having a similar pick-up pattern—for use in high-quality sound systems.

It is fairly well known that using two or more microphones mixed together to provide correct balance can result in very strange frequency responses and composite polar diagram if sound from one source is allowed to reach both transducers. This is, of course, when the microphones are out of phase with one another. And there are two ways of correcting this situation, one electrical—by reversing the connections of one transducer, and the other acoustic—by turning one microphone through 180°.

Now I have noticed, when listening to pairs of male voices I know well, one placed on either side of a ribbon microphone, that one sometimes sounds more realistic than the other, even over rudimentary reproducing apparatus. This has been dismissed in the past as imagination—but I have recently made some recordings of three such voices, spaced round a diaphragm-type cardioid transducer placed vertically so that pick-up was circular in plan. And the effect was not present in this one instance. Some male speech is, of course, markedly asymmetrical, and one would expect the effect to show up most with two speakers of this type.

So far, so good. So we must paint one side of our ribbon microphones black, and avoid using it. But the problem is even worse than that. Consider the making of a recording under reverberant conditions—in a concert hall, or even worse, a church—reverberation reaching the back of the microphone will be "out of phase" (and now we need a more precise term—out of absolute phase) so we can't use ribbon microphones at all. Omnidirectional types, and some cardioids should be all right, yes, but ribbons, no!

Does this explain some of the microphone lore—that some engineers prefer ribbons for music recording, for instance, compared with even the superlative quality modern diaphragm types? Some people, after all, prefer too much bass boost. The point is that a difference is noticed. Some of us have noticed that some music recordings, although unimpeachable from the point of view what has, in the past, been regarded as distortion, just sound "strange" whatever is done to them. I think most people would try to avoid mixing between ribbon and diaphragm microphones under reverberant conditions. Does absolute phase explain why it is so often possible to make a much better recording with one omnidirectional microphone, given patience and scope in positioning, than with multi-microphone techniques?

There's one further point. I suffered a large hearing loss in my right ear some years ago—about 40dB, in fact. Yet I can still tell the difference between stereo and mono, particularly by flicking the loudspeaker phasing switch. This works with some stereo signals only—and to phase loudspeakers correctly for someone else to listen I usually fall back on one of my own mono recordings—made with one diaphragm-type cardioid microphone. Again, could absolute phase be the answer to this? I know I'm not alone in this facility, because soon after the loss occurred I spoke to John Gilbert of the Northern Polytechnic—and he asked me whether I could still tell stereo from mono, as he'd come across someone else who could. But I've yet to meet the binaural man who can tell stereo from mono with one channel at −40dB—that is, 0.1% directional distortion to a mono source. Isn't it about time we found out, Mr. Editor? Let's have some proposals for research.*

RICHARD OLIVER

Surbiton, Surrey.

* By all means. Why not repeat the monaural listening experiment with a stereo system having as low a distortion as the mono system?—Ed.

Transistor U.H.F. Oscillator

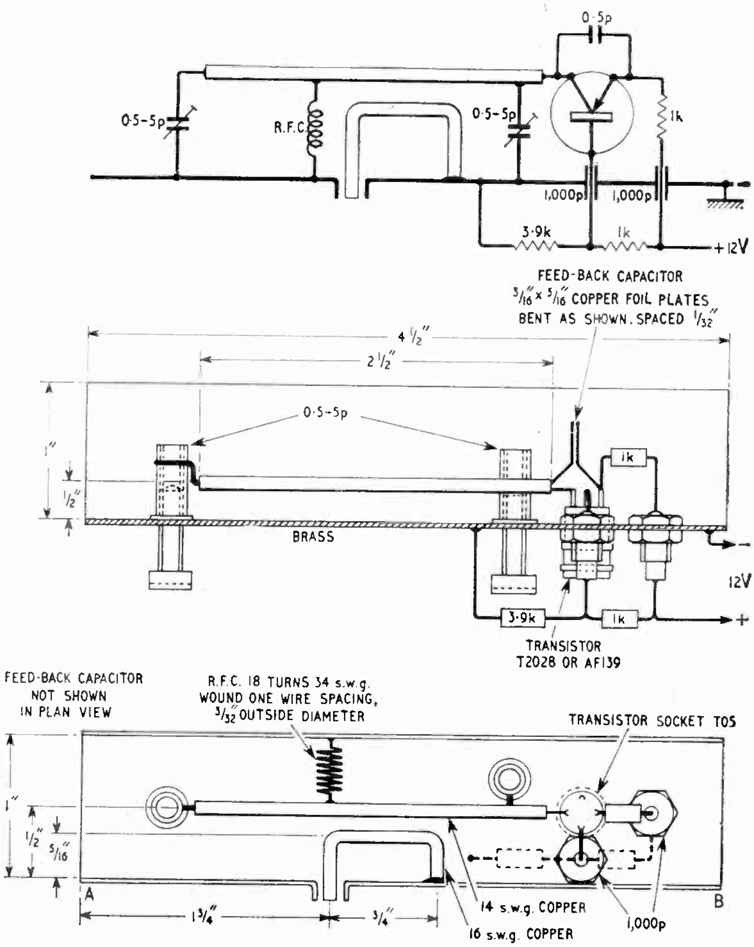
MY co-author and I feel that your readers may be interested to know of a transistorized version of the u.h.f. test oscillator which was the subject of our previous article in the June edition.

The recent availability of germanium u.h.f. transistors, such as the T2028 and the AF 139 at a reasonable price, make the idea of a compact battery-operated u.h.f. signal source very attractive, and we felt that the design of such an oscillator could be simplified so as to be well within the construction ability of the amateur.

The resonant circuit we have used is a half-wavelength trough line which in this case takes the form of a copper conductor of half-wavelenth electrical length situated close to the base of a rectangular brass trough. The line is best thought of as two quarter-wavelength lines in series with a node at the middle. The line is made physically much shorter than a half-wavelength so that there is an inductive reactance at each open end. A piston capacitor at each end of the line tunes these inductive reactances to resonate the line at the required frequency.

The half-wavelength line was chosen in preference to a quarter-wave one for two reasons. First, the variable tuning capacitor can be of reasonably large value and placed at the far end of the line from the transistor; secondly, the preset capacitor at the transistor end is in parallel with the collector-base capacitance. Changing the transistor will have a minimal effect on frequency for the above reason.

As can be seen from the figure, the oscillator is housed in a rectangular brass box only $4\frac{1}{2}$ in $\times$ 1 in $\times$ 1 in, closed at the farthest side from the line by a simple lid which



need not be an accurate fit. Indeed, since the line is well below the centre-line of the trough, the lid has little effect on the operation or the frequency of the oscillator.

Operation with the collector earthed to d.c. is desirable at these frequencies, and this is accomplished by a r.f. choke within the trough. The r.f. choke is soldered to the resonant line at approximately the nodal point and connects it to the adjacent wall of the trough. The supplies to emitter and base are brought in by feed-through capacitors, and the transistor is mounted in a p.t.f.e. base so that the pins are on the inside of the trough and positioned as indicated.

Feedback is introduced mainly through the internal capacitances of the transistor, the oscillator being of the Colpitts type. The extra capacitance between the collector and emitter, formed from two small copper foil plates in close proximity to each other, ensures strong oscillation. The plate spacing is, in practice, varied for optimum results.

The piston capacitor at the transistor end of the line is set to about 2 pF, the main tuning being achieved with the capacitor at the far end.

Output coupling is from a magnetically coupled loop and, in the position shown, gives an output impedance of about 70 ohms.

Audio modulation of the oscillator is quite straightforward and can take the form of a multivibrator, the output of which is coupled to the junction of the 3.9 kΩ and 1 kΩ resistors in the bias network.

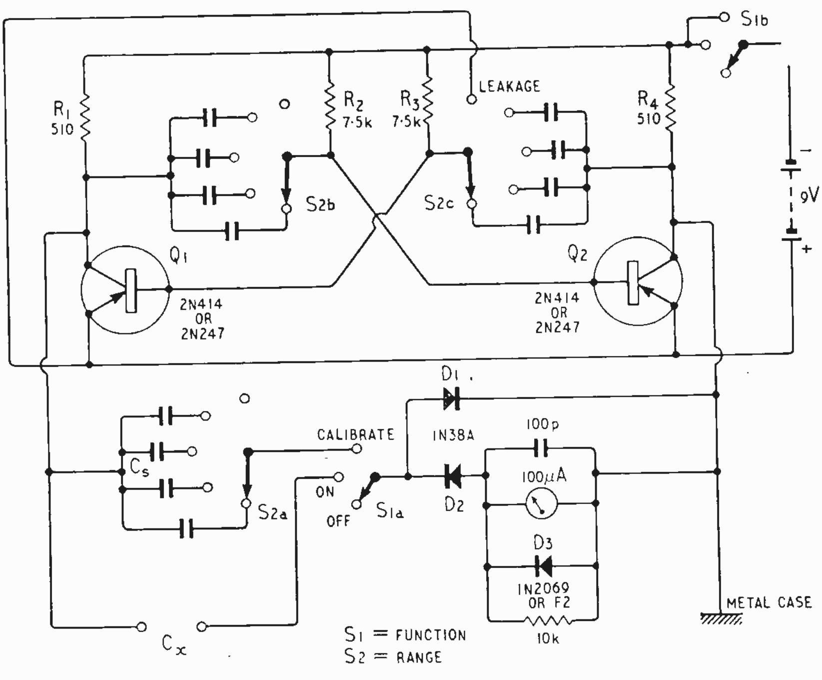
The oscillator will tune from about 500 Mc/s to 700 Mc/s with an output sufficient for most purposes.

Teddington. R. H. BRADSELL
M. GRIMSHAW

"Direct-reading Capacitance Meter"

CONGRATULATIONS to Mr. D. F. Bailey on an excellent article in the April 1964 issue of *Wireless World.*

Mr. Bailey and your readers may be interested to learn of a somewhat similar design which appeared in the American Amateur Radio magazine "73" [1]. The basic circuit of this design is shown in Figure 1. The reference voltage is provided by the battery; when Q1 is conducting and Q2 is cut off, C_x is charged to practically the full battery voltage through D1; on the next half cycle C_x discharges through D2 and the meter. The purpose of the silicon diode is to protect the meter from damage due to shorted capacitors; being biased in its forward conduction direction it limits the battery voltage across the meter to about half a volt. The 100pF capacitor across the meter eliminates spikes due to capacitor charge when the diode conducts prematurely and provides additional meter damping. Four decade ranges are provided by this instrument with maximum indications at 100p, 1n, 10n and 0.1μF respectively. The design has the additional advantage of a position for leakage test which can be understood by reference to the circuit below; on turning the range switch to "Leakage" Q1 is cut off by shorting the base to ground, while Q2 heavily conducts, causing practically the full battery voltage to appear across the capacitor under test via the meter.



Basic circuit of capacitance meter described by R. A. McCarthy.

I have not built an instrument to Mr. McCarthy's design, so I am not able to comment on its effectiveness. However, the lucidity of Mr. Bailey's article made me attempt a slightly more ambitious instrument to his design. This has seven ranges with full-scale deflection of the meter indicating 100p, 300p, 1n, 3n, 10n, 30n, and 0.1μF respectively. Using a meter having fifty divisions, calibrated 0-50 enables multipliers to be used in the series ×2, ×6, ×20 etc. I used Mazda XA152 switching transistors which have a published h_{FE} of 100, and f_1 of 5.5 Mc/s, with V_{CE} of -2V and I_c of -10 mA. The only slight drawback I have encountered is that the oscillator will not start from scratch on the lowest capacitance range where the switching frequency is of the order of 125 kc/s; it is necessary to switch on with the instrument oscillating on the next range and then operate the range switch.

Leaky capacitors will give misleading results and may damage the diode D1 in Mr. Bailey's article. It should be simple to incorporate a leakage test with an extra wafer on the range switch and an additional switching position, utilizing a limiting resistance to prevent excess current through the meter. However, such an arrangement would increase the stray capacitances. It would be useful to have provision for a leakage test in the instrument but I am somewhat doubtful about incorporating Mr. McCarthy's idea owing to the utilization of non-linear meter shunting which leaves me with the uneasy feeling that the capacitance indication may be adversely affected by some non-linearity. I have checked my instrument on the three lowest capacitance ranges both against a standard variable capacitor and silver mica capacitors of 1% tolerance and find that the linearity is excellent: the next two ranges have also been checked against 1% silver mica capacitors with a similar showing. In my instrument stray capacitance across the C_x terminals amount to 3p which increases to 4.5pF when I use a plug and crocodile-clip arrangement on the terminals to facilitate rapid measurement.

After one month's use of the Capacitance Meter I am left wondering how I have managed for the last 20 years without it!

Hong Kong. R. H. MUNRO

[1] "Direct-reading Capacity Meter." Roy A. McCarthy. "73" Vol. 1, No. 1 (October 1960).

Photographic Analogue?

MOST readers are doubtless fully familiar with the approximate equation which indicates that

$$f_{max} = \frac{1}{2 \times \text{rise time.}}$$

I find, quite empirically, that if you regard rise time as rise distance in a photographic image, that the equation is true, in that it relates the frequency, or number of lines per millimetre, to the rise distance in which the image density rises from 10% to 90% or full value, in the image itself. As an example, if one wishes an image to rise from zero to full density (about 3.0 log scale) in 40-micro inches (1 micron) then by simple calculation, the lens and emulsion must be capable of resolving 500 lines per millimetre, or 12,500 lines per inch.

I wonder if any of your readers have come across this equivalence, or heard it mentioned in connection with micro printed circuits?

Bolton, Lancs. P. C. SMETHURST
Smethurst High-Light Ltd.

