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Wireless World

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COMMUNICATION VIA SATELLITES

THE idea of long-distance communication by reflection from or relay by artificial earth satellites has been with us now for at least 15 years. At first it was treated as a rather pleasant exercise in speculation, and even today it is often difficult not to regard it as still part of science fiction. But the hard facts are that commercial interests in all parts of the world are putting teams of engineers and scientists to work on the detailed design of systems which are now feasible, thanks to advances in rocket propulsion, u.h.f. and s.h.f. generation and the techniques of noise reduction in receivers. In America ground stations have been built and satellites of both the passive ("Echo") and active ("Score" and "Courier") kinds have been put into orbit to prove the merits of alternative methods.

Quite apart from the natural reaction of those nations who can afford to meet the scientific and technological challenges of space exploration, the military advantage of reliable communication and the commercial gains awaiting increased traffic handling capacity are sufficient justification for the present expenditure on satellite communications.

In the band width available a million telephone channels could in theory be provided for about the same cost (£88 M) as the proposed Commonwealth round-the-world cable, which has a capacity of only 80 telephone (3kc/s) channels. That is not to say that the Commonwealth telephone cable project should be scrapped. It is based on a proved system and one which will fit into any future scheme of world communications.

Before satellite communication systems can carry the load of daily traffic, many years of testing and development lie ahead. There is no lack of feasible ideas and many have been worked out in considerable detail. The case for one type of active satellite system is stated in an article published in this issue, and equally detailed analyses of other proposals can be read in *Proc.I.R.E.* for April 1960. No doubt fresh ideas will appear in the Brit. I.R.E. Communications and Space Research Convention, which is to be held in Oxford next July.

Everything is in a state of flux but, as things stand at present, passive satellites in 24-hour orbits, and thus apparently fixed 22,300 miles above points on the equator, would seem to offer the best solution. The reflection process is linear and no problems arise from cross-modulation; but a large structure, preferably spherical, is required to return an adequate and constant signal. No one yet knows whether such a reflector can be placed exactly in the right orbit, and if so how long it will stay there under the influence of sun and moon gravitational perturbations, radiation pressure or meteor impacts. A better short-term policy would seem to be to use several lower-altitude, shorter-period reflectors spaced so that at any time at least one was above the horizons of both transmitting and receiving stations. Such reflectors can be placed in orbit (with relatively few misfires) by rocket vehicles at present in quantity production, but the system presents difficulties in location and tracking, in following Doppler frequency shifts and in smooth transition from one satellite to another to maintain a continuous service.

Active satellites simplify problems of signal-to-noise ratio and, being more solid and compact structures, are probably less vulnerable to meteor damage than thin metallized balloon reflectors. Being equipped with solar cells they can no doubt find the energy for position and attitude correction under ground control, if enough ejection matter can be included in the payload to provide the necessary reaction. Attitude stabilization can be neglected or reduced if less directional aerials (of lower gain) are employed—but at the price of high transmitter power and more weight. In low-altitude active satellites, which travel for a large part of their time in the earth's shadow the problem of energy storage is important and there is room for the development of batteries of even higher capacity/weight ratio which will work for long periods when sealed.

Thanks to parametric amplifiers and masers, noise in receivers is no longer a limiting factor and a limit to performance in this respect is now set by cosmic background noise. The selection of suitable modulating systems under the guidance of information theory has further extended the distance at which reliable signals can be exchanged. Much has been learnt from experience with telemetry, and the successful communication with Pioneer V out to a distance of 23 million miles gives the measure of present-day performance.

Looking to the future and assuming that one or more of the available communication systems is put into service, there still remains the very big problem of interference. Passive reflectors are aperiodic and will return to earth any u.h.f. and s.h.f. signals which would otherwise have penetrated the ionosphere and been lost in space. Active satellites will add their quota to a rising interference level and will themselves be vulnerable to interference. The whole future of satellite communications will depend more than anything else on the decisions of an Extraordinary Administrative Radio Conference of the International Telecommunication Union to be called in 1963, and on the readiness of all concerned to abide by the decisions then to be taken on frequency allocation.

ACTIVE SATELLITES

By L. POLLACK *

PROSPECTS FOR WORLD-WIDE COMMUNICATION SYSTEMS

Paper presented at the U.R.S.I. XIII General Assembly, London, September, 1960

THE subject of earth satellites as radio relays has received great attention in the communication industry during the past several years. The need for such satellites to extend the capacity of commercial long-haul systems has been well documented, and it is now a generally accepted fact, to we who are close to the subject at least, that the capacity of international communication routes may be most economically increased by an artificial satellite relay system.

Various systems of satellites such as passive and active, at low altitude orbit and synchronous altitude orbits, have been analysed for application as multichannel communication relays, by several authors, e.g., Pierce and Kompfner in *Proc. I.R.E.*, March, 1959. As a result of similar studies at I.T.T. we have concluded that an active satellite repeater in a synchronous orbit will prove to be the most economical system.

Development of this active system, however, will probably progress from the low-altitude type to the synchronous orbit "real time" repeater.

General System Constraints

Factors such as choice of operating frequency and modulation scheme apply with equal weight to all satellite relay systems. With respect to the operating frequency, operation must be in the 1 to 10 kMc/s band as determined by cosmic noise and atmospheric absorption, considerations which have been described elsewhere† and are summarized in Fig. 1. In active systems where weight of the satellite is so important, two further factors are considered in determining the optimum frequency: (a) satellite r.f. components, particularly power amplifiers, diplexers and antennæ decrease in size and weight with increasing frequency; and (b) the efficiency (d.c. power input, r.f. output) of radio-frequency amplifiers seems to improve with the number of applications for such amplifiers; at present substantially higher efficiency is available at lower frequencies.

This question of transmitter efficiency is the more important in determining the weight of the satellite and the cost of placing it in orbit. Improvement in efficiency decreases the weight of power supplies rapidly, particularly in present supplies using solar cells and rechargeable batteries. In addition, with increased efficiency, the problem of heat dissipation is ameliorated and the weight of heat sinks or radiators will be less.

The selection of an operating frequency, then, becomes a matter of determining which of the frequencies between 1000 and 10000 Mc/s can be generated and transmitted most efficiently. At the present state of the art this seems to be in the 2000 to 4000 Mc/s band.

Since satellite power is limited, the modulation method that will yield the desired channel signal-to-noise ratio, say 50 to 55 dB, with the least transmitted power is preferred. Therefore, a type of modulation is indicated which will yield substantial improvement of the channel signal-to-noise ratio over the carrier-to-noise ratio at the expense of bandwidth.

For the active relay the choice of modulation is further limited by the peak-to-average ratio of the multichannel modulated carrier or carriers, particularly if a beam type amplifier such as a travelling-wave tube is used in the output stage of the satellite.

System Description

Let us consider two systems which may illustrate the instrumentation that will be used:

(a) **Delay Repeater Type.**—The first system, a delayed repeater type known as project Courier, has been in operation since the launching of the satellite on Oct. 4, 1960.

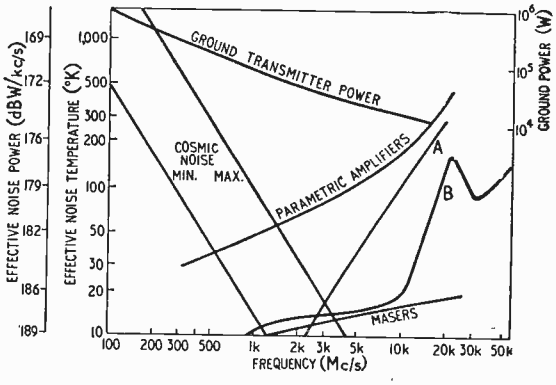


Fig. 1. "Noise"-frequency curve. The effective noise power scale is in decibels referred to 1 watt per kc/s bandwidth. Curves A and B show respectively absorption during heavy rains and clouds, and oxygen-water vapour absorption above 10° antenna elevation.