COMMERCIAL LITERATURE

"**1964 Electron Tube Handbook**".—A number of new types of Brown-Boveri tubes are included in this new edition of the handbook; previous edition published in 1961. Eleven chapters are presented in English, French and German. The first chapter sets out, next to an index which appears in a new form, the symbols used. Two hundred and twenty pages are devoted to the next chapter, "Definitions and Useful Information," which provides application data on the choice and operation of transmitting and rectifier tubes and thyratrons. Chapter III tabulates formulae, tables and wiring diagrams. The next seven sections present detailed information on their rectifier and transmitting tubes and thyratrons. A detailed table of tube equivalents is also included in this 800-page publication, which is obtainable from British Brown-Boveri Ltd., Glen House, Stag Place, London, S.W.1.
11WW 329 for further details

A touring map of west Germany and Berlin showing the main roads and *autobahnen* and the frequency, wavelength or channel number of v.h.f. and medium-wave ARD broadcast transmissions available in each locality has been issued by the receiver manufacturers, **Graetz**, 753 Pforzheim, Germany.
11WW 330 for further details

Five new B.I.C.C. leaflets on **radio frequency cables** are available from British Insulated Callender's Cables Ltd., 21 Bloomsbury Street, London, W.C.1. Leaflet M942A deals with miniature coaxial cables, M943A with circular and flat twin cables for use in the lower frequency ranges, M944A delay cables with nominal velocity ratio delays from 1.7 to 8.5μs/100ft, M945A high attenuation cables with nominal attenuation ratios from 0.69-2.9dB/100ft at 1 Mc/s to 23.4-48.3dB/100ft at 1 Gc/s, and M946A deals with 50 and 75Ω anti-microphonic cables.
11WW 331 for further details

Driver and controller units for silicon controlled rectifier applications, including current limiting units and supply transformers, are described in the Westinghouse technical data sheet TD63. Copies of this 20-page publication are obtainable from the Westinghouse Brake and Signal Company, 82 York Way, King's Cross, London, N.1.
11WW 332 for further details

"**Points on Pick-Ups**".—The fifth edition of the pick-up head, cartridge and styli replacement guide, entitled "Points on Pick-Ups," is now available, price 7s 6d, from A. C. Farnell Ltd., Hereford House, North Court, Vicar Lane, Leeds, 2. In the introduction of this 125-page edition, the author states that he "has endeavoured to cover all cartridges of British manufacture and almost all foreign types which have been encountered in this country to date."

A 12-page booklet describing the Type T948 **instrument cathode ray tube** is available from the English Electric Valve Company, Chelmsford, Essex. A full electrical specification is given for the T948H (blue-green fluorescent and afterglow colour) and for the T948N (yellowish-green). Both of these tubes are of 5 in diameter and designed for use in wide-band, high-speed oscilloscopes.
11WW 333 for further details

Copies of the Marconi quarterly technical house journal entitled "**Marconi Instrumentation**" are obtainable on application to Marconi Instruments Ltd., Longacres, St. Albans, Herts. Six articles appear in the June, 1964, issue, under the headings: "Time and Frequency," "Counter Type TF 2401," "An Introduction to Counter Logic," "Voltmeter Zero—Its Significance," "Tunable Rejection Filter Type TF 2334" and "The Evaluation and Testing of Ferrites."
11WW 334 for further details

Newmarket Transistors Ltd. has produced an easy reference guide for its range of transistors. In tabular presentation, it lists the current range of Newmarket devices and "provides users with all the information they would normally require to select units for a given project." Copies of this "ABC" are obtainable from the company's headquarters, Exning Road, Newmarket, Suffolk.
11WW 335 for further details

"**RF Voltmeter Applications Brochure**" is the title of a 16-page publication produced by the Boonton Electronics Corporation, of America. It gives information on high frequency transistor testing, v.s.w.r. measurements, r.f. bridge techniques in the measurement of signal gain and loss, and the use of peak and null detectors in harmonic distortion studies. Copies are available from the U.K. representatives, Livingston Laboratories Ltd., 31 Camden Road, London, N.W.1.
11WW 336 for further details

An application report on the 4X150/250 series of forced air-cooled **u.h.f. power tetrodes** has been forwarded to us from the valve division of Standard Telephones and Cables Ltd., Brixham Road, Paignton, Devon. More than half of the 60-page publication is devoted to practical aspects of u.h.f. transmitter circuits.
11WW 337 for further details

A comprehensive selection of **knobs and dials** for electronic and instrument applications are included in a brochure sent to us by Stockli, 18 rue Galilee, Montreuil, Seine, France. The 16-page brochure, which is available in English, French and German, also includes details of their reduction drive assemblies, dial locks and shaft couplings.
11WW 338 for further details

Elements of Transistor Pulse Circuits

7.—"PUMPS" AND "SCHMITTS"

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

TWO of the lesser-known but widely-used pulse circuits are the diode pump and the Schmitt trigger. The diode (or transistor) pump basically produces a " staircase " output from a pulse train input. The Schmitt trigger is a bistable whose state depends on the d.c. level at the input. Although both are common pulse-circuit elements, it is difficult to find easily-accessible simple descriptions of their design such as are given in this article.

Diode Pump

The diode pump basic circuit is shown in Fig. 67. There are two arrangements, (a) and (b), with different diode phasings. The circuit operation can be simply described as follows. Let us suppose that a string of positive pulses of amplitude V_{in} is applied to the circuit in Fig. 67(a). The first input pulse will cause the capacitor C_2 to charge up through C_1 and diode D2 with a time constant equal to the product of $(C_1 + C_2)$ times the sum of the generator and diode resistances. If this time constant is small compared with the pulse duration, then C_1 and C_2 will charge up fully to V_{in} across the two before the pulse end. By capacitor divider action, this gives an output $C_1V_{in}/(C_1+C_2)$ across C_2 at the end of the pulse. C_1 is usually small compared with C_2, so that the voltage change across C_2 on a pulse is small compared with V_{in}. During the pulse, D1 has been cut-off, but at the end of it, the input falls to zero, and D1 now conducts to discharge C_1. The output is unaffected during this discharge because the polarities are such that D2 is cut off. The next input pulse restores V_{in} across C_1 and C_2 in series, and repeats the small incremental charging up of C_2 as before. We thus get a series of steps to give an output " staircase " voltage waveform.

The same sort of analysis can be applied to negative input pulses, and also, as shown in Fig. 67(b) to diodes phased the other way round. The outcome of a positive pulse train will always be a positive-going staircase and *vice-versa*. Depending on how the diodes are phased, the output steps may coincide with the beginning or end of the input pulses. Notice that the diodes always point in the same direction . . . either both towards the output or both away from it.

Ideally, we would like to have the staircase voltage change by equal steps on each input pulse as shown in Fig. 67(c). However, in the simple diode pump shown, each successive input pulse is applying V_{in} across C_1 and C_2 with the voltage across C_2 rising on each step. As a result, each successive pulse causes a progressively smaller voltage rise across C_2 and we get a drooping non-linear staircase as in Fig. 67(d). It can be shown that for a train of pulses of amplitude V_{in} applied to the basic diode pump with C_2 initially discharged, the nth output voltage step is given by

$$dV_n = V_{in}/(1\text{-}x)x^n$$

where $x = C_2/(C_1 + C_2)$. As an example, if we take $C_1 = C_2/9$, then $x = 9/10$, and, expressed as a percentage of the input pulse amplitude V_{in}, the staircase steps rise 9%, 8.1%, 7.3%, 6.6%, 5.9%, 5.3%, 4.8% . . . By the seventh pulse, the step rise has almost halved. From this analysis, it is clear that to keep the staircase reasonably linear, C_1 should be as small as possible compared with C_2. Unfortunately, the smaller we make C_1, the smaller are the output voltage steps.

For satisfactory staircase generation, fairly stringent requirements are placed on the input pulses. They should be constant in amplitude, as otherwise the output steps (which are proportional to the input pulse amplitude) will be of irregular height. They should be of large amplitude so that the output steps are not inconveniently small. They should be fairly regular, so that discharge of capacitors between pulses due to diode leakage does not introduce irregularities in the output. They should be supplied from a low impedance source and should be reasonably rectangular. One of the simplest methods of achieving all this is to feed the diode pump from a multivibrator through a buffer emitter follower.

The diodes have been assumed perfect in the

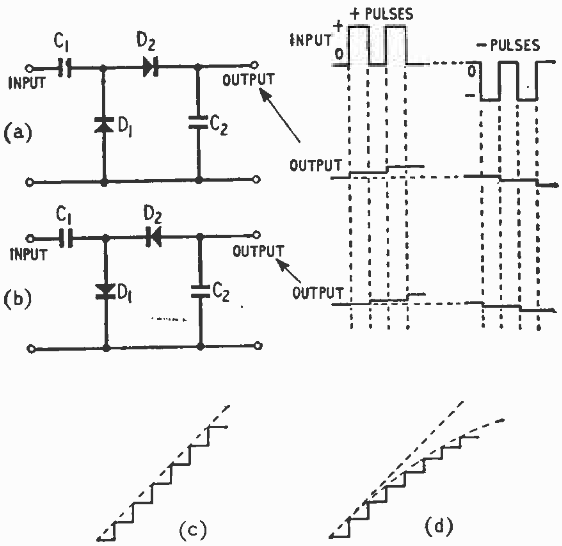


Fig. 67. Diode-pump circuit and associated waveforms. (a) positively phased diodes (b) negatively phased diodes (c) Linear staircase output (d) non-linear staircase output.

*Newmarket Transistors Ltd.

above analysis, i.e. with zero forward voltage drop, infinite reverse resistance and zero switching times. In practice, for not too high-speed operation, conventional good-quality point-contact, gold-bonded or small junction diodes are satisfactory. In the case of precision requirements, high-speed, low-leakage silicon diodes may be necessary.

The capacitors should be low-leakage types, e.g. paper or mica, and their values depend on the pulse repetition rate. Usually the upper capacitor C_1 is chosen not greater than 1/20th of C_2, and the value of C_2 can be selected initially approximately as T/20R where T = pulse length and R = pulse generator source resistance.

In the discussion above, no load resistance is shown on the pump output, but in practice there must be some impedance across the output, even if it is only the megohms and picofarads of an oscilloscope input. It is desirable to keep the input impedance of the stage following a diode pump as high as possible, and an emitter-follower buffer is often used for this purpose.

Apart from the various restrictions noted on the character of the input pulses, the limitations of the output load, etc., the diode pump has one basic drawback. The staircase envelope is non-linear, and the steps at the top of the " flight " are so shallow that it may become difficult to distinguish between them.

Transistor Pump

A variant of the diode pump that does give an intrinsically linear staircase is the " transistor pump " shown in Fig. 68. In this, the diode across the input is replaced with the base-emitter diode of a transistor and the pump output voltage is fed back direct to the transistor base. The operation of the circuit is basically similar to that of the diode circuit, except that, when the transistor Q1 conducts, it clamps the right hand side of capacitor C_1 to the output voltage at the top end of C_2 and not to earth. This means that each input pulse is added on top of the existing output voltage and the voltage steps

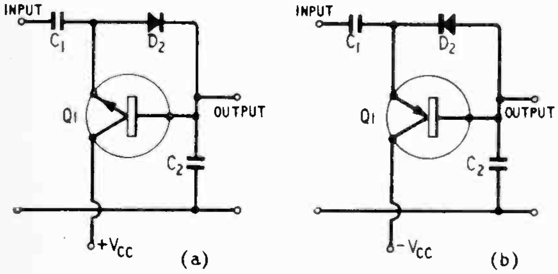


Fig. 68. Transistor pump circuit. (a) positively phased diode (b) negatively phased diode.

there will be all equal (at $V_{in}C_1/(C_1+C_2)$). We thus get a linear staircase. This is just one further example of using bootstrapping to linearise a waveform. Two versions of the transistor pump are shown: Fig. 68(a) with a positively-phased diode (and n-p-n transistor) and Fig. 68(b) with negatively-phased diode (and p-n-p transistor). In each case the supply voltage, V_{cc}, of the transistor must be materially greater than V_{in}, so that it can always operate as an amplifier.

Miller Integrator Pump

It is also possible, as shown in Fig. 69, to linearise the pump staircase output by using a Miller integrator circuit. In this, the output of the simple diode pump of Fig. 67 is fed to a high-gain phase-inverting amplifier, with the bottom end of the output capacitor, C_2, connected to the inverter output,

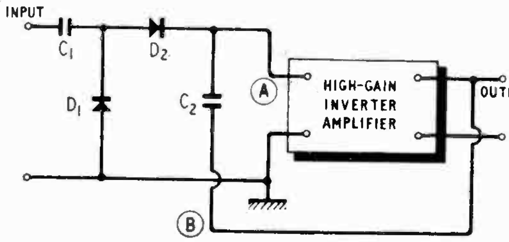


Fig. 69. Miller integrator linearised diode pump.

instead of to earth. The voltage at point " A " remains effectively zero because any change there is phase inverted in the amplifier and applied in opposite sign at point " B ", the other end of C_2. When a pulse of amplitude V_{in} is applied to the pump input, it can be shown that C_2 will receive a voltage increment, C_1V_{in}/C_2, which is independent of its previous state of charge. This means a linear staircase, of course, at the output.

Applications

The commonest application of the diode pump is to count. If to the output of the basic circuit we add a voltage comparator circuit which discharges the output capacitor C_2 whenever the staircase voltage reaches a certain level, we have a " storage " or " scoop " counter. (It is under one of these two titles that the diode pump is often indexed in text-books.) The levels can be set so that after, say, five input pulses, the comparator " fires " and thus resets the pump to zero. We then have a simple " divide by five " circuit with the output pulse for every five input ones. The storage counter becomes a little uncertain if it is asked to divide by more than about ten at the most, but provided the pulses are fairly regular and of constant amplitude, this storage counter is an economical substitute for a bistable multivibrator counter.

The diode pump can also be used effectively as a simple staircase voltage generator, for such applications as switching the transistor base current in a series of steps in a curve tracer to display a family of characteristic curves on an oscilloscope.

A frequency meter can also be made up with a diode pump. If we shunt the output capacitor, C_2, in the pump with a resistor, R, it can be shown that for a train of pulses of repetition frequency, f, and amplitude, V_{in}, the average output voltage will settle down to fRC_1V_{in}, provided R is much less than $1/(fC_1)$ and C_2 is much greater than C_1. Now, if R, C_1 and V_{in} are kept constant, the average output voltage is proportional to the frequency. A high-impedance voltmeter (e.g. valve voltmeter) across the output can thus be calibrated directly in repetition frequency. This type of frequency-voltage converter has been widely used in frequency modulation radar systems and nuclear radiation measurements.

The diode pump can also be set up as a capacitance meter. If the above frequency meter is operated at a fixed frequency, the average output voltage, fRV_{in}. C_1 will be proportional to C_1. This forms the basis of a direct-reading capacitance meter, where the capacitance to be measured is inserted as C_1.

Schmitt Trigger

The other type of widely used basic pulse circuit to be described is the "Schmitt Trigger." Under the innocuous title "A Thermionic Trigger," Otto H. Schmitt gave, in the Journal of Scientific Instruments, 1938, Vol. XV, p. 24, the first account of an interesting bistable valve circuit he had developed. Basically it was a cathode-coupled bistable multivibrator, whose state depended only on the d.c. level at the input terminal. This proved a most useful circuit and came into common use with valves before it was adapted to transistors during the 1950's. In the transistor version, the Schmitt trigger is often given the name "emitter-coupled binary" in textbooks, but most working engineers call is just a "Schmitt."