The programme (directed by the U.S. Army Research and Development Laboratory) brought together the efforts of the I.T.T. Corporation for the ground stations, the Philco Company for the satellite, and Radiation, Inc., for the tracking antennæ. Two stations were linked during the first experiments, one

* I.T.T. Laboratories, Nutley, N.J., U.S.A.

† Radio Communication Using Earth-Satellite Repeaters. L. Pollack, *Electrical Communication*, Vol. 36, No. 3, 1960.

at Ponce, Puerto Rico, and the other at Deal, New Jersey.

In the Courier concept, each ground station can accommodate the output of 20 teleprinter machines operating continuously at 100 w.p.m. The messages are recorded at slow speed on magnetic tape (about 1.6in/sec) during the time the satellite is not in view. When the satellite, which is in a 650 nautical mile orbit at 28° inclination, comes into view, the ground station transmits the recorded signals at higher speed, 60 in/sec, and the satellite stores them on magnetic tape. Simultaneously, previously stored messages are transmitted to the ground, on another frequency, and later played back at the 1.6in/sec speed to a paper tape punch for eventual teleprinter machine read-out. The klystron recorder and control console are shown on the right of Fig. 2. Each of the four digital types of satellite tape machines can record 15 million bits. A fifth machine is an analogue recorder.

Fig. 2. Control console, klystron recorder and tape machines in the control van for the Courier project.

The satellite normally transmits a 50 mW v.h.f. beacon signal for acquisition and tracking. When it comes within range of a ground station, a coded command from the v.h.f. ground transmitter to the v.h.f. receivers in the satellite will activate the satellite u.h.f. transmitters and receivers.

Operating in the 1700 to 2400 Mc/s band, the four satellite message transmitters permit reception at the ground of horizontal and vertical polarization at two frequencies. The H- and V-polarized transmissions at each frequency are combined prior to detection in the ground receiver at i.f. The two base band outputs are further combined, yielding a four-fold diversity system which will resist signal variations caused by satellite tumbling and nulls in the antenna pattern.

The 1-kW ground transmitter, through orthogonal illumination of a 28-foot parabolic reflector, directs a circularly-polarized signal to the satellite receivers. The 4-watt satellite transmitter output and ground receiving system noise figure of 3 dB should yield a signal-to-noise ratio of better than 21 dB at the maxi-

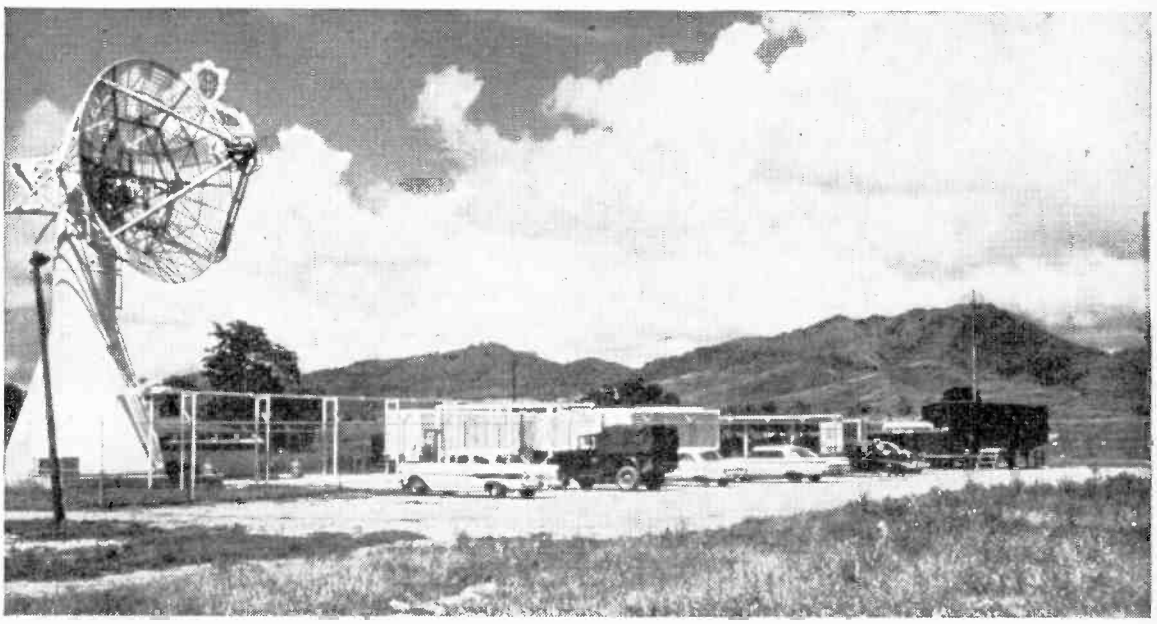


Fig. 3. The Ponce, Puerto Rico, ground station for "Courier."

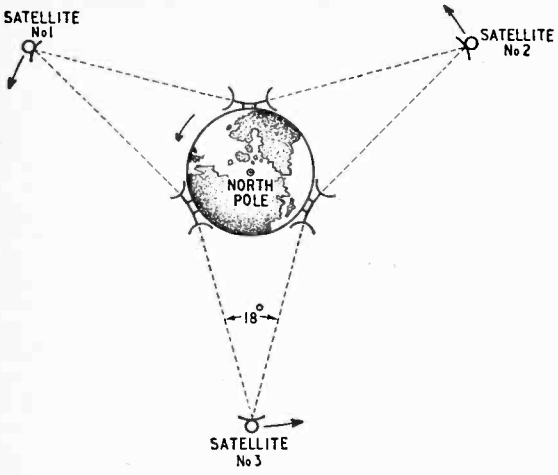


Fig. 4. Synchronous-orbit satellite system. The vehicles are in an equatorial orbit at 22,300 miles. Their orbital speed and the rotational speed of the earth are 2π radians per 24 hours so that they maintain a constant position relative to the earth.

mum slant range. This corresponds to an error rate of better than 1 part in 10^5 at 2700 miles. A photograph of a complete ground station is shown in Fig. 3.

(b) Synchronous Orbit Real Time Repeater.—The single delayed repeater satellite may be the economical method for teletype or other digital transmission when a delay of as much as 12 hours can be tolerated. However, it is the synchronous orbit repeater which is expected to meet economical telephone standards.

The commercial system that we have designed for early implementation would operate in the 2 to 4 kMc/s band. The satellite would weigh less than 450lb to use available booster rockets, e.g., the Atlas-Agena, and would carry a simple wideband repeater with an assured operating life of at least one year.

A three-satellite synchronous-orbit system, shown in Fig. 4, would furnish communication to most of the inhabited areas on earth.§

The satellite vehicles would be attitude and position controlled to keep station at points in space above the mid-Atlantic, mid-Pacific and Indian Oceans.

The maximum gain satellite antenna has a beam width of 24° which allows a margin of ±3° for attitude control error in addition to the 18° required for hemispherical coverage. The radio repeater block diagram shown in Fig. 5, is a simple ultra-high frequency translator using all solid state components except for a single travelling-wave tube which will amplify the translated signal and simultaneously generate the translating frequency.

The command and control signals, for operating the propulsion system and turning on a spare u.h.f. translator, should this be required, plus the telemetry signals, which indicate operating conditions in the satellite, will be radiated over a separate v.h.f. transmitter.

By frequency-modulating the carrier with the multi-channel information in pulse code form, the travelling-wave tube can be operated at power output saturation with good efficiency (perhaps 25-30%).