The transistor Schmitt circuit arrangement is shown in Fig. 70 (with n-p-n transistors so that positive voltages read conveniently upwards in the diagram). The resistor values are so chosen that normally when no voltage is applied at the input, transistor Q1 is cut off, and Q2 is conducting. If a voltage more positive than V_U (the "upper trip voltage") is applied to the input, Q1 is driven on and Q2 switches rapidly off. So long as the input is held above V_U, Q1 remains on and Q2 off. If now the input voltage is allowed to fall below V_L (the "lower trip voltage"), Q1 switches off again and Q2 comes on. Thus Q2 is on or off depending on whether the input voltage is low or high. The circuit exhibits "backlash" or hysteresis in that the upper trip point V_U is above the lower trip point V_L and the circuit switches on at a higher input voltage than it switches off. The circuit is actually a regenerative bistable whose state depends on the amplitude of the voltage at the input. It belongs to the bistable multivibrator family, but the familiar "X" of cross-coupling resistors does not appear, because, although one collector is cross-coupled to the opposite base through R_5, the other cross-coupling is by means of the common-emitter resistor R_2. Hence arises the alternative name "emitter-coupled bistable."

A full design taking into account backlash control, high temperature operation and switching speed is too complex for the scope of this article. However, a "first order" design can be given which shows how the circuit operates and can be used to produce practical approximate results for not too high speeds or temperatures, or too small backlash limits. Usually the designer wants to switch a peak-to-peak voltage, V_0, in an output load resistance (R_1 in Figure 70) with specified input trip voltages, V_U (upper) and V_L (lower), giving an input backlash, V_U-V_L. When Q2 is on, it must pass a current $I_0 = V_0/R_1$. This passes through the common-emitter resistor R_2 and gives a voltage V_0R_2/R_1 at the common emitters. Q1 is cut off and contributes no current to R_2. If the input voltage on the base of Q1 is taken steadily positive from zero, the circuit will begin to switch over when Q1 base voltage passes V_U. Neglecting base-emitter voltage drops (which are relatively small), this gives $V_U = V_0R_2/R_1$, and thus fixes the common emitter resistor value $R_2 = R_1V_U/V_0$. We can now select the rail voltage, V_{cc}, to be the next standard battery voltage greater than $V_U + V_0$. To make the circuit insensitive to spreads of current gain in Q2, we make the bleeder current down R_3, R_5, R_4 ten times the maximum base current to be met with in Q2. This maximum base current will be $V_0/(R_1h_{FEmin})$, where h_{FEmin} is the minimum d.c. current gain anticipated in Q2 at current V_0/R_1. Since Q2 is on, the voltage at its base will be approximately equal to its emitter voltage (which we have already shown to be V_U). Thus $V_U = 10\ R_4V_0/(R_1h_{FEmin})$, from which $R_4 = h_{FEmin}R_1V_U/(10V_0)$.

If we now assume that the voltage across the input has been increased just above V_U, the circuit will have switched to the state where Q1 is on and Q2 off. The current through Q1 is approximately V_U/R_2. The collector load resistor, R_3, of Q1 could now be computed by setting out the various Kirchhoff equations for the circuit, but as a simplifying assumption (which agrees with many practical circuits) we assume instead that $R_3 = R_1$, i.e. make the two collector resistors equal. If we now reduce the input

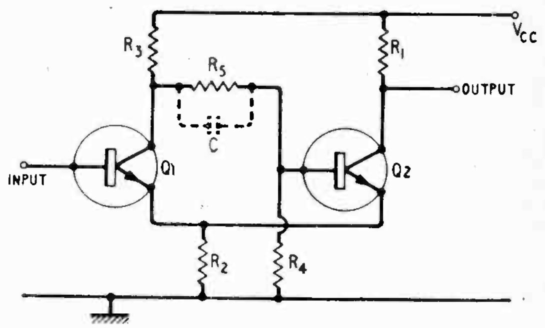


Fig. 70. Schmitt trigger basic circuit.

voltage below V_U the circuit will eventually be on the verge of switching over to Q1 off and Q2 on, when Q1 base input voltage has fallen to V_L. The emitter of Q1 will be approximately at the same voltage, V_L. As Q2 is beginning to switch on, its base voltage also is approximately equal to V_L. This means that the current down R_4 is approximately V_L/R_4, and this is supplied down the chain R_3, R_5. Through R_3 also flows the collector current of Q1, which we saw is approximately V_L/R_2. Thus the voltage at the collector of Q1 must be $V_{cc} - R_3(V_L/R_4 + V_L/R_2)$. The voltage at Q2 base being V_L, we find by proportional division across R_4, R_4 that R_5 must be given by

$$R_5 = (V_{cc}/V_L - 1 - R_3/R_4 - R_3/R_2)\ R_4.$$

We have thus arrived at first order formulae for all the resistance values in the basic Schmitt Trigger of Fig. 70.

To put illustrative values to this design, assume that $V_0 = 6V$, $I_0 = 6mA$, $V_U = 4V$, $V_L = 2V$, $h_{FEmin} = 50$. This leads to $R_1 = 1k\Omega$, $R_2 = 680$ ohms, $R_3 = 1k\Omega$, $V_{cc} = 12V$ (allowing 2V above

$V_0 + V_U$), $R_4 = 3.3\text{k}\Omega$, $R_5 = 12\text{k}\Omega$, and Q1 = Q2 = NKT129 (with minimum h_{FE} at 6mA of 50).

It must be emphasized that the design outline method given is largely empirical. A full theoretical design is, of course, possible, but very complex, and usually a little unprofitable, because transistor parameters have such wide spreads in practice. The simplified design given can be used to get first approximate results, and final adjustments to meet the exact design requirements can be made by cut-and-try methods. Those interested in a rigorous detailed design should consult page 6-55 of "Selected Semiconductor Circuits Handbook," by S. Schwarz, Wiley and Sons, 1960, or page 334 of "Transistor Logic Circuits," by R. B. Hurley, Wiley and Sons, 1961.

So far we have not mentioned the capacitor C, shown dotted in Fig. 70. This is the "commutating" capacitor used to speed up the circuit switchover, where the pulse repetition rate is high and fast switch over is essential. This capacitor should, with its shunt resistance, provide a time constant shorter than that of the transistor input impedance. Values in the range of 100-500pF are common. A theoretical design value can be worked out, but common practice is to select a suitable value by trial, making it as large as possible consistent with reliable triggering at the maximum pulse repetition rate aimed at. For slow repetition rates, up to several kc/s, the speed-up capacitor can usually be omitted.

The Schmitt trigger is a most attractive circuit to the designer in that its trigger sensitivity and stability can be very high. The input impedance tends to be high because of the undecoupled emitter resistor. The skeleton design given earlier did not take into account switching rates, but reliable switching repetition is easily achieved up to 100kc/s with a.f. alloy transistors, to 1Mc/s with r.f. alloy types and to 10Mc/s with diffused-alloy types.

Refinements.—A number of refinements can be added to the basic circuit of Fig. 70. Firstly the amount of backlash in the circuit can be controlled by a resistor R in series with the emitter of Q2 as shown in Fig. 71(a). By making R variable, the backlash can be made adjustable. R should be selected initially at about one-tenth of the common emitter resistor value and then adjusted by trial and error. Practical circuits also often include an input series resistor (R′ in Fig. 71(a)) to prevent over-driving of Q1. A suitable rule of thumb is to start with this equal to the collector resistor and adjust by trial and error.

Another variant of the basic circuit often met with is shown in Fig. 71(b). Here the base of Q1 is connected to the slider of a variable resistor RV connected with a limiting resistor R across the d.c. supply rail. This arrangement enables the quiescent voltage on the base of Q1 to be preset so that the supplied input voltage necessary to trigger the Schmitt can be set at any convenient d.c. level. RV can conveniently be selected at about ten to one hundred times the common emitter resistor value R_e, and the limiting resistor R can be chosen as about one-tenth of RV.

Up till now we have dealt with d.c. operation of the Schmitt but the input trigger pulse can be a.c.-coupled *via* a capacitor, C, shown dotted in Fig. 71(b). The output may also be a.c.-coupled by a transformer as also shown in Fig. 71(b), and this

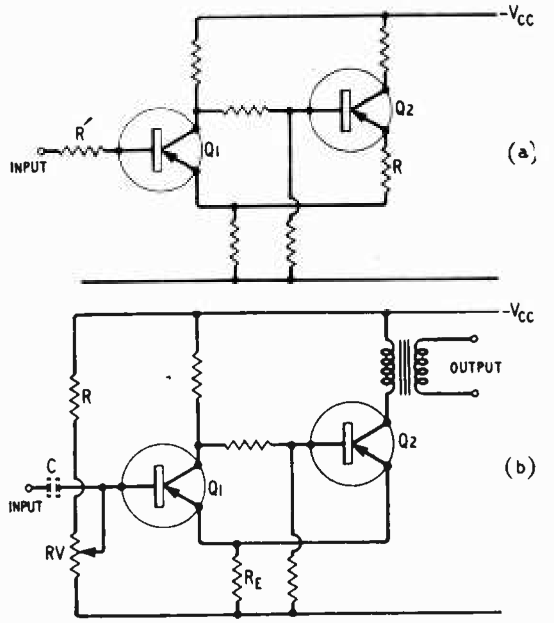


Fig. 71. Variants of basic Schmitt trigger. (a) backlash control by Q2 emitter resistor. (b) trigger d.c. level set by RV, capacitive input, and transformer coupled output.

gives an output pulse rather than a step voltage for an input step.

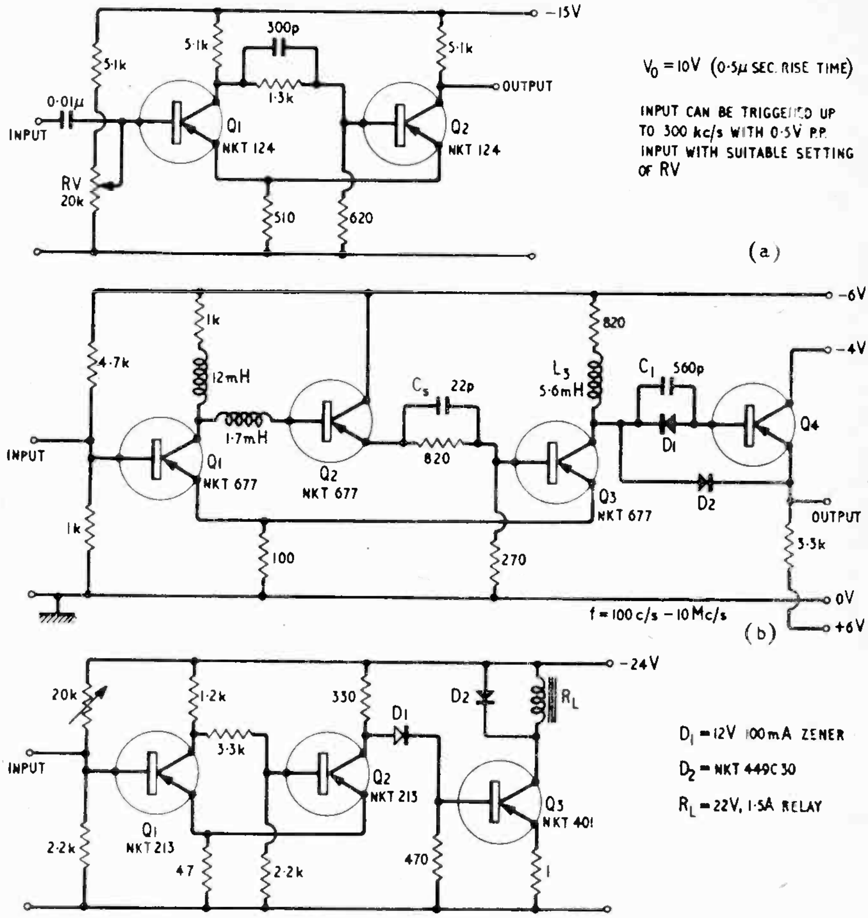
Practical Schmitt Triggers.—Three typical practical examples of Schmitt triggers are given in Fig. 72. In these it will be noted that the various component values do not agree exactly with the simplified design given earlier, but they will be found to be of the same order of magnitude, and the Schmitt is a delightful circuit in that many of its values are non-critical.

Fig. 72(a) shows a conventional circuit to give 10V output with a d.c. trigger level adjustment that enables the circuit to be driven by a 0.5V p.-p. input up to 300kc/s.

Fig. 72(b) shows a more sophisticated modification of the basic circuit to achieve operation from 100c/s to 10Mc/s. Note the peaking coils L_1, L_2, L_3 inserted to enhance the high-frequency response. The emitter follower Q2 is used so that the speed-up capacitor, C_3, may be large without unduly increasing its circuit time constant. The output is taken from the collector of Q3 through the diode-capacitor filter, D1, C_1, to the base of the final emitter follower, Q4, which provides a low output impedance. D2 is a silicon diode used to protect the base-emitter diode of Q4 (which in a diffusion transistor of the type specified has a low voltage rating).

Finally, in Fig. 72(c) we have a Schmitt trigger used to drive a 22V, 1.5A power relay. In this circuit, as only slow repetition rates are possible due to the speed limitation of the output alloy power transistor, the speed-up capacitor is omitted. The Zener diode D1 forms a useful d.c. coupling from the Schmitt output Q2 to the relay driver Q3. When the collector voltage of Q2 falls below 12V, the Zener diode cuts off and isolates the output stage, so that it is not affected by the residual voltage on the Q2 collector. As a result, the transistor Q3 is able to

Fig. 72. Practical Schmitt trigger circuits. (a) 300kc/s 10V output (b) 10Mc/s Schmitt (c) 22V, 1.5A relay driver.



cut off completely. The diode D2 is a clamp to short circuit any possibly harmful reverse voltage inductive spikes on the collector of Q3 when it switches off.

Applications:—In general, the Schmitt provides a snap-action switch, and may simply be used as a fast-acting on-off switch.

The commonest application of the Schmitt, however, is probably as a "*squarer*." This is illustrated in Fig. 73. Here an input sinusoidal signal shown at the top swings above the upper trip level, V_U and below the lower trip level, V_L. The output switches up to V_{cc} when the input rises above V_U and falls to V_{cc}-V_U, when the input falls below V_L. This gives a rectangular output for a sinusoidal input, i.e. it "squares" the input signal. By adjusting the mean input level, V_{DC}, halfway between V_U and V_L, we can make the output a true square wave with equal on and off periods. In this application, the Schmitt is really a *pulse-shaper*, converting sine waves into square.

If the input is a train of nominally rectangular pulses, whose shape has been degenerated, the Schmitt can be used as a *pulse reshaper or restorer*, converting the ragged input pulses into precise rectangular output pulses. Incidentally, since the output pulse amplitude is independent of the input pulse amplitude, the Schmitt trigger can also make a useful *pulse amplifier*. Again, because the output levels are only indirectly related to the input, the Schmitt can be used as a *signal level shifter*.

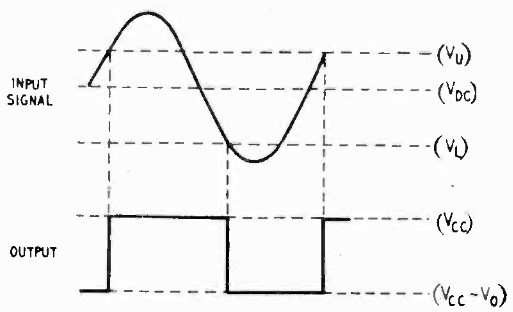


Fig. 73. "Squaring" with Schmitt trigger.

The Schmitt trigger often finds use as a *d.c. level detector*, since it can indicate positively when an input voltage rises above a specified reference level. When the reference level is zero volts, the circuit becomes a *zero cross-over detector*. Many more refined applications are possible. A particularly interesting one in where the input consists of an adjustable control level voltage mixed with a periodic time-varying signal, and the circuit is used as a *variable duty cycle switch* for certain control and regulator problems (*and possibly as a variable time delay device*).

Conclusion

An attempt has been made to outline the main design features and uses of the diode (or transistor) pump and the Schmitt trigger. With the ever-increasing use of digital pulse circuits in electronics, these are both becoming widely used as "bricks" in switching systems. They merit fuller exposition than is possible in the scope of this article. Unfortunately no current textbooks give completely satisfactory analysis of these two circuits in their semiconductor versions. Until such become available, this article should at least give some general guidance as to their design and applications.

D 10

Design of CATHODE REJECTORS for Television Receivers

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IN domestic television receivers both the vision and sound carriers are generally present on the video detector and will be demodulated together. In consequence, an inter-carrier signal also appears with the video signal in the output from the detector. The frequency of this inter-carrier signal is the difference of the carrier frequencies, i.e. 6 Mc/s in the C.C.I.R. 625-line system and 3.5 Mc/s in the British 405-line system.

In the C.C.I.R. system this inter-carrier signal serves to provide sound reception and is therefore necessary. In the British system inter-carrier sound reception is not possible and great care is taken to keep the level of sound carrier on the video detector as low as possible. Because of tolerances of components and in alignment, however, total elimination of the inter-carrier signal is not practicable.

If this inter-carrier signal were passed unrestricted together with the video signal through the video amplifier, a fine pattern would appear on the picture tube, which would be found objectionable by the viewer. Steps must therefore be taken to attenuate the inter-carrier signal to an acceptable level, without at the same time affecting the higher frequency components of the video signal.

There are several different solutions to this problem. One of the most popular methods is shown in its basic form in Fig. 1. The object of this article is to attempt to analyse the performance of this circuit and to establish the design parameters.

As it is shown on Fig. 1, the video amplifier consists of a single stage. The valve works into an anode load R_a, has a mutual conductance g_m, its grid is connected to the video detector and has a series combination of a resistor R_κ and a tuned circuit with impedance Z_κ in the cathode providing negative feedback. It is evident, that the larger the impedance Z_κ, the larger the negative feedback and so the lower the amplification of the stage. Eventually Z_κ reaches its maximum value at its resonance—frequency f_r which is also the frequency of the maximum rejection. The tuned circuit is therefore referred to as a rejector.

To simplify this investigation it is assumed that both the anode and grid circuits are frequency independent and only the negative feedback influences the frequency response of the amplifier.

The amplification of the circuit, i.e. the ratio of the anode voltage to the grid voltage:

$$A = \frac{g_m R_a}{1 + g_m (R_\kappa + Z_\kappa)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

This formula gives the amplification at any given frequency of the pass-band and takes into account the effect of the frequency dependent negative feedback.

At its resonance frequency, f_r, the impedance of the rejector circuit Z_κ, takes a particular value, $Z_{\kappa r}$. By substituting this into eqn. (1), one gets the amplification A_r at frequency f_r.

Thus:

$$A_r = \frac{g_m R_a}{1 + g_m (R_\kappa + Z_{\kappa r})} \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

The amplification of the stage without the rejector, i.e. $Z_\kappa = 0$,

$$A_o = \frac{g_m R_a}{1 + g_m R_\kappa}$$

The ratio of A_r to A_o gives a measure of the attenuation caused by the rejector, at the rejection frequency f_r.

$$a_r = \frac{A_r}{A_o} = \frac{1 + g_m R_\kappa}{1 + g_m (R_\kappa + Z_{\kappa r})} \quad \ldots\ldots\ldots\ldots \quad (3)$$

($\frac{1}{a_r}$, the value of which is always greater than unity will be referred to as the rejection)

From eqn. (3)

$$Z_{\kappa r} = \frac{1 + g_m R_\kappa}{g_m} \left(\frac{1}{a_r} - 1 \right) \quad \ldots\ldots\ldots\ldots \quad (4)$$

The rejector is a parallel resonant circuit, with a coil having a finite loss. This loss is represented on the circuit diagram of Fig. 1 by the resistance R_o. The impedance Z_κ will therefore be:

$$Z_\kappa = \frac{1}{\frac{1}{R_o} + j\left(\omega C_\kappa - \frac{1}{\omega L_\kappa}\right)} = \frac{\frac{Q_r}{\omega_r C_\kappa}}{1 + jQ_r \eta} \quad \ldots \quad (5)$$

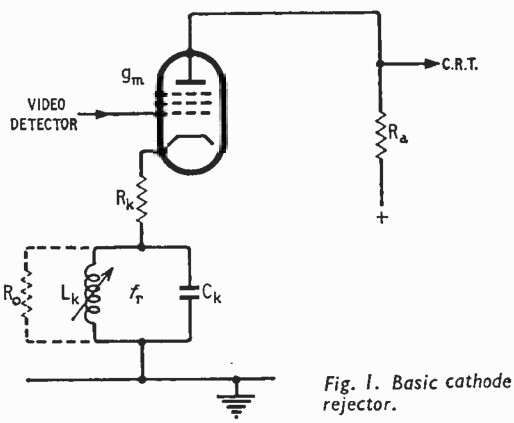


Fig. 1. Basic cathode rejector.

*Radio & Allied Industries Ltd.

where $\omega = 2\pi f$ ($2\pi \times$ frequency)
$\omega_r = 2\pi f_r$ ($2\pi \times$ resonance frequency)

$$Q_r = \frac{R_o}{\omega_r L_\kappa} = R_o \omega_r C_\kappa \quad \text{(Quality factor of rejector circuit)}$$

$$\eta = \frac{\omega}{\omega_r} - \frac{\omega_r}{\omega} \quad \text{(Relative detuning from resonance)}$$

At frequency f_r, $\eta = 0$, and therefore

$$Z_{\kappa r} = \frac{Q_r}{\omega_r C_\kappa} \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Substituting eqn. (6) into eqn. (4) one gets:

$$Z_{\kappa r} = \frac{Q_r}{\omega_r C_\kappa} = \frac{1 + g_m R_\kappa}{g_m}\left(\frac{1}{a_r} - 1\right) \quad \ldots\ldots (7)$$

and from here:

$$C_\kappa = \frac{Q_r}{\omega_r} \cdot \frac{g_m}{1 + g_m R_\kappa} \cdot \frac{1}{\frac{1}{a_r} - 1} = \frac{Q_r}{\omega_r} \cdot \frac{g_m}{1 + g_m R_\kappa} \cdot \frac{a_r}{1 - a_r} \quad (8)$$

Equation (8) is the first important result, giving the necessary value of C_κ to achieve $\frac{1}{a_r}$ rejection with given values of Q_r, ω_r, g_m and R_κ. It does not, however, give any indication of the effect of the rejector on any other frequency but the rejection frequency. Nevertheless, it is clearly important to make sure that the rejector does not influence unduly the amplification of those frequencies which contain the video information proper. It means, that e.g. in the C.C.I.R. system it does not make sense to provide 40 dB rejection at 6 Mc/s if at the same time there would be an attenuation of say 10 dB at 4 Mc/s.

Let $Z_{\kappa\phi}$ be the impedance of the rejector at frequency f_ϕ. Then using eqn. (1)

$$A_\phi = \frac{g_m R_o}{1 + g_m (R_\kappa + Z_{\kappa\phi})} \quad \ldots\ldots\ldots\ldots (9)$$

and

$$a_\phi = \frac{|A_\phi|}{A_o} = \frac{1 + g_m R_\kappa}{|1 + g_m (R_\kappa + Z_{\kappa\phi})|} \quad \ldots\ldots (10)$$

Where $|A_\phi|$ is the modulus of A_ϕ and a_ϕ is the attenuation introduced by the rejector at frequency f_ϕ. (Since apart from the resonance frequency, $Z_{\kappa\phi}$ and therefore A_ϕ are complex quantities, it is necessary to use the modulus of A_ϕ to have a_ϕ as a real number.)

Applying eqn. (5)

$$Z_{\kappa\phi} = \frac{\frac{Q_r}{\omega_r C_\kappa}}{1 + jQ_r \eta_\phi} \quad \ldots\ldots\ldots\ldots\ldots\ldots (11)$$

Substituting eqn. (11) into eqn. (10):

$$a_\phi = \frac{1 + g_m R_\kappa}{\left|1 + g_m\left(R_\kappa + \frac{\frac{Q_r}{\omega_r C_\kappa}}{1 + jQ_r \eta_\phi}\right)\right|}$$

$$= \frac{1}{\sqrt{\left(1 + \frac{g_m}{1 + g_m R_\kappa} \cdot \frac{Q_r}{\omega_r C_\kappa} \cdot \frac{1}{1 + Q_r^2 \eta_\phi^2}\right)^2 + \left(\frac{g_m}{1 + g_m R_\kappa} \cdot \frac{Q_r}{\omega_r C_\kappa} \cdot \frac{Q_r \eta_\phi}{1 + Q_r^2 \eta_\phi^2}\right)^2}} \quad \ldots\ldots\ldots\ldots (12)$$

Solving eqn. (12) for η_ϕ (see appendix) one gets:

$$\eta_\phi = \pm \frac{1}{Q_r}\sqrt{\frac{\left(\frac{g_m}{1 + g_m R_\kappa} \cdot \frac{Q_r}{\omega_r C_\kappa} + 1\right)^2 - 1}{\left(\frac{1}{a_\phi}\right)^2 - 1} - 1} \quad (13)$$

From eqn. (7)

$$\frac{g_m}{1 + g_m R_\kappa} \cdot \frac{Q_r}{\omega_r C_\kappa} = \left(\frac{1}{a_r} - 1\right) \quad \ldots\ldots\ldots\ldots (14)$$

and substituting into eqn. (13):

$$\eta_\phi = \pm \frac{1}{Q_r}\sqrt{\frac{\left(\frac{1}{a_r}\right)^2 - 1}{\left(\frac{1}{a_\phi}\right)^2 - 1} - 1} \quad \ldots\ldots\ldots\ldots (15)$$

Equation (15) shows that, with given Q_r and a_r, there will be two frequencies, corresponding to $+\eta_\phi$ and $-\eta_\phi$, where the attenuation will be a_ϕ. The value of $+\eta_\phi$ corresponds to a frequency above f_r, while $-\eta_\phi$ corresponds to a frequency below f_r. In TV receivers only the latter has importance and will be taken here into account.

For $a_\phi = 1/\sqrt{2}$, i.e. at the frequency where the rejector introduces a 3 dB attenuation, from eqn. (15):

$$\eta_\phi = \eta_{3dB} = -\frac{1}{Q_r}\sqrt{\left(\frac{1}{a_r}\right)^2 - 2} \quad \ldots\ldots\ldots (16)$$

The frequency f_ϕ corresponding to η_ϕ

$$f_\phi = \frac{f_r}{2}\left(\sqrt{\eta_\phi^2 + 4} + \eta_\phi\right) \quad \ldots\ldots\ldots\ldots (17)$$

and from eqn. (16) and (17)

$$f_{3dB} = \frac{f_r}{2}\left(\sqrt{\eta^2_{3dB} + 4} + \eta_{3dB}\right)$$

$$= \frac{f_r}{2}\left(\sqrt{\frac{\left(\frac{1}{a_r}\right)^2 - 2}{Q_r^2} + 4} - \frac{1}{Q_r}\sqrt{\left(\frac{1}{a_r}\right)^2 - 2}\right) \quad (18)$$

Equation (18) is the second important result, giving the frequency f_{3dB}, where there is 3 dB attenuation on account of the rejector, in terms of f_r, Q_r and a_r.

The foregoing treatment contains no approximations whatever and the results can be applied where there is a need for exceptionally accurate calculations.

In TV practice, however, there is no need for extreme accuracy and for $a_r \leqslant 0.1$ (20 dB rejection or more) and $Q_r \geqslant 30$, eqn. (18) can be greatly simplified.

$$f_{3dB} \approx f_r - \frac{f_r}{2Q_r a_r} \quad \ldots\ldots\ldots\ldots (19)$$

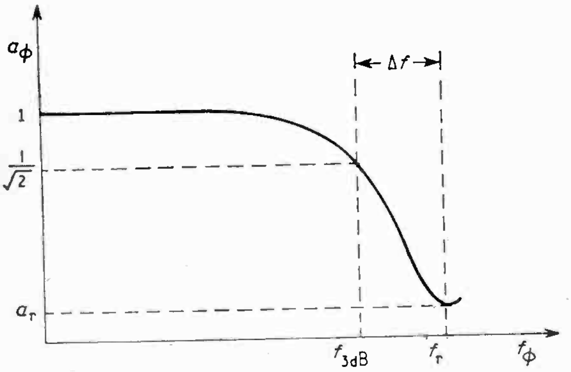


Fig. 2. For a given rejection frequency and circuit Q, the ratio of bandwidth to the degree of rejection is constant.

From here:

$$f_r - f_{3dB} \equiv \Delta f \approx \frac{f_r}{2Q_r a_r} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (20)$$

and:

$$\frac{\Delta f}{\frac{1}{a_r}} \approx \frac{f_r}{2Q_r} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (21)$$

Equation (21) is the most important result of this investigation. It shows, that the ratio of the bandwidth affected by the rejector (see Fig. 2) to the amount of rejection is constant and depends only on the rejection frequency f_r and the quality factor of the rejector circuit Q_r and is independent of the g_m of the valve and of the cathode resistor R_K. The bandwidth-to-rejection ratio can be regarded as an analogous figure of merit to the gain bandwidth product of amplifiers, since for given f_r, and Q_r the rejection can be increased only at the expense of attenuating a wider band of frequencies at the same time.

The practical design procedure is as follows:—

1. The value of the highest practical quality factor, Q_r, of the rejector circuit has to be established.
2. A compromise has to be made between rejection and bandwidth. From eqn. (21) the values of Δf and a_r have to be calculated.
3. Substituting the values of a_r and Q_r into eqn. (8) C_K has to be calculated.
4. From f_r, and C_K, L_K can be readily obtained.

An implication of the results obtained is that the frequently encountered use of tapping of the rejector coil can be justified only for the purpose of avoiding inconvenient values of L_K and C_K or eventually to increase the quality factor Q_r of the rejector circuit itself (disregarding the loading by the output impedance of the cathode circuit of the valve).