The ground station would use 60-ft diameter reflectors and parametric converters, with a receiving system noise temperature of 95°. If we take, for example, the usual p.c.m. case of a 6-bit code at a voice channel sampling rate of 8 kc/s the base-band bandwidth for the assumed 960 channel system is 2.3×10^7 c/s. To transmit the information with the least power, a gaussian shaped band-pass response is used.

The 3-dB bandwidth of the overall system would be 46 Mc/s to obtain an acceptable inter-channel cross-talk ratio. Since the pulse information frequency-modulates the f.m. threshold, the r.f. carrier must be exceeded. In addition, there is a p.c.m. threshold below which noise improvement fails; this point is reached when the pulse signal cannot be separated from noise with great certainty. An r.m.s. base-band signal to r.m.s. noise of 9 dB is an acceptable threshold value.

The carrier power required (in dB referred to 1

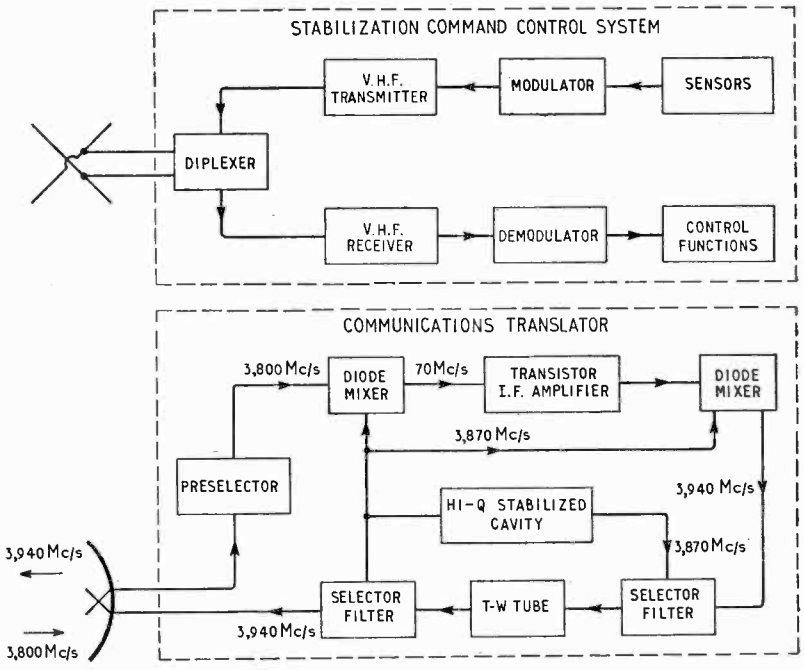


Fig. 5. Schematic of satellite communication equipment using solid-state components and one travelling-wave tube.

§ This system was first suggested by A. C. Clarke in *Wireless World*, October, 1945.—Ed.

watt), neglecting for the moment the f.m. threshold, is:

$$P_{tr} = -10 \log \frac{1}{KT} + 10 \log B - 20 \log \frac{\sqrt{3}\Delta f}{f} + 9 + L$$

B = I.f. bandwidth
L = Path loss in dB (the sum of receiving and transmitting antenna gain and free space loss)
K = Boltzmann's Constant 1.38×10^{-23}
T = Effective temperature of the receiving system, i.e., receiver noise temperature + antenna temperature.

If in addition we use a synchronous demodulator, the p.c.m. threshold of 9 dB will determine the system breaking point.

With such a receiving system a satellite power output of five watts would allow a 9 dB margin above the system threshold. The satellite's overall dimensions are:—length 5ft and diameter 3ft. The major portion of the weight of 450.b is due to the station-keeping propulsion equipment, the control system, and the vehicle frame. The electronic equipment weighs only 80lb. The 5-watt translator, operating on 3.7-4.2 kMc/s, with a bandwidth of 50 Mc/s, has a capacity of 500 channels.

In the particular case considered here, small solid fuel rockets such as used in the Tiros weather satellite will correct initial orbit injection velocity and position errors. Once the satellite is in proper orbit propulsion along the three axes for station keeping will be accomplished with gas jets.

The satellite attitude reference system consists of an infra-red horizon sensor to determine the earth vertical and horizontal. A sun sensor will provide orientation of the solar collectors and the third plane of reference. Corrective torques are applied whenever the satellite attitude or position drifts beyond specified limits. Thus, the satellite will slowly oscillate about a nominal position between pre-set limits.

Traffic Requirements

Initially, a world-wide system channel allocation could be arranged as shown in the Table. The Atlantic satellite would link Western Europe, Africa, all of South America and Eastern United States. This satellite would handle the greatest traffic, with a total of 960 voice channels. These allocations are based on traffic studies for the immediate future rather than long-term estimating. The channel allocations for the Pacific and Indian Ocean satellites are based on linking small as well as large countries where growth in communications has been hampered by natural barriers.

By initially designing a wide-band system with sufficient channel capacity to apportion traffic to all interested countries through international agreement, it is hoped the problem of unauthorized use of the satellite will be avoided.

Problems

It is recognized that several factors in the ultimate establishment of the satellite system require development to achieve a fully operational commercial system. The life of the satellite repeater has been mentioned. The life of components can reach ten to twenty years, as demonstrated by submerged repeater experience. We have proposed a time division system; however, the synchronization accuracy required has not been achieved. The launching vehicles and the space tracking networks to control orbit injection have been developed to a high state of perfection by the Defense Department and National Aeronautical and Space Administration as part of our weapons and space science programme. Attitude control devices which must cycle on and off many thousand times during a one-year life must be proved. The operating frequencies for the satellite system must be allocated and international agreement obtained.

A 960 channel system, such as envisaged for the Atlantic satellite, would occupy a 50 Mc/s band for the duplex transmitting and receiving channels.

The useful bands available for a common carrier system under present F.C.C. allocations are 2110-2200; 3700-4200; 5925-6425; and 10700-11700 Mc/s.

If for the moment we assume we can share frequencies with common carrier line-of-sight stations, the bands 3700-4200 or 5925-6425 Mc/s would appear attractive since these fall close to the optimum frequency for communications through a satellite radio repeater and a 500-Mc/s band, well in excess of our requirments, is available.

The line-of-sight transmitters in common carrier service operate at less than 10 watts output with antenna beam widths of less than 10°. At the synchronous orbit altitude the interference of these line-of-sight transmitters with the satellite is certainly negligible. Similarly, the 10 watts or less radiated by the satellite will not interfere with the line-of-sight receiver by a margin of 30 to 40 dB. The problem then is with the satellite system ground transmitter possibly interfering with the line-of-sight receiver and alternately the line-of-sight transmitter interfering with the satellite system ground receiver. It has been shown that by restricting the elevation angle of the satellite system antenna to *not* less than

VOICE CHANNEL ASSIGNMENTS

Atlantic Satellite	
England	144
Germany	96
France	72
Italy	24
Switzerland	24
Belgium	12
Denmark	12
Netherlands	24
Norway	12
Sweden	12
U.S.A.	288
Cuba	24
Bahamas	12
Puerto Rico	24
Argentina	24
Brazil	24
Venezuela	36
Colombia	24
Bermuda	12
Dominican Rep.	6
Ethiopia	6
South Africa	6
Belgian Congo	6
Morocco	6
Nigeria	6
Egypt	6
Inter-Sector	18
	960

Pacific Satellite	
Hawaii	48
New Zealand	36
Australia	72
Japan	72
Philippines	48
Eastern U.S.S.R.	48
New Guinea	12
Alaska	12
Inter-Sector	36
	384

Indian Ocean Satellite	
Central U.S.S.R.	96
China	36
Borneo	12
Saudi-Arabia	6
Turkey	6
Israel	6
Greece	6
India	36
Pakistan	6
Afghanistan	6
Iran	6
Inter-Sector	18
	240

10° above the horizon, a prerequisite to avoid noise due to the hot earth, and the choice of site to areas where low man-made noise conditions prevail, will avoid, ground-terminal-to-ground-terminal interference. A calculation of a typical system at 3 kMc/s would show that a separation of 30 miles between competing stations would assure that the interference level is 20 dB below the desired signal.

These thoughts consider the immediate future, perhaps the next ten years; however, thinking of the long-range growth of communication requirements, several common carrier trunks will be required across the oceans. To accommodate the expansion ten to twenty additional 50-Mc/s bands will be required. The provision of a frequency allocation for the exclusive use of these earth-space-earth relaying services will indeed be a difficult problem.

The time delay in transmitting from one ground station through the satellite to another ground station is about 0.5 sec. Operational tests of the disturbance caused by this delay to the conversing parties indicate that it is not serious. In fact, the observers participating in the tests were not aware of the delay until it was called to their attention. Delays longer than 0.5 sec, with appreciable echo present, were annoying. Increased attention to echo suppression at the subscriber terminals will be necessary.

It is interesting to consider the economic potential of the 24-hour satellite system. The estimated cost of a small ground station (6-12 channels) is $400,000 and that of a large station (70-280 channels) $1M. The first cost of the ground system and operation for ten years allowing for twenty high-capacity and twenty low-capacity stations is estimated at $50M, based on an annual operating cost of $1M for the large stations and $500,000 for small stations. Assuming four misfires in placing the first satellite in orbit and using existing government launching facilities, the cost of the first satellite in orbit is expected to be $30M. With time, misfires should decrease, and in a ten-year period, the satellites would be replaced four times at an approximate total cost of $130M. The over-all cost of the system, then, is $180M—an average of $18M per year over the ten-year period. F.C.C. statistics for communication carriers for the year 1957 indicated a gross revenue per overseas telephone channel of approximately $85,000. Considering the trans-atlantic satellite with 960 channels, with the present channel utilization factor and the same message charges, the gross income would be in excess of $80M per year.

Comparing this income of the single Atlantic satellite with the estimated cost of $18M per year for the system indicates that it would certainly pay for itself and suggests the strong possibility of a substantial reduction in the tariff charge per message.

With this note of optimism I conclude.

Electronic Railway Signal-Interlocking

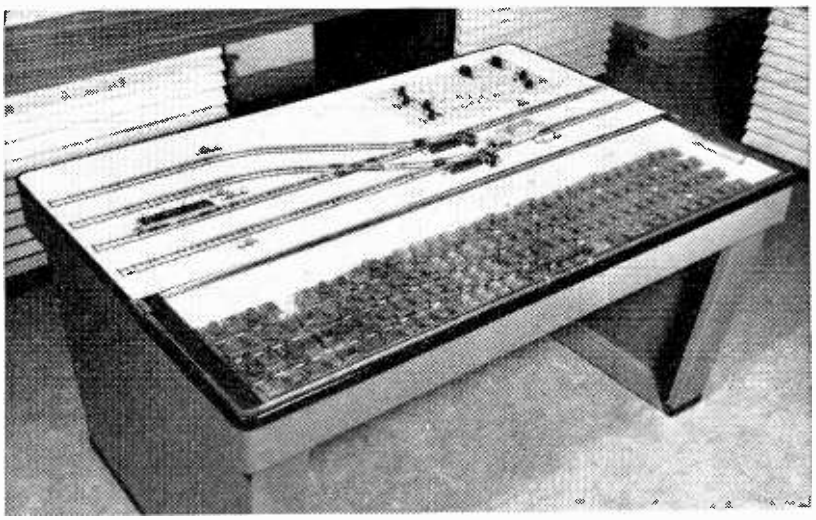
THE Western Region of British Railways are to install at Henley-on-Thames what they believe to be the first electronic signal-interlocking system in the world.

The plant, developed by Mullard Equipment, Ltd., employs solid-state circuitry exclusively, the avoidance of mechanical components introducing great economies in maintenance costs.

The logic of the system is composed, in the main, of "AND" gates with inputs from the track circuits. The signal controls are of the "switch entrance, push-button exit" type, and the state of each route is indicated by appropriately coloured lights in the signal-box. Inputs from all track circuits and points are required by a succession of "AND" gates before the exit push-button can conclude the logical sequence initiated by the entrance switch. If any part of the route is in the wrong state, the route cannot be cleared, and the signals remain at red. When a train has passed the first track circuit of its cleared route, the entrance signal is automatically returned to red, and the route cannot be used again until the logical sequence has been repeated.

The system is arranged to "fail safe"; any fault occurring in the logic circuitry causes all signals to return to red. In addition, a route set up incorrectly by the signalman may not be corrected immediately. All signals must first be set to red, and the route set up correctly after a sufficient time-delay to allow the train to stop has been imposed automatically.

The plug-in logic units, employing semiconductors and ferrites, are capable of operating reliably over a wide temperature range.



Simplified demonstration model of the signal-interlocking system to be installed at Henley-on-Thames signal-box.

Applications of Frequency-Sweep Oscillators

1.—DIRECT TEST AND MEASUREMENT

By R. BROWN

The basic principle of the frequency-sweep oscillator is that its r.f. output, whilst remaining constant in amplitude, is changed in frequency at an a.f. rate. This variation of frequency may be accomplished, in the electrically-simplest units, by a motor-driven tuning capacitor or some other form of mechanical modulation. In more recent instruments, however, the wide-band frequency modulation or sweep is accomplished electrically, typical means being a back-biased semiconductor junction, a reactance valve or a section of ferrite material whose effective permeability is varied by an a.c. passed through a winding. These devices are connected in the frequency-determining circuits of an oscillator and the voltage or current used to vary the frequency of the oscillator also deflects a c.r.t. spot, so forming a line. Points along this line then represent frequencies, rather than times, as they would on the x-trace of a normal c.r.o.*

ONE of the most time-consuming and boring tasks that have to be carried out in the construction or repairing of electronic equipment is the adjustment and measurement of frequency-response curves. It is here that the frequency-sweep oscillator, wobbulator, or sweep generator, as it is variously called, comes into its own. Its use always brings about a very great saving in time, and in most of its numerous applications the skill required is very much less than would be required were other types of instrument or techniques used.

Perhaps the best known application of this instrument is the alignment of intermediate-frequency amplifiers. The block diagram of apparatus set up for displaying the response curves of such amplifiers and similar equipment is shown in Fig. 1. A timebase is used to sweep the frequency of the oscillator across the passband of the equipment under test. The output from the tested equipment is detected and displayed as y-axis deflection of an oscilloscope. The oscilloscope timebase is synchronized with the sweep of the oscillator, so that distances along the horizontal axis of the display are a function of oscillator frequency. Distances along the vertical axis of the display will, of course, be proportional to the output of the equipment, that is to the gain or response. The trace thus represents curve of the gain/frequency characteristic of the tested equipment.

Calibration

This displayed response curve is very informative; but if the aim is accurate alignment some means of calibrating the x and y axes, that is frequency and gain scales, must be included in the instrument. The first necessity is a datum or horizontal line corresponding to zero gain and, therefore, no output from the equipment under test. This datum line can be produced by pulse modulation of the frequency-sweep oscillator, so that it is switched off during each alternative oscilloscope scan. The oscilloscope will thus display the response curve on one scan, and the datum line on the next scan.