APPENDIX

Substituting into eqn. (12)

$$K \equiv \frac{g_m}{1 + g_m R_K} \cdot \frac{Q_r}{\omega_r C_K} \cdot \frac{1}{1 + Q_r^2 \eta_\phi^2} \quad \ldots\ldots\ldots\ldots \quad (A1)$$

one gets:

$$a_\phi = \frac{1}{\sqrt{(1+K)^2 + K^2 Q_r^2 \eta_\phi^2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (A2)$$

and

$$\left(\frac{1}{a_\phi}\right)^2 = (1+K)^2 + K^2 Q_r^2 \eta_\phi^2$$
$$= 1 + 2K + K^2(1 + Q_r^2 \eta_\phi)^2 \quad \ldots\ldots\ldots\ldots \quad (A3)$$

Further

$$K^2(1 + Q_r^2 \eta_\phi^2) + 2K + 1 - \left(\frac{1}{a_\phi}\right)^2 = 0 \quad \ldots\ldots\ldots \quad (A4)$$

and

$$K = \frac{-2 \pm \sqrt{4 - 4(1 + Q_r^2 \eta_\phi^2)\left[1 - \left(\frac{1}{a_\phi}\right)^2\right]}}{2(1 + Q_r^2 \eta_\phi^2)} \quad \ldots (A5)$$

re-substituting eqn. (A1) into eqn. (A5):

$$\frac{g_m}{1 + g_m R_K} \cdot \frac{Q_r}{\omega_r C_K} \cdot \frac{1}{1 + Q_r^2 \eta_\phi^2} = \frac{\pm \sqrt{1 - (1 + Q_r^2 \eta_\phi^2)\left[1 - \left(\frac{1}{a_\phi}\right)^2\right]} - 1}{1 + Q_r^2 \eta_\phi^2} \quad \ldots\ldots (A6)$$

and

$$\left(\frac{g_m}{1 + g_m R_K} \cdot \frac{Q_r}{\omega_r C_K} + 1\right)^2 = 1 + (1 + Q_r^2 \eta_\phi^2)\left[\left(\frac{1}{a_\phi}\right)^2 - 1\right] \quad \ldots\ldots (A7)$$

$$\frac{\left(\frac{g_m}{1 + g_m R_K} \cdot \frac{Q_r}{\omega_r C_K} + 1\right)^2 - 1}{\left(\frac{1}{a_\phi}\right)^2 - 1} - 1 = Q_r^2 \eta_\phi^2 \quad \ldots\ldots (A8)$$

and finally

$$\eta_\phi = \pm \frac{1}{Q_r} \sqrt{\frac{\left(\frac{g_m}{1 + g_m R_K} \cdot \frac{Q_r}{\omega_r C_K} + 1\right)^2 - 1}{\left(\frac{1}{a_\phi}\right)^2 - 1} - 1} \quad \ldots (A9)$$

WEATHER SATELLITE DEVELOPMENTS

AUTOMATIC PICTURE TRANSMISSION FROM TIROS 8

By C. E. GOODISON

AMONG the new host of heavenly bodies, is TIROS 8 the latest meteorological satellite to be launched by N.A.S.A., the United States space organization. It is one of the weather observing satellites in the Television and Infra Red Observing Satellite series. The first TIROS orbited on April 1st, 1960, and since then there have been 100,000 cloud cover pictures taken by TIROS-type satellites.

These pictures are taken by a TV camera, which is scanned, and the picture information stored, by a tape recorder, before the camera is used again. The tape storage capacity is 32 complete pictures and there is a 30-second interval between each picture. When TIROS is over one of the Control and Data Acquisition Stations in North America, the stored pictures are rapidly read out by the ground station. The pictures are then sent through meteorological channels to weather services throughout the world.

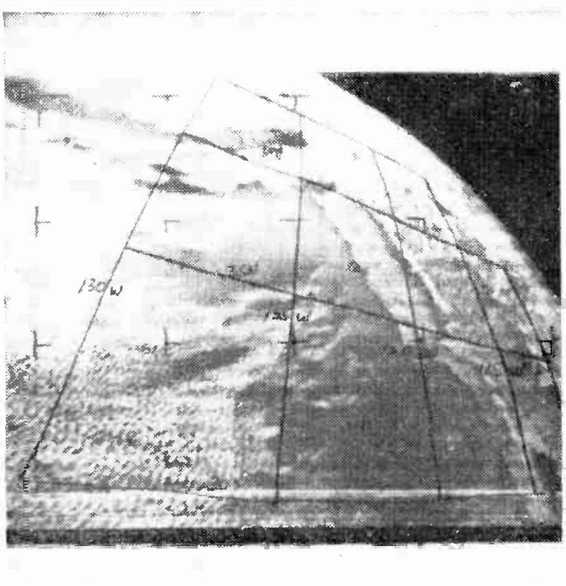
Due to certain constraints[1] (of which the principal are:—(1) orbit latitude limits—normally 58°N. to 58°S, (2) illumination of territory passed over, (3) tape storage—as mentioned above, (4) geographical situation of read-out stations—North America) the pictures obtained do not provide world-wide cover with any regularity. Pictures of areas of particular interest to meteorologists in U.K. may only be available after a delay of up to 24 hours.

The forecaster at Meteorological Office H.Q. works to a strict timetable and has to meet several deadlines throughout his working day. These deadlines vary from issuing B.B.C. radio forecasts at specific hours, to briefing aircrews who must take off at regular times. These various forecasts are based on synoptic charts drawn up every 6 hours throughout the day.

It is obvious then that to be a really useful meteorological aid cloud pictures of the surrounding area should be as regular and as reliable as possible and in the forecaster's hands with the minimum of delay.

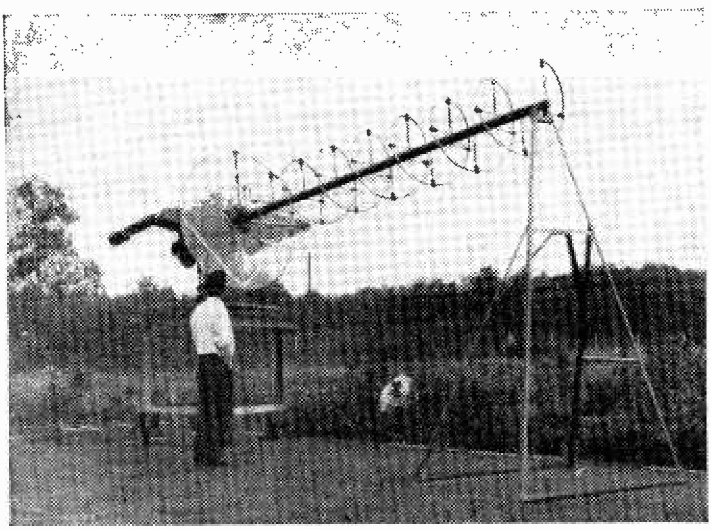
It is with the aim of reducing these delays that APT (Automatic Picture Transmission) has been installed experimentally in TIROS 8 so that an operational assessment could be made of its capability of delivering to any forecaster in the world with suitable receiving equipment "instant" cloud pictures of the surrounding area, which may be up to a half million square miles, within three minutes of the picture being shot. The orbit of TIROS 8 does not give the regularity of observations required but this will be obtained later when a new type of weather satellite is sent up on a circumpolar orbit.

TIROS 8 orbits in about 100 minutes at an altitude of about 470 miles. At this height the APT camera takes square pictures with a side of 700 miles when the camera is pointing vertically. Of course, verti-



Courtesy RCA Astro-Electronics Division

Typical cloud photos taken over the Californian coast by TIROS 8 in Feb. 1964. Superimposed grid represents lines of latitude and longitude.



Helical aerial and mount for the Meteorological Office receiving station at Bracknell.

cality in space is meaningless; in the context of the APT camera the local vertical is meant. This condition cannot occur more than once per orbit since TIROS is a spin-stabilized satellite, the axis of which remains at a fixed angle to the earth's axis throughout its orbit. This angle, can be changed by the elegant expedient of passing a current through a hoop around the satellite. The magnetic field caused in this way interacts with that of the earth and the angle of the satellite is changed.

The camera shutter is open for 40 milliseconds, which is short enough to cause minimal blurring of the picture, although the satellite is travelling at around 16,000 m.p.h. After exposure the read-out time lasts for 200 seconds during which time the orthicon tube of the APT camera is scanned at 4 lines per second. Since the APT equipment on TIROS 8 is an experimental installation there is a timing sequence which allows the take/read-out cycle to repeat about 10 times, i.e. for half an hour, when commanded by a N.A.S.A. ground station.

The output from the orthicon frequency modulates a 136.95 Mc/s, 5 watt transmitter and this signal is radiated by the satellite. The frequency deviation is ± 10 kc/s.

The ground station which is necessary to receive these facsimile type transmissions is of a comparatively simple type. In fact its simplicity is the great merit of this meteorological satellite system.

When the satellite rises and sets the distance between the transmitter and receiver is at a maximum, 3,000 kilometeres. At this range using a frequency of 137 Mc/s, a receiver with a noise factor of about 5 or 6 dB, and an aerial with a gain of 10 dB will deliver a usable facsimile signal.

The amplitude modulated sub-carrier of 2,400 c/s is fed to a specially designed recorder. There are several proprietary models of this recorder being produced and in fact "packaged" complete ground stations have been produced by N.A.S.A. and installed at various sites throughout the world. The U.S. base at High Wycombe is equipped with one of these stations. The British Meteorological Office is constructing its own station at Bracknell.

The most popular type of aerial used to give the necessary gain without recourse to a narrow beam response is the helical array used in the axial mode. An 8-turn helix, with a diameter of 27½in, and 21in between turns gives[2] a beam width of 35° between half-power points and a gain of 13 dB. With such an aerial accurate tracking is not required and most aerial pedestals, although remotely controlled, are positioned manually. The Meteorological Office plan to use in their prototype station an aerial mount originally designed for use with an early AA radar. This aerial when used operationally was aligned by the auto-follow circuits attached to the radar, but in the first model the APT Ground Station aerial will be manually controlled. Later models may have a programming unit in control so that the satellite may be tracked automatically from orbital data supplied by N.A.S.A.

The receiver used by most American stations is a very sophisticated space telemetry set with phase lock loop detection and many other exotic features. The Meteorological Office will be using a British built commercial communications receiver with a pre-amplifier designed by R.R.E., Malvern.

The facsimile recorder which will be used is a Muirhead D.900S which operates at 240 lines per minute. It will start automatically on receipt of a "start" signal from the satellite and at the end of 200 seconds a square picture of 800 lines measuring 9in×9in will be completed. As stated earlier, the equivalent side of the picture is 700 miles and it is interesting to note that, although the orthicon in the satellite camera is only one inch in diameter, the resolution at the centre of the picture is said to be about 2 miles.

Initial experiments were carried out in collaboration with R.R.E. Malvern and Muirheads of Beckenham and APT pictures were received on the first few orbits of TIROS 8. These pictures were only of a limited usefulness since they were marred by an overall scallop pattern which was caused by malfunctioning of a circuit in the satellite electronics. This type of interference is present on all TIROS 8, APT pictures, although the American Weather Bureau were able to use photographs which showed cloud cover and easily recognizable geographical features such as Lake Huron. Until now the pictures taken over Western Europe have produced no distinctive coastlines or landmarks since camera angle has always been such as to photograph the Atlantic or the Sahara.

When APT becomes fully operational it will prove a useful addition to the way in which electronics is helping the weather forecaster.

The author wishes to thank the Director-General, The Meteorological Office, for permission to publish this article.

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1 "An Explanation of the Limitations to the Coverage provided by TIROS," by W. K. Widger, Jr., and C. P. Wood. *Weatherwise*, Dec. 1961, p. 230.
2 "Antennas," by J. D. Kraus. (McGraw-Hill.)

INTERNATIONAL CONFERENCE ON MAGNETIC RECORDING

LONDON, JULY 6TH—10TH

ORGANIZED by the I.E.E., I.E.E.E., and I.E.R.E., well over 100 overseas visitors registered for this conference which was opened by the Rt. Hon. Quintin Hogg.

The introductory paper was presented by the Director of the European Region of The Institute of Electrical and Electronics Engineers, Mr. H. Rinia. In this paper, Mr. Rinia outlined the rapid growth of magnetic tape applications over the past 15 years. The remaining papers fell conveniently into the following categories: recording media, analogue recording, digital recording, audio, video and general.

Metal Films

The first paper of the first session at first glance looked like a return to early magnetic-recording days. Entitled "High Density Digital Recording on Thin Metal Tape," we immediately thought of the dangers of some high-speed steel tape machines. However, the work of the authors, Messrs. G. Bate, J. R. Morrison and D. E. Speliotis, all from I.B.M., Poughkeepsie, New York, was based on the fact that in traditional recording media (gamma ferric oxide in the form of single-domain particles) used for analogue recording techniques, the particles are usually orientated so that there is a predominance of long axes in the direction of tape motion. It has become apparent though that other orientations are preferable for high-density digital recording. The recording medium used by the authors in their high-density work consisted of metal films of cobalt with 1%-5% phosphorus, chemically deposited on flexible substrates. The thickness varied from 1 to 220 μin but most of the measurements were taken on films 5-10 μin thick. Having described the tape and the carefully controlled recording process, the authors outlined the results and offered the conclusion that the high-density recording properties of thin plated surfaces which are presently superior to those of magnetic tape can be ascribed principally to the thinness of the metallic variety leading to a favourable demagnetizing factor, narrow transition regions and narrow pulses.

Still in the realms of recording media, Mr. Stübbe, of the Institut fur Rundfunktechnik, Munich, touched on a subject near and dear to all those who, like the reporter, are devotees of television programmes. To such, one of the most noticeable differences which characterizes a video-tape recording in contrast to a live television production is the appearance of white or grey stripes along the lines of the television image without any attachment to the image content. Known as drop-outs, these are mostly attributed to bad handling of the tape but Mr. Stübbe's paper dealt with drop-out faults occurring during production. Drop-out was explicity defined as the non-appearance of video information for a short time. It has long been supposed that holes in the magnetic layer of the tape are the reason for these effects. However, this point of view has not been verified by Mr. Stübbe and his co-workers. In nearly all cases there are distance effects between head and layer which cause the signal breakdowns. Such distance has more influence in the recording process than at playback. Thus, if a particle of dust is located between head and layer during recording then the damage is done even if the particle is removed. On the other hand with a good recording and during replay the same particle between head and tape results in an appreciable signal. Photomicrographs were shown demonstrating typical tape faults, these being mainly remains of air bubbles bursting during drying and minute dust particles pressed into the layer by a headwheel. A drop-out analyzer was described which can be used to provide an indication of drop-out errors and gives results for the valuation of tape quality, the number of drop outs and the total signal-breakdown times for a certain length of tape. The analyzer operates in this manner. The signal from the tape recording (with any programme content) is fed to the first stage of the instrument. This is a limiter adjusted to approximately the same characteristics of the recorder used. A demodulator stage follows this so that the demodulated signal is applied to an amplitude discriminator which serves three indication units, these being the control stage for the recording instrument, impulse generator for the electronic counter and an adding stage for the signal breakdown time indicator.