Frequency calibration can be carried out by mixing the output of the frequency-sweep oscillator with the output from a separate marker oscillator: or, alternatively, by connecting an absorption-type wavemeter to the output of the frequency-sweep oscillator. The markers produced by the first method are known as "active" markers, whilst

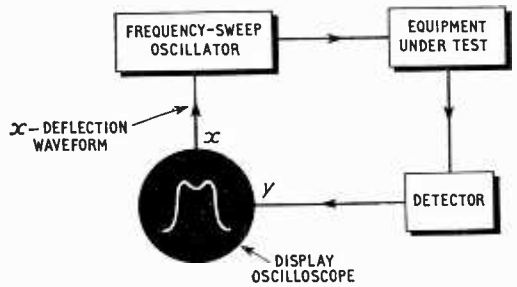


Fig. 1. Typical arrangement of apparatus for displaying amplitude/frequency response curves.

those produced by the second method are described as "passive" The source of markers can be a variable-frequency calibrated oscillator—a signal generator for example—or it can be a crystal oscillator. The output from the frequency-sweep oscillator will beat with the marker oscillator and when their frequencies approach synchrony, this beat will show up on the displayed response curve. If a crystal is used, its frequency can be chosen so that the frequency-sweep signal will beat with the individual harmonics of the crystal and produce a series of markers at fixed intervals.

Active markers would, if produced as described above, be required to pass through the equipment; but some may well occur at frequencies outside the

* See, for instance, *Wireless World*, Vol. 62, p. 252 (June, 1956).

equipment's passband and thus not visible: they might also be difficult to see on the skirts of the response curve. This defect can be avoided if part of the swept-frequency signal is tapped off and mixed separately with the output from the marker oscillator; the beats so produced can, after passing through a low-pass filter to limit their width, be mixed with the detector output and displayed.

The beats produced by both of these methods of producing active markers do distort the trace to some extent. A better approach is to shape the beat produced by this secondary process into a narrow pulse. This narrow pulse is then used to modulate the intensity of the oscilloscope beam so that the spot is extinguished when a beat occurs. The blank point produced can be made very sharp, and it gives a very distinct marker which does not distort the response curve.

Passive markers are produced, as has been said, by connecting an absorption wavemeter across the output of the frequency-sweep oscillator. The wavemeter will absorb some of the energy in the signal when the signal frequency coincides with the wavemeter frequency, so a dip will appear in the displayed response curve. This type of marker is sometimes difficult to see, particularly on the skirts of the response curve or near the cross-over point of an f.m. demodulator. If the equipment under test includes an efficient limiter, the marker may not appear at all.

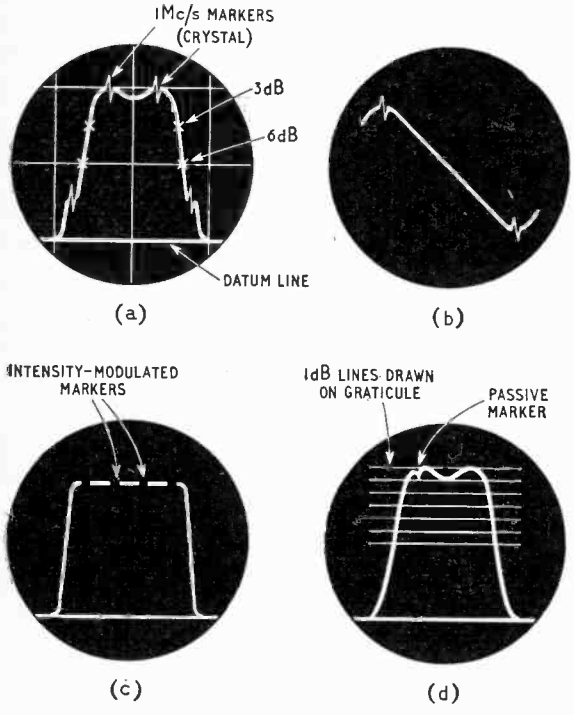


Fig. 2. Typical displays: (a) response curve of bandpass amplifier showing active crystal markers at 1Mc/s intervals and datum or zero-output line. —6dB and —3dB points are estimated on the display, —6dB being half way (half output) between zero and top of curve. (b) F.m. discriminator showing crystal markers. (c) Wideband amplifier response curve with intensity modulation of c.r.t. beam for markers. (d) Bandpass amplifier curve with passive (absorption wavemeter) marker. Lines drawn at 1dB intervals enable amplitude measurements to be made.

Relative amplitudes within the response curve can be roughly estimated from the display. If, however, an attenuator is fitted to the frequency-sweep oscillator the oscilloscope graticule can be calibrated accurately. This can be done in the following manner:—

A horizontal line is first drawn on the graticule at the height of the top of the response curve; the oscillator output is then reduced by a convenient amount, say 1dB, and a second line is drawn at the new position of the top of the response curve. The oscillator output is then reduced in level in further steps of 1dB, a horizontal line being drawn at the height of the top of the response curve at each step. When the oscillator output is restored to its maximum level, the relative levels of the different points on the displayed response curve can be accurately determined by making use of the series of 1dB lines that have been drawn.

Some typical response curves are shown in Fig. 2. The various types of frequency marker are shown, and also two methods of assessing relative levels within the displayed response curve.

In some applications such as equipment alignment on a production line a large number of similar items have to be aligned and checked. A considerable saving in time and skill can be achieved by displaying the response of the equipment under test and a correctly adjusted equipment simultaneously. Fig. 3 shows a suitable arrangement. Two detectors and a double-beam oscilloscope are used: on one beam of the oscilloscope is displayed the response curve of the equipment under test, while on the other beam is displayed the response curve of the standard correctly-adjusted equipment. All the operator has to do is adjust the components in the equipment under test until the two response curves are identical. There is no need then to refer to any frequency or amplitude calibration.

Sources of Error

There is a tendency for the frequency-sweep generator to be used only for the initial alignment of amplifiers, filters etc. and reliance to be placed on well proved point-by-point methods for making the final adjustments and for carrying out precise measurements on the equipment under test. Yet, if reasonable precautions taken, sweep-generator measurements will be found to yield results which are quite as accurate as point-by-point measurements.

Sweep Rate.—One of the most important points over which care should be taken is the rate at which the frequency of the generator is swept[1]. It is essential that the sweep rate is slow enough to allow the voltages in all the circuits in the network under test to reach their full amplitude. The circuit time constants are not important when making measurements at one frequency, for there is then ample time for all the circuits to reach their steady-state condition; but if these time constants are not taken into consideration when using sweep-generator techniques serious errors can occur. The effects of having too fast a sweep rate are unfortunately not easily recognizable except in extreme cases, and these cases are not often met in practice.

In the event of the sweep rate being too high

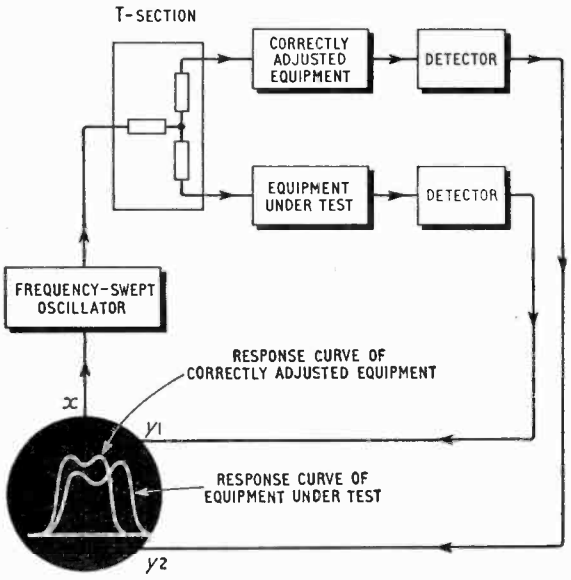


Fig. 3. Arrangement of equipment for use on repetitive work. Double-beam c.r.o. displays, superimposed, both desired (from previously adjusted equipment) curve and that obtained from equipment under test.

there will not be sufficient time to allow the voltages in the circuit to reach their normal maximum value, the response curve displayed will have a lower amplitude than the actual response curve. Also, even after the frequency of the sweep generator has been swept past the top end of the passband of the network under test there will still be some output from the network as the circuits slowly return to the no-signal condition. These effects produce in addition to a reduced amplitude, an apparent increase in bandwidth, a displacement of the displayed response curve in the direction of the sweep, and an asymmetrical response curve with the trailing edge stretched out more than the leading edge (Fig. 4). In extreme cases a damped oscillation can be produced after the trailing edge of the response curve; but long before this effect becomes apparent the other effects will have produced very serious errors.