Vibrating Sample Magnetometer

Dr. E. Pearce (E.M.I. Research Laboratories), during his paper on the "Measurement of the Magnetic Properties of Recording Tape," described a vibrating sample magnetometer based on design by G. W. van Oosterhout and used by Dr. Pearce for magnetic measurements on tapes carrying acicular γ-Fe_2O_3 particles. The chief advantage of this apparatus being that only small specimens of tapes or powders are required. The equipment consists of a metal rod mounted horizontally and vibrated longitudinally at 25 c/s with an amplitude of 1.5 mm by means of an electric motor and cam. A plastic sample holder attached to the end of the rod carries the specimen. The electrical pick-up system consists of two short co-axial coils spaced $\frac{3}{4}$ in apart and connected in series opposition to a well-screened tuned amplifier. The coils are fixed at the centre of a supplementary coaxial solenoid which provides the fields required for anhysteretic studies. The main magnetizing coil surrounds this assembly. Its maximum field strength is 2,600 oersteds which is sufficient to approach magnetization saturation in most commercial tapes. This latter solenoid can be switched to a 50 c/s source for demagnetizing, etc. Before readings are taken, the specimen is vibrated and cyclically magnetized to saturation. The platform holding the pick-up coils and the two solenoids is adjusted for maximum output voltage. The instrument is calibrated with a thin nickel rod (or sheet) with a known saturation magnetization. The tape specimens normally used are $\frac{3}{4}$ in squares. Powders are measured packing them into small-bore plastic tubes $\frac{3}{4}$ in long. The vibrating sample magnetometer is used to measure various tape parameters under steady field conditions, and in the presence of, or after the application of, combined a.c. and d.c. fields.

The rapid spread of magnetic tape for bulk data storage has brought with it the problem of compatibility since there are now indications that there is an increasing requirement for the use of magnetic tapes as a means of data interchange between different computer installations. Mr. G. Ziman of Ampex International and a member of the Electronic Engineering Association's Data Processing Working Party on Magnetic Tape reviewed the problems affecting compatibility between magnetic tape units on computing systems. To ensure that data can be exchanged reliably, the magnetic tape itself, the spool on which it is wound and the layout of data on the tape need to be carefully specified. Mr. Ziman reported that several national and international organizations were working towards these ends but that no final conclusions have yet been reached. The speaker, however, felt that if agreement on codes and standards can be obtained between users, the use of magnetic tape for the exchange of data between computers does not present any undue difficulties.

A number of papers on the subject of recording heads were presented by workers from N.V. Philips, and it was not surprising that in a fast-moving world of improving magnetic tapes, improving tape-transport devices and increasing applications of magnetic recording that tape heads too have taken enormous strides and indeed are still being improved. Existing conventional heads suffer badly from the wear problem and much has been done to combat this by the use of dense ferrites with glass bonding. We were told that for some time ferrite magnetic heads have been designed and manufactured on a laboratory scale and that low magnetic losses, high resistance against wear and well defined gaps were claimed for heads thus made. These properties, of course, are very important and much welcomed by the user but difficulty was experienced in ensuring the desired qualities when the heads were manufactured on a production basis. However, a completely new type of Ferroxcube material with a high density and a new gap-forming technique were developed which, together with a radical departure from the conventional approach to head design were necessary to manufacture such heads to a satisfactory standard in sufficient quantities. The papers described in some detail the design philosophy, manufacture of the materials and the method of construction of the heads, and some of the electrical and mechanical properties. The bias current required at 100kc/s is about half of that required by a nickel-iron head with laminations of 0.2mm thickness. (At higher bias frequencies this ratio decreases in favour of the ferrite head.) The modulation current required at audio frequencies is close to that required by metal heads. The output voltage of the playback ferrite head is about 2dB higher than that obtained from professional (Philips) metallic heads. On the mechanical side and after some exhaustive testing the authors came to the conclusion that minimum expected lifetime of the ferrite heads is at least 10 times longer than that of conventional heads.

In such a large conference in which research workers and designers of magnetic tapes and tape-recording equipment predominated it was not surprising that time was also given to the tape user. Represented mainly by the B.B.C., papers read on the user side dealt with bulk erasure problems, editing of sound tapes without cutting, the establishment of magnet recording characteristics at low audio frequencies, and the automatic stop and sequence control of tape reproducers.

BOOKS RECEIVED

Transistor Circuits in Electronics, by S. S. Hakim and R. Barrett. An introduction to semiconductor physics and to the application of transistors and diodes in electronics, as opposed to communications. After graphical analysis of amplifiers, the commonly-used equivalent circuits are derived, the main part of the book being a discussion of the operation of amplifiers, oscillators, switching and logic circuits, and modulation. Pp. 341. Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.1. Price 63s.

Short Wave Amateur Radio, by J. Schaap (PAØHH). Starts right from the beginning of the history of amateur radio and of electrical and radio theory and carries the beginner through to the design and operation of a station. There is a useful chapter on operating procedure. Pp. 172. Philips Technical Library, Cleaver-Hume Press Ltd., 10-15, St. Martin's Street, London, W.C.2. Price 21s.

Stereophony: the Effect of Cross-talk between Left and Right Channels, by H. D. Harwood, B.Sc., A.Inst.P., A.M.I.E.E. and D. E. L. Shorter, B.Sc.(Eng.), A.M.I.E.E. B.B.C. Engineering Monograph No. 52 describes experiments designed to assess subjective reactions to varying degrees of cross-talk in different parts of the audio spectrum as well as cross-talk irrespective of frequency. Some interesting incidental observations were made, for example, that the acuity of the observers' directional sense was greater in an average living room than in free-space conditions. Pp. 23. B.B.C. Publications, 35, Marylebone High Street, London, W.1. Price 5s.

Radio, Television and Electrical Repairs, edited by Roy C. Norris. Fourth edition of a comprehensive guide to the maintenance of domestic equipment. Starting from first principles and contributed to by experts in different fields, it should help in starting apprentices and amateur enthusiasts on the right lines. Pp. 576. Odhams Books Ltd., Long Acre, London, W.C.2. Price 50s.

Waves and Oscillations, by R. A. Waldron starts with a general physical concept of the similarities and differences of waves in different media, leading to guided waves and topics (including wave filters) in network theory. Pp. 135. D. Van Nostrand Co., Ltd., 358, Kensington High Street, London, W.14. Price 14s.

British Standard 3693: Part 1: 1964 on recommendations for the design of scales and indexes, and in particular for instruments of bold presentation and for rapid reading. Specimens of preferred scale divisions and shapes of numerals are included. Pp. 44. British Standards Institution, 2, Park Street, London, W.1. Price 10s.

Amplifiers, by H. Lewis York. Part of a series on the technique of sound reproduction, this volume deals with "high-fidelity" audio amplifiers, chiefly of the valve type though a chapter on transistors is included. There is a large appendix giving reference data on the characteristics of some popular audio valves, the reactance of standard capacitors and of inductors, current rating of resistors, etc. Pp. 254. Focal Press Ltd., 31, Fitzroy Square, London, W.1. Price 42s.

E.M.F. (continued)

By "CATHODE RAY"

LAST month we found a good deal of confusion in some quarters about e.m.f. and the difference, if any, between it and p.d. Even the British Standard definitions of these terms (in BS.205: Part 1: 1943) seemed a bit shaky on the subject.

One thing emerged quite clearly: no arrangement of static electric charges can produce a net electric field around any closed path (conducting or otherwise). So the work you would do in carrying a test charge around such a path would be zero. Along part of the route there would be repulsion, making you do work to move your charge; elsewhere there would be attraction, so that the charge would do work on you. The potential, though it may be varying all the way, always comes back to the same in the end; there can be no p.d. between the start and finish if they are the same point.

You could hardly carry out such a test literally, but Fig. 1 shows how the principle applies in practice in certain kinds of valves. An electron is released at A on a cathode, whose potential we shall regard as zero. There is another electrode at the some potential, and between them a grid maintained positive. Our electron is attracted to this and is rapidly accelerated thereby, but as A happened to be exactly equidistant from two wires of the grid the electron goes straight through. It is now retarded, and its speed (and therefore kinetic energy) is brought to zero just when it is about to land on the zero-potential plate. The process is now repeated in reverse, bringing it back to A, where its speed is again zero. At the start the electron had high potential energy, and the field between it and the grid did work on it, giving it kinetic energy, which was at a maximum where the p.e. was zero, between the grid wires. This k.e. then carried it against the field, restoring the original state, so that the total work done on it by the field was zero. This cycle is gone through again on the return to A.

An e.m.f. produces an electric field not due to charges, though it often creates a charge field as well. Fig. 2 shows a battery, which charges the top wire positively relative to the bottom one. So a charge electric field is created between the two. If you trace any closed path—for example from top to bottom via the dotted line and back via the same or any other path *except through the battery*—you will find that the net work done on a test charge is zero, as before. Put mathematically, the line integral of the electric field strength ($\mathcal{E}$) around the path is zero. But the battery was able to separate out the positive and negative charges and thereby create this

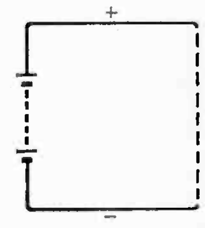


Fig. 2. A state of balance between a charge field and an e.m.f. field.

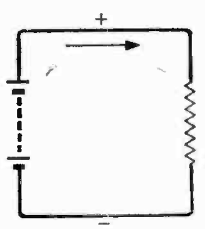


Fig. 3. When the arrangement in Fig. 2 is made into a complete circuit, charges can flow completely around it, delivering up energy which is brought into the circuit by the source of e.m.f.

field only because its e.m.f. is a reverse field, confined in this case to the path through it. This e.m.f. field moves negative charges (electrons) downwards until the charge field so created is exactly equal to the e.m.f. field. There is then no net field either way through the battery, so no further current. If you trace a circular route including the battery, you get no net field through it, yet your potential changes by its voltage; on the return, say via the dotted line, you get back to your original potential, through the field. So this time the line integral of electric field around the path is not zero; it is equal to the p.d. between the wires, which is equal to the e.m.f. That is what the BS definition of e.m.f. means when it says that the e.m.f. around a circuit is equal to the line integral of the electric force*. Without an e.m.f., on the other hand, there is always an exact balance between positive and negative.

What we have been considering is not a circuit—not a closed one, anyway—so in Fig. 3 we have com-

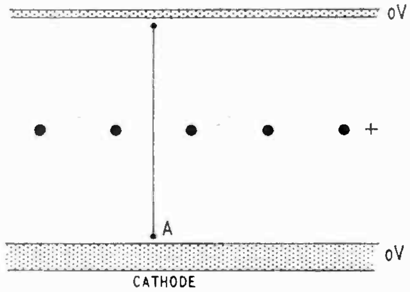


Fig. 1. Arrangement of valve electrodes which could be used to demonstrate that the total work done on a small electric charge making a return journey is zero.

* BS. 205 prescribes a distinctive symbol, $\mathcal{E}$, for electric field strength. BS. 1991: Part 6: 1963 has abandoned this and specifies the symbol E for both electric field strength and e.m.f., with no alternative for either. So the BS. 205 statement that e.m.f. is equal to the line integral of the electric force around the circuit must appear officially as

$$E = \oint E \, ds$$

Could anything be more confusing?

pleted it by a resistor. Current now flows as shown. Neglecting battery resistance, we still have the same field between + and −, and that field exists both in space and in the resistor. So the line integral test for e.m.f. still holds good. But if you carry out the test in imagination with a small charge, an electron say, you will find that the work you (or the battery) has to do to transfer it from + to −, which is recoverable as k.e. of the electron if it returns to+ through space, is lost as heat if it goes through R. So although, for the purpose of finding the line integral by measuring the net work you do going round the circuit, you are not allowed to include the work done by the battery, you must include the

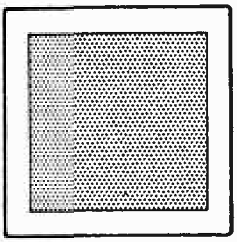
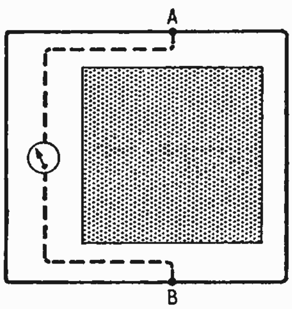


Fig. 4. Here a core carrying a steadily varying magnetic flux s enclosed by a wire loop. There is e.m.f. but no p.d.

Fig. 5. Voltmeter experiment on the system shown in Fig. 4.



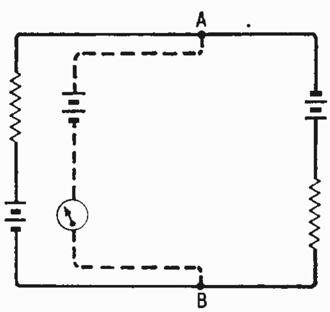


Fig. 6. Lumped equivalent of Fig. 5.

work the electron does on the resistor, in heating it, as work received by you.

As we saw last month, the B.S. definition suggests that the idea of p.d. doesn't strictly apply where there is an e.m.f. It is true that for purposes of reckoning the e.m.f. as just described you are not allowed to count the work done by the battery, and so your test charge gets through the battery without yourself having to do any work on it. This shows that the net field that way is zero, and you might therefore say that you had experienced no p.d., whereas if you went by any other route between the same two points you would, and therefore there is and there isn't a p.d. between the same two points at the same time, which is nonsense, and so the p.d. idea breaks down via an e.m.f. Personally I think it is much more sensible to say that for purposes of p.d. you count work done by the e.m.f. After all, the B.S. definition of p.d. just says "work done", and somebody or something *always* has to do work to move a charge to a point of higher potential. Looking at it another way, you can say that for reckoning p.d. you take account of fields due to charges only and ignore the e.m.fs.

Imagine yourself in an amusement park, having paid your money and taken your place in one of the cars starting from ground level in a switchback or whatever they call it nowadays. A source of power raises the cars up a steep slope to a considerable height above ground. Thereafter they move under the influence of the gravitational field, and whatever the vicissitudes on the way they eventually return to ground level and to a relatively slow speed, the energy they were given by the power source having been dissipated frictionally as heat. You, representing a test charge travelling around a circuit, would hardly deny the existence of a difference in height between start and finish of the power-driven section, just because you were sitting at ease and didn't have to do any work. You would take into account the amount of work the power source had to do on your weight to raise it, or else you would think of the work you would have to do to raise yourself without it. Alternatively you could arrive at the height raising capability of the power source by finding how much work your body could do in descending, either by contributing to the heating of the system by increasing the friction, or more catastrophically by throwing yourself out at the start of the descent.