There is luckily a very simple method which can be used to determine approximately, for any given circuit, the maximum permissible sweep rate. This is based on the response, to a swept-frequency signal, of a resonant circuit of bandwidth B_g which has an amplitude characteristic approximating to a gaussian error-distribution curve. The relationship between the sweep time t(sec), the sweep width w (c/s), and the bandwidth B_g (c/s) of such a circuit can be expressed by the following formula:—

$$A = 1 + 0.195\,(w/tB_g^2)^2 - \tfrac{1}{4} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where A is the ratio of the displayed amplitude to the amplitude that would be measured were point-by-point methods of measurement used. From this it would appear that correct results will only be obtained with point by point measurements; but small errors can be accepted and for most purposes an error of less than 5% is not serious. This allows the simplification of Equation (1):—

$$B_g = \sqrt{(w/t)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

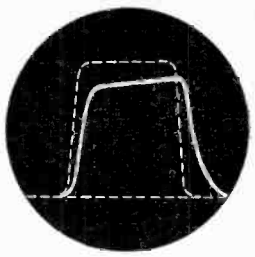


Fig. 4. Effect of sweep rate too high. Dotted curve is true response, full line shows display with asymmetrical, low-amplitude curve displaced in direction of sweep.

B_g now gives the minimum bandwidth that can be correctly displayed for any given sweep rate.

These two equations are correct where the rate of change of frequency is linear with time—a condition which holds when the waveform of the voltage used to control the sweep is a sawtooth. In some sweep generators, however, the sweep-control voltage is sinusoidal as it is obtained from the a.c. mains supply. Thus the rate of change of frequency will vary throughout the sweep and, where this is the case, it is necessary to use the maximum sweep rate as the basis for obtaining the minimum bandwidth that can be correctly displayed. A sine wave is steepest at the point where it crosses the zero axis and, at this point, the frequency will be swept at 1.57 times faster than would be the case were a sawtooth waveform used. Hence for a sinusoidal sweep waveform Equation (2) must be changed to:—

$$B_g = \sqrt{1.57w/t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

In many cases the shape of the response curve of networks does not conform to a gaussian error-distribution curve, and there does not seem to be any simple means of determining directly with the fastest permissible sweep rate. The most common type of response curve which does not conform to a gaussian error curve is shown in Fig. 5. This has a flat top with very steep sides, and is typical of the response curves of many filters and wideband amplifiers. The critical portions of such a response curve, as far as maximum sweep rate is concerned, are the leading and trailing edges, the width of the flat top being of no importance. One way out of the difficulty is to draw the expected response curve, and then draw the response curve of a resonant circuit (with a gaussian error-distribution curve) which has the same steep side as the response curve of the equipment under test. The sweep rate must then be chosen so that it is slow enough to display correctly the response curve of this equivalent resonant circuit.

In generators using a sinusoidal sweep from the mains supply the duration of the sweep is fixed at 10msec—the time of one half cycle of the mains frequency—and this is the period used in almost all commercial instruments. Alterations in the

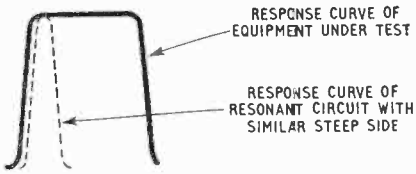


Fig. 5. Determination of maximum permissible sweep speed for circuit with response other than that of gaussian error curve.

sweep width are then achieved by altering the rate at which the frequency is swept. Fig. 6 shows a graph relating sweep width to minimum bandwidth for a generator with a sweep duration of 10msec. As an example of the use of this graph, consider a wideband i.f. amplifier having steep sides and a passband of three-and-a-half megacycles. A sweep width of, say, 5Mc/s would have to be used in order to display completely the skirts of the response curve. The graph shows that for such a sweep width the sides of the response curve will be displayed correctly provided that they are not steeper than the sides of the response curve of a resonant circuit which has a response curve corresponding to gaussian error distribution curve and a bandwidth of 28kc/s.

Harmonic Distortion.—Harmonics of the frequency-swept signal, produced either in the sweep generator itself or by non-linearities in the characteristic of the equipment under test can be a serious source of error. This is particularly so when testing equipment which has a response in which the passband is very wide compared with the centre frequency. With a response curve of this type the second and third harmonics of the frequency-sweep signal may well be within the passband for part of the sweep. Fig. 7 shows the response curve of an equipment which has a passband extending from 500kc/s to 3.5Mc/s, the full line shows the actual response while the dotted line shows the effects of the presence of the second and third harmonics. From the leading edge of the response curve at 500kc/s to 1.17Mc/s the second and third harmonics, as well as the fundamental, are within the passband of the equipment and the displayed response has an amplitude which is the sum of the three components. At 1.17Mc/s the third harmonic passes outside the passband of the equipment, and the displayed amplitude is then the sum of the second harmonic and the fundamental. At 1.75Mc/s the second harmonic passes outside the passband of the equipment and the true amplitude is displayed. The harmonics will also produce a response on the display at frequencies below 500kc/s, where the fundamental is outside the passband.

Perhaps the most serious type of error encountered as a result of harmonics being present is that which occurs when measurements are made on the response of the high-selectivity trap circuits which are often included in broad-band equipment. These circuits are designed to suppress unwanted signals, often by as much as 40 to 50dB. With a correctly-adjusted trap the fundamental of the frequency-swept signal will be suppressed by this amount, but if there are any harmonics present which fall within the passband of the main equipment, they will be passed through without any suppression and will be displayed.

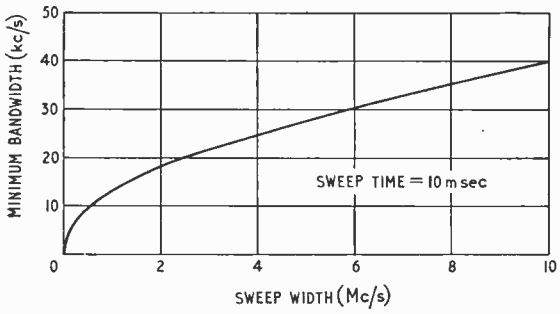


Fig. 6. Relation between sweep width and minimum bandwidth that can be displayed correctly, for a sweep time of 10msec.

Matching.—It is most important that the cable connecting the sweep generator to the equipment under test is correctly matched. The result of any mismatch will be that some of the energy from the sweep generator will be reflected at the input of the equipment under test and standing waves will be set up on the cable. As the frequency is being varied continuously, the number of standing waves in the cable will vary throughout the sweep. This results in the voltage at the input to the equipment under test varying throughout the sweep—if the sweep width is wide enough this voltage will pass through a number of maxima and minima.

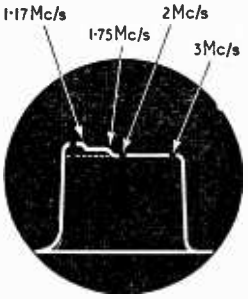


Fig. 7. Effect of harmonic distortion in generator when harmonics fall within passband of equipment under test.

The actual errors produced will depend upon the degree of mismatch, the electrical length of the cable and the width of the frequency sweep. The maximum possible error will occur when the sweep width and the electrical length of the cable are such that the voltage at the equipment under test varies at least from one voltage maximum to the next voltage minimum.