In another part of the park you might get into a power-driven car to travel around a level course. Here, by definition, there would be no changes in height. There would be no sustained motion either, unless the car was provided with a source of power, converting its energy continuously into frictional heat. This is the analogue of an electrical situation that sometimes provokes argument. Fig. 4 shows a cross section of a magnetic core encircled by a continuous loop of uniform resistance wire. By means of another coil around the core the magnetic flux through it is made to change at a constant rate, inducing a constant e.m.f. around the wire loop. Obviously, because of symmetry, no point on the wire can be at a higher potential than any other point; there is no p.d. But there is an e.m.f. of a definite voltage, and a current. Although there is no static charge system to create an electric field, starting as the books tell us on positive charges and ending on negative, there is undoubtedly on electric field around the core, due to the e.m.f. If represented by lines of force this field would appear as endless loops. The energy it imparts to the electrons in the resistance wire is immediately passed on to the wire as heat. The field is accompanied by electrical displacement around the core; there would be electrical strain in a dielectric ring around it, just as if the dielectric material were between the plates of a charged capacitor, yet no p.d. As we said earlier, for taking account of p.d. we have to ignore e.m.f. fields and count only charge fields, and here there is none.

In Figs. 2 and 3 we found that the e.m.f. field existed only inside the battery. Everywhere except actually via the battery the only field was that due to the charges which had been separated by the e.m.f.

Fig. 7. If suitable charge carriers are available the p.d. between A and B can cause a current between those points.

The reading of the voltmeter used to measure that e.m.f. would be the same no matter where the meter and its leads were placed. That is not true of the e.m.f. due to a varying magnetic field. The amount of such an e.m.f. around any path is proportional to the rate at which the magnetic flux enclosed by that path is changing.

In Fig. 4 we assumed the flux was changing at a constant rate, so as to yield a constant e.m.f. Let us check by experiment that there is no p.d. between any two points on the wire, say A and B in Fig. 5. To be quite sure let us use a no-current voltmeter, such as a suitable valve type. We will find that if we take the voltmeter leads one side of the core, as shown, we do get a reading. If we take it the other side we get a reading of opposite polarity. Only if we bore a hole through the core and take the lead that way can we get a zero reading.

Does this mean that the p.d. between A and B is positive, negative and zero all at the same time? Of course not. Fig. 6 shows the equivalent lumped circuit, in which e.m.fs are represented separately by batteries. The e.m.f. each side of the main loop is devoted entirely to driving current through the resistance of that half of the wire, so there is no p.d. between A and B. The closed circuit formed by the left-hand half of the loop and the voltmeter leads encloses no varying flux, so there is no net e.m.f., the half-loop e.m.f. being exactly counteracted by the equal e.m.f. generated in the voltmeter leads, which the voltmeter reads because its leads are connected between two points of equal potential. The same e.m.f. is required if we consider the circuit formed by the voltmeter leads and the right-hand half-loop, which encloses the whole varying flux and therefore the full e.m.f. represented by four cells in series. Running the leads to the right of the core reverses the e.m.f. in them and the meter reading. Only if the voltmeter leads divide the flux into equal halves is no e.m.f. generated in them and no reading shown.

In the substitute arrangement shown in Fig. 6, with the e.m.fs. and resistances of the main loop separated, the potential would of course rise and fall twice around it. Relative to A and B, the positive poles of both batteries would be positive, so there would be charge electric fields between those points and A and B, counteracted within the batteries only by equal and opposite e.m.f. fields so that the line integral of electric force around the circuit would be equal to the total e.m.f. of the two batteries, in accordance with the B.S. definition. In Fig. 5 however there is no p.d.; only a continuous e.m.f. electric field all the way round the loop.

Of course there is no need to have a core to introduce the varying magnetic flux; the whole loop could be placed in a uniform magnetic field, varying at a constant rate, at right angles to it. Then the reading of voltmeter would vary from a positive maximum, through zero, to a negative maximum, as its leads were moved from one side to the other of the space enclosed by the loop. This experiment should convince us that, in varying magnetic fields (a) the e.m.f. is distributed in space instead of being confined to the source as in a battery, and (b) a voltmeter is unlikely to read the correct voltage between the points to which it is connected, unless care is taken about the position of the leads. This is particularly important to remember when dealing with radio-frequency apparatus.

With a suitable voltmeter, the whole experiment could be performed with a.c., which is a more convenient means of obtaining a continuously (though not uniformly) varying magnetic field.

After all this we may feel quite sure we know the difference between p.d. and e.m.f. It is true, as the B.S. definitions say, that both tend to cause electric currents. But the B.S. goes on to draw a distinction: the current due to a p.d. is from *point to point*; that due to an e.m.f. is *in a circuit*.

If you release electrons at A in Fig. 7 they will be repelled from it and attracted to B. We call their movement from A to B a (positive) electric current from B to A. If they moved through unobstructed space they would gain just enough kinetic energy from the field to carry them back to A, if the energy was so applied. But in a circuit the current normally encounters resistance, which diverts the energy as heat. Consequently charges cannot flow right round a circuit unless there is some agency (i.e., an e.m.f.) for bringing in energy from outside.

Even point-to-point currents would be impossible without e.m.f., needed to separate positive and negative charges to create a p.d. in the first instance. Fig. 8(a), although it looks like a circuit, is essentially the same as Fig. 7. At some time in its history an e.m.f. (not shown) must have been used to charge the capacitor. It is now discharging through a resistor. Fig. 8(b) looks very much the same on paper and (except perhaps for the time scale) the actual behaviour is similar. Both can keep the current going only so long as their store of energy lasts. But let us apply (in imagination) the test of carrying a positive charge from A to B and then back via the resistor.

In (a) we undoubtedly have to do work to give our charge enough energy to get it from A to B, even inside the capacitor. The field then gives back the energy, though we ourselves don't receive it—it goes as heat in the resistor. But we have agreed we must take that into account and find that the gain and loss exactly balance and the line integral around the closed path is zero. So no e.m.f.

In (b) we do no work getting our charge from A to B; it is done for us by the e.m.f. So there is no entry on our outgoing side of the energy account. But there is the same incoming entry as in (a), and this is therefore the net result, indicating e.m.f. at work.

Some definitions of e.m.f. (not B.S.) say that it is

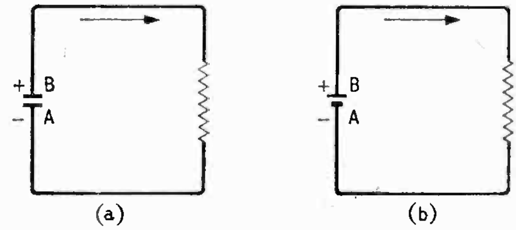


Fig. 8. These two circuit diagrams look much alike and behave similarly (if the capacitance and resistance in (a) are both very large). How similar are they in theory?

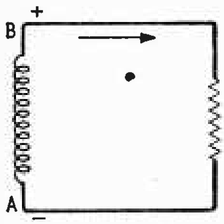


Fig. 9. To what extent is this analogous to Fig. 8(a)?

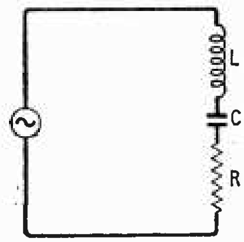


Fig. 10. Is this a circuit?

a reversible conversion of non-electrical energy to or from electrical energy. That is true of (b) but not of (a), where the energy behind the current is stored as an electric field.

Yet another distinction is that the moving charges forming the current in (b) go right round, whereas in (a) they go only from B to A, not between the capacitor plates.

Finally, in (b) there is an electric field that cannot be due to charges so it is due to an e.m.f.; in (a) there is no field that cannot be accounted for by electric charges, so where is the e.m.f.?

All these things being so, the B.S. (and most other) definitions leave no room for doubt that in (b) there is an e.m.f. and in (a) there is none, and that (b) is a circuit and (a) is not. Just before you regard the matter as closed, however, allow me to point out what you are letting yourself in for by accepting this orthodox teaching.

Compare Fig. 8(a) with Fig. 9. No one—certainly not one of the orthodox—would question that in Fig. 9 we have an e.m.f. Charges are going right round what is undoubtedly a circuit. Besides the electric field between the separated + and − charges, there is an electric field due to decline of magnetic flux linking the turns of the coil; this field is in opposition to the charge field and is responsible for the current. The electrical energy thus brought into the circuit is obtained by conversion from magnetic energy stored in a magnetic field. That energy conversion is reversible; at some previous time, electrical energy must have been put into the circuit to build up the magnetic field. It may have been derived from an a.c. generator in series which at the instant shown is at one of the two zero-voltage phases in each cycle and was therefore not worth showing in the diagram. If you took a test charge with you, it would in no way add to your effort in getting from A to B through the coil. In brief, Fig. 9 satisfies every test of an e.m.f. And on the same basis Fig. 8(a) satisfies none.

So when you come to the familiar arrangement of Fig. 10, or any other with a capacitor in series, you must stop calling it a circuit, because you cannot take a charge right round it. It is just the same in principle as Fig 8(a); merely a capacitor together with a rather elaborate system, including two sources of e.m.f., one independent and the other dependent, for charging and discharging it periodically. Your study of a.c. theory, which has taught you to regard L and C as two opposite varieties of the same kind of thing, has proved to be false. Currents in a.c. circuits are opposed in L by the e.m.f. of self-inductance and in C by something quite different. The beautiful analogy between them, on which the theory of radio waves rests, collapses. And what about Kirchhoff's second law in its orthodox form? In Fig. 10, for example, you have no difficulty about putting your two e.m.fs on one side of the equation and the one iR drop on the other. Where does the fourth voltage logically come in? I leave you to sort that one out. At least it helps one to see why the trend is towards calling them all just "voltages" and making their algebraical sum equal to zero.

Having just made such an agonizing reappraisal of orthodox views of e.m.f., you may be susceptible to some heretical suggestions. For one of these we can refer to as respectable an authority as Maxwell, who for the purpose of his great electromagnetic theory had to postulate a kind of current between the plates of a charging or discharging capacitor—or in fact any place where an electric field was varying. He called it displacement current. Although admittedly in empty space, there are no moving charges; displacement current gives rise to a magnetic field, just like a real current. And where there is a dielectric there is even a limited movement of charges, though no one charge moves continuously through.

Then if a current due to the collapse of a stored magnetic field is everywhere acknowledged to be driven by an e.m.f., why spoil the wonderful and helpful analogy between inductive and capacitance reactance and electric and magnetic fields both in space and around circuits by denying the existence of an analogous e.m.f. when the current is being maintained by the collapse of an electric field? The fact that the voltage drop across C is dependent on the current, and might therefore seem to be more like the voltage drop across R than the e.m.f. of the generator is no argument against calling the capacitor voltage an e.m.f., because it is equally true of the inductor e.m.f. And while the voltage drop across R inevitably reverses when the current is reversed, the voltage drop across C does not but behaves more like the e.m.f. of a battery. Regarding C as a source of e.m.f. abolishes the difficulty with Kirchhoff's law in its orthodox form, because every voltage is then either an e.m.f. or an iR drop.

It is a pity that as regards such an important thing as e.m.f. we must divide ourselves into orthodox and heretics. Or do we just hide our different doctrines under the umbrella of "voltage" and all remain mates together?

British Association Meeting

"THE Sun and the Ionosphere" is the title of the address to be given by J. A. Ratcliffe, F.R.S., on August 28th at the annual meeting of the British Association for the Advancement of Science being held at Southampton from 26th August-2nd September. Mr. Ratcliffe will be president of the section devoted to mathematics and physics. On the same day Professor W. J. G. Beynon will deliver an evening lecture on "The International Years of the Quiet Sun." Some of the proceedings during the annual meeting will be televised live by Southern Television.

ALOUETTE—the Canadian Ionospheric Satellite

DETAILS DISCLOSED AT AN I.E.E. LECTURE

KNOWN more familiarly as a "topside sounder," Alouette was the first earth satellite to make a full study of the ionosphere from above. This study was, in fact, primarily an attack on the "main area of ignorance" of the ionosphere which existed at the time; and the duration of the investigation was set at one year by the Canadian Defence Research Telecommunications Establishment in the programme evolved in association with the main collaborator, N.A.S.A., and D.S.I.R.

That "the satellite was successful beyond the hopes of the designers" (the C.D.R.T.E.) was stated in a recent I.E.E. lecture covering both the engineering and scientific aspects of Alouette, and given by Mr. E. D. R. Shearman and Dr. J. W. King before the Professional Group on Electromagnetic Wave Propagation.

The ionospheric sounding technique which is used is basically identical with that which has been employed for some years by ground stations to produce propagation ionograms. In this ground station method the "carrier" frequency of a pulsed radar type transmitter is swept over a wide band to give vertical echo range information over this (swept) terms of propagation time against frequency. Oblique radio path measurements are also made between two stations which are separated by an appreciable distance, e.g., the ground distance of some 1,800 miles between a sounder transmitter at Anchorage, Alaska, and a receiver at San Francisco, California.

Swept Frequency Sounding

In the case of Alouette, however, in a circular orbit at a constant height of 1,000 km above the earth, the path lengths involved are go-and-return between the transmitter and receiver in their common "site" in the satellite. Thus for the primary experiment, the measurement of electron density distribution from above the ionosphere by swept-frequency pulse ranging, the data signals are received in the satellite in simple radar form. The timebase of 15 msec (approximately 1,500 "radar miles") commences with the 100 μsec transmitter pulse. The echo signals from the ionosphere, lying within this timebase, can vary in apparent width from the transmitted 100 μsec up to 10 msec depending on the distribution relative to the satellite of the reflecting surfaces in the ionosphere. The emitted radio frequency is swept over the range 1 to 12 Mc/s during a "frame" period of 18 sec, the sounder pulse ranging "line" signals being produced with a repetition rate derived from a crystal oscillator and corresponding with the 15 msec timebase length. The data signals are mixed with appropriate frequency marker and frame and line synchronizing signals (7 msec and 100 μsec pulses respectively) to give a composite video signal with a sequential television structure.

This video signal is transmitted to the ground recording stations over a telemetry link with a high-frequency cut-off better than 15 kc/s to avoid pulse rise-time distortion with consequent loss of range resolution (the overall video response of the satellite sounder receiver is d.c. to 10 kc/s). At the same time the telemetry receiver is given a low frequency cut-off of 0.5 c/s in order to achieve proper reproduction of the frequency marker pulses (20 or 40 msec duration) and the "spread" echo signals.