Oscillator-output Variation.—Even with the most careful work, it is practically impossible to build a frequency-sweep oscillator in which the output level remains constant throughout the sweep. With any of the methods commonly used to sweep the frequency—reactance valve or ferrite modulator, motor-driven tuning, etc.—the sweep voltage has some effect on the oscillator output. 0.25 to 0.5dB is a common variation and the output change can be even greater. This, however, can be reduced considerably by including in the instrument some form of automatic level control. One way of doing this is to connect a detector across the output of the swept oscillator. The detector output, which will be proportional to the sweep-oscillator output, is used to control the gain of one of the amplifier valves in the instrument, and so tends to reduce the variations in oscillator output. With such an automatic level control in circuit, the variations in oscillator output can be reduced to something like ± 0.1dB.

Applications

The frequency-sweep oscillator has a multitude of applications additional to the direct display of

the amplitude/frequency curve. Much greater accuracy of amplitude/frequency alignment, for instance, can be achieved if, instead of displaying the amplitude/frequency characteristic, the first derivative of the amplitude/frequency is displayed; or the difference between the input and output of the equipment under test, instead of simply the output, can be displayed. These two applications, together with several others, will be described in later parts of this article.

REFERENCES

1. H. Lucius. The Polyskop., Rhode und Schwarz-Mitteilungen. Vol. 10 (1958), p. 145 and Hor. Gunner, Response of Linear Resonance Systems to Excitation of a Frequency Varying Linearly with Time. *J. App. Phys.* Vol. 19 (1948), p. 242.

2. D. G. Haley. 20Mc/s Sweep Generator Type TF 1099. *Marconi Instrumentation*, Vol. 6 (1958), p. 166.

(To be continued)

Electronic Nerve Cell

FOUR-TRANSISTOR CIRCUIT ANALOGUE

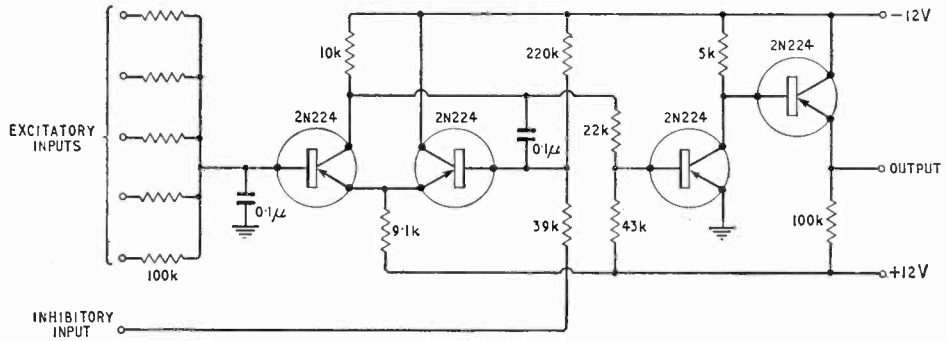
By MICHAEL LORANT

SCIENTISTS of the Bell Telephone Laboratories in the United States have recently developed a new and simple electronic circuit that simulates some functions of the individual biological nerve cell, or neuron. Numbers of these artificial cells are being combined into experimental networks that are roughly analogous to the nerve systems of the eye or ear.

The main function of the nerve cell which has been simulated by this circuit is the transmission of electrical pulses in response to those stimuli that meet certain conditions. The neuron circuit fires electrical pulses of standard amplitude and duration, just as a biological cell usually does. If the circuit is driven by a constant stimulus trains of pulses are emitted, simulating receptor cells as in the eye or ear. A higher intensity of excitation increases the frequency of pulsing. When the neuron circuit is excited continuously the frequency of the pulses can be made to decrease with time, exhibiting accommodation like a living nerve cell. Input excitation must, as in a biological cell, surpass a threshold value, and the circuit will integrate two or more input pulses below the threshold value to cause firing. A particular input connection can also, while energized, inhibit firing of the neuron circuit by other inputs. Similarly, immediately after firing, the electronic neuron's threshold rises to a very large value and for a few milliseconds no input signal can fire the neuron circuit again.

The circuit includes four transistors, thirteen resistors, and two capacitors. The pulse length it delivers, about six milliseconds, is considerably longer than that of a biological nerve cell, but can be shortened if desired. The circuit has an integrating time constant of two milliseconds and a refractory time constant of about ten milliseconds, approximating the time constants of the biological neuron. Because the electronic inputs and outputs are compatible, the circuits can be assembled into chains and networks.

Electronic neurons can be combined with photoresistive cells to simulate simple functions of nerves in the retina. Some receptors, known as "on" receptors, fire only when the light intensity they receive is increasing; "off" receptors fire only when the light is decreasing; and "during" receptors fire only while they receive a steady light. Flicker-fusion phenomena have also been produced. In the human eye, these can cause a sequence of flashes to be seen as continuous illumination; this property of vision is exploited in motion pictures and television. Mutual inhibition of cells in an array has also been demonstrated experimentally. Some animals have been observed to possess this arrangement, in which a cell receiving a greater light intensity inhibits the firing of nearby cells that receive less light. This results in local sharpening of image boundary detail.



Circuit diagram of electronic nerve cell analogue developed at Bell Telephone Laboratories.

WORLD OF WIRELESS

R.I.C. Backs 405 Lines

THE Radio Industry Council, which speaks for the set-making industry, has come out strongly against a change to 625-line television standards in this country in its representations to the Pilkington Committee, which have now been made public. The difficulties of planning receiver production over the next 15 or 20 years, when the demand for v.h.f. and u.h.f. sets of either or both 405- and 625-line standards would fluctuate unpredictably, are emphasized. It is pointed out that new dual-standard sets with v.h.f. and u.h.f. to cover the transition period would cost from £15 to £20 more than at present, and that the 405-line components would ultimately become redundant. Such sets would have no export value.

The advantage of 405 lines in allowing in the available bandwidth at least one more alternative programme than would be possible with a 625-line standard* is underlined and the Council concludes that " . . . because it would appear that if a change were made to 625-line standards a period of 15/20 years would be required to give National coverage to more than three programmes, during which the public would suffer confusion and additional cost, the Council can do no other than recommend the maintenance of 405-line standards in Bands I and III and their extension into Bands IV and V."

The Council would like to see the introduction of a colour TV service, but supports the T.A.C. report in saying that this should be deferred until the question of line standards is settled. It would also welcome an extension of sound broadcasting to cater for local interests, and the introduction of stereo sound broadcasting provided that this can be transmitted over single radio channels.

*See *Wireless World*, July 1960, pages 322 and 313

Westward TV

FULL-POWER test transmissions will begin from the I.T.A. Caradon Hill station near Liskeard, Cornwall, on February 1st. They will consist primarily of Test Card C and will begin at 10 a.m. daily except Sundays. The station will radiate vertically polarized signals in Channel 12.

Caradon Hill, which will have a vision e.r.p. varying from 10kW to 200kW according to direction, is the first U.K. station to operate in this channel. The actual carrier frequencies will be 209.74325Mc/s (vision) and 206.23Mc/s (sound).

It is planned to bring the station into service toward the end of April. The programme contractors for this station and the sister station being built at Stockland Hill, near Axminster, Devon, are Westward Television Ltd.