Telemetry working has been covered by a world-wide network of 13 ground stations based on the N.A.S.A. Minitrack chain, but including three Canadian and three British stations. The latter are operated by the D.S.I.R. Radio Research Station who have also taken an active part in data analysis, etc., throughout the programme.

Plasma Phenomena

It will be appreciated that the mass of data which has been accumulated is such that analysis will continue for a long time to come—Alouette was launched from the Pacific Missile Range in California on September 29th, 1962. The sounder measurements are presented initially in the form of ionograms which are analysed visually, full attention being paid to the detection and interpretation of physical trends.

Among the phenomena which have been shown to have a major bearing upon the behaviour of the ionosphere are those which occur at the "plasma" and "gyro" frequencies, and which may be described as "ringing" type resonance effects.

The plasma frequency determines propagation cut-off in that virtually no transmission takes place below the local plasma frequency, the effective dielectric constant being zero with propagation phase velocity extremely high and group velocity correspondingly low. The condition is very similar to that of propagation into the ground.

These various physical effects can be considered to be taking place in a spherical section including and extending downwards from the F layer, itself centred at some 300 km above the earth where the order of pressure is 10^{-6} mm mercury. One result of the investigation has been to demonstrate the existence of isolated sheets of ionization which appear to be aligned with specific shells of magnetic force. In the satellite the echoes appear to come nearer and then recede as the ionized sheet is encountered and left behind.

The final outcome of the Alouette sounder programme is a totally different picture of ionospheric storms and the way in which they are produced by the "impact" of solar wind on to the earth's magnetic field which leads to the generation of the storm as a shock wave.

R. E. Y.

NEWS FROM INDUSTRY

SGS-Fairchild Ltd. has introduced a new range of integrated circuits specially designed for commercial and industrial markets. Although the units in this range are in the same configurations as their Micrologic and Milliwatt Micrologic units designed for military use, the temperature range and price have been reduced. They are guaranteed over the range +15°C to +55°C. In tracing the price history of integrated circuits, Mr. Peter Tagg, the company's general manager, said that a half-shift register selling at £80 in 1960 is now being sold in the military market for under £14. The functional equivalent for commercial and industrial use is priced at 62s 6d, less than 4% of its original price. One of the new units, a binary element containing 15 transistors and 17 resistors in a single die of silicon measures less than 1/250th of a square inch.

Japanese Imports.—An association to promote the orderly marketing of electrical and electronic products of Japanese origin and to guarantee the reliability, quality and servicing of the products handled by the members of the association was formed on 1st July. The founder members of the Japanese Electrical & Radio Importers Association represent the following brands: Crown, Hitachi, National, Sanyo, Sharp, Sony, Standard and Toshiba. The association has offices at 103 Kingsway, London, W.C.2, and will be known under the initials of J.E.R.A.

International Aeradio Ltd. announces a re-organization of its internal structure in preparation for the move of its London head office to Southall, Middx., in the autumn of next year. The engineering division and the technical and air traffic services departments have been amalgamated to form a new department to be known as Technical Services. Mr. A. E. Jaquemet has been appointed general manager of this department. The commercial department is now responsible for negotiations for new business and for technical sales.

New microwave links to increase the number of international telephone circuits between London and Lille in northern France, and also to provide a permanent Eurovision link—to replace the B.B.C's temporary system between Folkestone and London—are to be supplied by Standard Telephones and Cables Ltd. Transistorized 6,000 Mc/s microwave equipment, capable of carrying up to 1,800 telephone circuits is to be used on the London-Folkestone link, which will have two repeater stations. From Folkestone to Lille, an existing microwave link, completed by S.T.C. in 1959, will continue to be used to carry Eurovision signals and telephone circuits. However, this section is to be supplemented by a 4,000 Mc/s link to provide 600 extra telephone circuits. Equipment, valued at about £175,000, to meet this order is to be made at S.T.C's East Kilbride and North Woolwich factories.

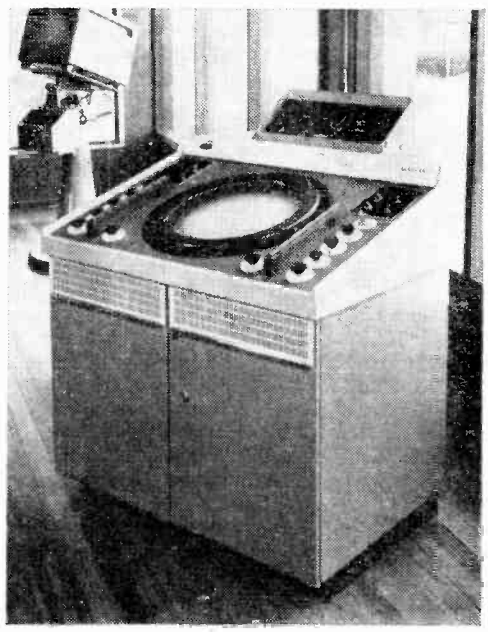
The **International Marine Radio Company** has received a substantial order from the BP Tanker Company for complete radio communication installations for eleven tankers now under construction. The new 1,200 watt p.e.p. Type ST1200 single and double sideband transmitters are being fitted and will provide 61 channels in the h.f. telegraph/telephone bands, 25 channels in the m.f. telephone band and 8 channels in the m.f. telegraph band.

The Marconi Company has received an order for £45,000 worth of "Sixty Series" v.h.f. radio communication and navigation equipment for three Trident aircraft, which are due to enter service with Iraqi Airways in the spring of next year. This order follows earlier B.E.A. contracts for similar equipment for their entire fleet of 24 Tridents.

Philips Electrical Industries Ltd., the parent company of the British Philips group, has changed its name to **Philips Electronic and Associated Industries Ltd.** This change has been made to distinguish the parent company from one of its main operating subsidiaries, Philips Electrical Ltd., which is primarily concerned with the manufacture and sale of domestic electrical goods. The newly named company will conduct its affairs under the registered business name of Philips Industries.

Pye of Cambridge Ltd. has acquired a controlling interest in **Ether Controls Ltd.,** who earlier this year changed their name from Ether Langham Thompson Ltd. Although Ether announced a loss of £38,000 for the year 1962-63 (see page 238 of the May issue), the directors of Ether estimate pre-tax profits for the year ending 27th September, 1964, will be of the order of £200,000.

Anglia Television is the first television station in the United Kingdom to place an order, valued at £10,000, with **RCA Great Britain Ltd.** for one of their new TR-5 all-transistor television tape recorders. This machine has been bought for Anglia's newly designed mobile unit. It can be used for 405-, 525- and 625-line recording at either 7½ or 15 in/sec, and operates from any 230 volt, 50 cycle supply. The power demand, including that for the forced air ventilating system, is 1.2 kW. A feature of this machine is its small dimensions, which are only 22 × 22 × 28in.



Large-screen Radar.—*A 16-inch display and a restyled cabinet are features of the new version of the Argus stabilized-screen radar introduced by Marconi International Marine. Argus 16, as it is called, includes the BONUS (Bow or North-Up Stabilization) technique introduced in the original 12-in version described in our November 1962 issue.*

Lifeboat Radio.—*A new portable radio has been developed for use in ships' lifeboats by the International Marine Radio Company, of Croydon. SOLAS II, as it is called, uses transistors throughout, weighs less than 30lb and can be operated by one man. It conforms to the new requirements of the Merchant Shipping (Radio) Rules, which come into force next year. SOLAS II can be used to transmit manual or automatic morse, a two-tone alarm signal or speech. The receiver is tunable over the 8 Mc/s marine band and also operates on the three transmitter spot frequencies:—500 kc/s, 2.182 Mc/s and 8.36 Mc/s. The accessories, which include an 18ft whip aerial, are all stowed in the glass fibre case of the set, which measures 27 × 11½ × 9 in.*

Under a licensing agreement between G.E.C. (Electronics) Ltd. and **Quindar Electronics Inc.,** of Bloomfield, New Jersey, G.E.C. Electronics will manufacture Quindar's entire range of remote indication and control equipment and market it in the United Kingdom, the Commonwealth and Scandinavia. This equipment will supplement G.E.C. Electronics' range of Teledata frequency division multiplex equipment.

Saba, of Villingen, Germany, have decided to distribute their range of domestic sound reproducing equipment in the United Kingdom. A new company has been formed for this purpose under the name Saba Electronics Ltd. and will be managed by Mr. Dennis Marks, who until recently was managing director of Grundig (Great Britain) Ltd., and operate from Eden Grove, London, N.7. (Tel. NORth 8241.)

Thorn-AEI Radio Valves & Tubes Ltd. export some 80,000 Ediswan (Mazda) cathode-ray tubes every year to the French television receiver manufacturers. At present British-made Ediswan tubes are being fitted in fifteen brands of French domestic television receivers.

(*Continued on page* 422)

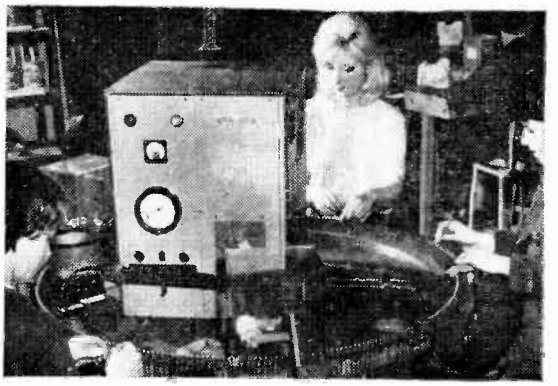
A.E.I. Radio Components.—Enquiries for radio, television and electronic components previously marketed through A.E.I. district offices, should now be directed to the Radio Components Department, Associated Electrical Industries Ltd., Barton Hill Works, Maze Street, Bristol, 5. (Tel.: Bristol 52041.)

Rediffusion Ltd.—Group trading profits and investment income for the financial year ended 31st March, 1964, amounted to £9,216,141 and show an increase of £889,003 on the previous year's result. Consolidated net profit for the year at £2,528,627 shows an increase of over £230,000 on the 1963 result. In his review, the company's chairman and managing director, Mr. John Spencer Wills, said "the improvement in profit came entirely from our home operations . . . . Income from trade investments, almost entirely accounted for by our dividends from Associated Rediffusion Ltd. [in which they have a 37½% interest], was the same as last year. Profit from our operations overseas was satisfactory, but for a number of reasons it was somewhat lower than last year's."

Brayhead Ltd. announce an after-tax profit of £194,233 for 1963, as against a loss of £9,963 in the previous financial year. In the chairman's statement to the shareholders, Mr. A. J. Richards said "I am happy to inform you that all companies are currently trading with full order books and prospects for 1964 are very bright . . . and present indications are that their profits for 1964 will not be less than £325,000." This year's pre-tax profit amounted to £300,092.

The **Ampex Corporation,** of California, announce that, compared with the previous year, sales rose 18%, to $140M, and net earning rose 16%, to $7M, in the financial year ended 2nd May, 1964. Mr. William E. Roberts, the Corporation's president and chief executive officer, said that sales outside the United States grew from 26% of the total in 1963 to 30% in 1964.

C.S.F.—Compagnie Générale de Télégraphie Sans Fil, one of the largest French electronic manufacturers, announce a net profit of Frs. 13,126,771 (approx. £960,000) for 1963, as against Frs. 12,378,938 (£906,000) in the previous financial year. Turnover last year rose by more than 13%, from Frs. 534,198,000 (£39M) in 1962, to Frs. 604,150,000 (£44M). Consolidated group turnover, including foreign subsidiaries, increased by more than 17% and exceeded Frs. 1,100,000,000 (£80M).



Semi-automatic machines like this one, which is used for precision soldering of small assemblies, are installed in Egen Electric's components factory on Canvey Island, Essex. Over half the factory's output, which is in excess of ten million components a year, is potentiometers. Attenuators and strip switches for TV sets are also made by this company.

Dansette Products Ltd. show a pre-tax profit of £251,763 for the financial year ended 31st March, 1964. This figure is just under £100 more than the previous year's result, which, incidentally, showed a drop of over £170,000 on the 1962 result. Tax this year took £133,848 as against £142,213 in 1963, leaving a net profit of £117,915 (£109,463). The company believes these results to be very satisfactory, particularly when the high costs of the company's move into the new factory at Honeypot Lane, Stanmore, Middx., are considered. Mr. Samuel Margolin, who has been with the company 12 years, now has control of the company's design and research and was recently appointed to the board.

Controls and Communications Ltd. announce a consolidated profit for the year ended 31st March, 1964, of £650,579 as against £567,263 in the previous financial year. The charge for taxation is £315,585 (£247,375) and the balance of profit for the year is £334,994 (£292,888). The net profit for the year amounted to £250,520.

Hitachi Ltd., of Tokyo, one of Japan's largest manufacturers, whose products range from a variety of electronic components and equipment (including computers, communications and broadcasting apparatus and scientific instruments) to complete power generating stations and railway rolling stock, announce net sales of Yen 370,000,000,000 (approx. £370M) in the financial year ended 31st March, 1964. This represents an increase in turnover of £26M on the previous year's result, £41M on 1962 and £117M on 1961. Net profit after taxation and other deductions this year totalled £14M and shows an increase of over half a million on 1961 and 1963, but a decrease of £1½M on the 1962 results. Communications and electronic apparatus expressed as a percentage of the group sales for the past five years were 8.2%, 6.2%, 5.6%, 6.7% and 7.6%.

G.E.C. Trading Profit Up £5.6M. The General Electric Company announce a trading profit of £12,965,841 in respect of the financial year ended 31st March, 1964. Taxation took £5,881,167 as against £3,150,228 in the previous year, leaving a net profit, after deductions, of £5,619,342 (£2,769,988).

Ferranti Ltd. announce that the company's group net profit for the year ended 31st March, 1964, amounted to £980,665 as against £778,772 in the previous financial year. Mr. S. Z. de Ferranti, the company's chairman, said in his statement to shareholders that he wanted to settle the controversy of the Bloodhound guided missile to the satisfaction of all concerned. He also mentioned that "development and production of Bloodhound II is well in accordance with the plans, and this weapon system shows every promise of being a great success."

Consolidated trading profit of **Ultra Electric (Holdings) Ltd.** for the year ended 31st March totalled £131,230 and represents a drop of over £150,000 on the previous year's result. However, net profit for the year was only £4,412 down at £76,911.

Group pre-tax profit of the **Simms Motor & Electronics Corporation** for 1963 amounted to £1,557,904 and shows an increase of over one million on the previous year's results. Consolidated profit after providing for taxation was up almost half a million at £750,904. The chairman and managing director, Mr. G. E. Liardet, told the shareholders that Dawe Instruments Ltd. had made satisfactory progress in overcoming difficulties from the previous year and N.S.F. Ltd., another subsidiary, has set an all-time profit and turnover record. He also mentioned that Dawe Instruments have agreed to found a lectureship (to be known as the Dawe Lectureship) at Southampton University.