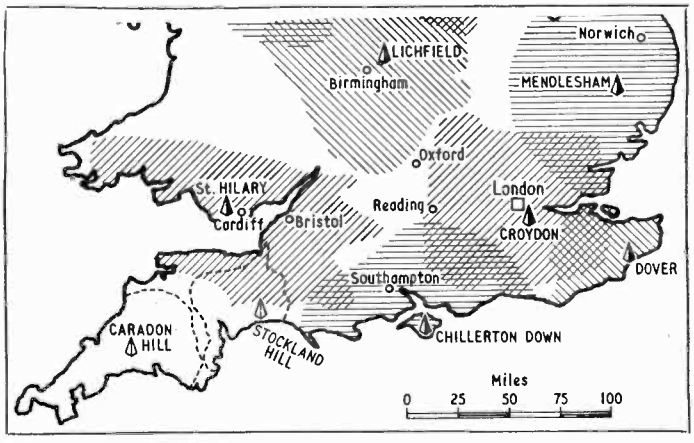
Research Council

THE appointment of three new members of the Council for Scientific and Industrial Research gives an opportunity to publish a list of the present members of the council which was set up in November, 1956, under the "Department of Scientific and Industrial Research Act" to be in executive charge of the D.S.I.R. The newly appointed members are Professor B. Bleaney, F.R.S., Professor of Experimental Philosophy at the University of Oxford since 1957 prior to which he was for ten years Fellow and lecturer in physics at St. John's College, Oxford; Dr. J. W. Cook, F.R.S., the research chemist who has been vice-chancellor of the University of Exeter since 1955; and Frank Cousins, general secretary of the Transport and General Workers Union.

The present constitution of the Research Council, of which Sir Harry Jephcott is chairman and Sir Harry Melville secretary is:—Prof. C. E. H. Bawn, Prof. B. Bleaney, Prof. C. F. Carter, Dr. J. W. Cook, F. Cousins, Sir Walter Drummond, Sir Willis Jackson, Vice-Admiral Sir Frank Mason, Sir Harold Roxbee Cox, Dr. C. J. Smithells and L. T. Wright.

Licensing Anomalies

A CLAUSE in the licence granted to operators of relay exchanges makes it obligatory for them to make a return to the Post Office of particulars of the broadcast receiving licence held by each subscriber. This, they feel, is unreasonable as no such demand is made upon the ordinary radio retailer when supplying a sound or television receiver irrespective as to whether the set is purchased outright, is on hire purchase or rented. At the annual luncheon of the Relay Services Association, at which Miss Mervyn Pike the Assistant P.M.G. was a guest, the chairman, J. W. Kinsman, asked the Post Office to "sort out" the matter.



Estimated service areas of the two transmitters to serve S.W. England are shown dotted on this map, giving the service areas of existing I.T.A. stations in Southern England and Wales.

Hirst Research Centre

THE reorganization of the General Electric Co. Ltd. has now extended to the Wembley Research Laboratories which will in future be known as the Hirst Research Centre as a tribute to the memory of the founder of G.E.C. A number of research units will be formed. The first, dealing with fundamental research, will be known as the Central Research Laboratories and the other groups will have a call on its advice and services. The second will be the Telecommunications and Engineering Research Laboratories and later the five operating groups of G.E.C. (Domestic, Installation, Lighting and Heating, Osram, and Radio and Television) will have the opportunity of setting up their own research units, thus securing a closer integration of applied research and technical development with production and sales.

O. W. Humphreys, C.B.E., continues as Director of Research, V. J. Francis will be deputy director in charge of central Research and R. J. Clayton, O.B.E., deputy director in charge of Telecommunications and Engineering.

Technical Education

BETTER educational opportunities for technicians are foreshadowed in a Government White Paper (Cmnd 1254) which the Minister of Education has described as "a charter for technicians." The White Paper sees the last years of school and the first years of work as a continuous period of co-ordinated education. It is planned to "broaden" the courses in technical colleges by including more mathematics, more scientific principles and more English.

It was recently stated by the Minister of Labour that the proportion of technicians to other employees was higher in the electrical and electronics industry (11.6%) than in any other.

Phys. Soc. Prize Winners

EACH year a competition to encourage craftsmanship and draughtsmanship in the scientific instrument industry is held in connection with the Physical Society Exhibition. John S. Palmer (Marconi's W/T) has won the Silvanus P. Thompson prize and the first prize in the senior section for scientific instruments and components with his reset motor assembly. Other prize-winners include:—

V. S. Marcham (Cambridge Insts.), reflecting electrostatic voltmeter
R. Croucher (Mullard), vernier measuring microscope
Peter Shrives (Hilger & Watts), measuring microscope workstage unit
J. Carrier (Elliot Bros.) rotary standing-wave indicator
Allan E. Pembroke (Mullard) impedance for 3-cm waveguide
Peter J. Perry (R.R.E.) simple oscilloscope
John Cross (Marconi's W/T) blanking and sync. mixer
John G. Wray (N.P.L.) transistor audio oscillator
Jack L. De'ath (Marconi's W/T) translator
William G. Payne (Hilger & Watts) pre-amplifier
Stephen S. Martin (Hilger & Watts) signal generator.

"Beam Indexing Tubes".—On page 7 of the first part of this article in the January issue it is regretted that a line of type was dropped. The sentence starts on line 7 and should read "This idea is based on the fact that whilst the phase of the chrominance signal is proportional to hue, the amplitude is proportional to saturation."

R.I.C. Appointments.—J. W. Ridgeway, O.B.E., commercial director of A.E.I. (Woolwich), has been elected chairman of the Radio Industry Council in succession to E. E. Rosen (chairman of Ultra Electric Holdings). Mr. Ridgeway was chairman of the Council from 1948 to 1952 and has also served for some years as chairman of the British Radio Valve Manufacturers' Association (B.V.A.). The new vice-chairman in succession to H. V. Slade (Garrard Engineering) is A. L. Sutherland (director of Philips Electrical) who is also chairman of the British Radio Equipment Manufacturers' Association. R. Kelf-Cohen, C.B., acting-director of the Council since the death of Sir Raymund Hart last year, has been appointed director and secretary.

Components Show.—Over 240 manufacturers have already booked space at the Components Show which will be held for the first time at Olympia from May 30th to June 2nd. It is being organized on behalf of the Radio and Electronic Component Manufacturers' Federation by Industrial Exhibitions Ltd.

International Instruments Show.—B & K Laboratories are once again organizing an international instruments show in which 50 exhibitors will participate. It will be held at their premises in Park Lane, London, W.1, from June 19th to 23rd.

TV Translators.—An experiment in the use of a very low-power translator to improve the television service in areas of unsatisfactory reception is being conducted by the B.B.C. in Hastings. The translator, of a new type developed by B.B.C. engineers, picks up the Crystal Palace Channel 1 transmissions and re-radiates them with horizontal polarization in Channel 4. Higher-powered equipment is being used at the new Sheffield station which re-radiates the Holme Moss Channel 2 transmissions in Channel 1 using horizontal polarization.

Television Centre.—The second of the large studios (No. 4) at the B.B.C. Television Centre in West London was brought into use on January 8th. It is equipped with E.M.I. cameras which, like the Marconi cameras in Studio 3, employ the English Electric 4½in image orthicon tube.

Space Electronics.—Decca Radar, Ltd., have formed a space electronics group to inaugurate the company's research and development effort in this field. The group will be set up in new laboratories at Somerton Airport, Cowes, Isle of Wight.

Licence Figures.—The November 30th figure for combined television-sound licences in the U.K. was 11,027,821. The month's increase was 64,954. Sound-only licences totalled 4,147,310 including 461,726 for car radio sets. The figures for West Germany (including West Berlin) on December 1st were 4,497,936 television sets and 15,854,319 sound radio receivers. Sweden reached her millionth television licence in the middle of December.

Computor Memories.—The Information Systems Branch of the U.S. Navy is holding a symposium on large-capacity memory techniques for computing systems in Washington, next May. Further details and a preliminary programme are obtainable from Miss J. Leno, Code 430A, Office of Naval Research, Washington 25, D.C.

Electronic Digital Computers.—A course of six lectures on the application of electronic digital computers to control problems will be given at the Norwood Technical College, Knight's Hill, London, S.E.27, on Tuesday evenings, commencing Febrary 14th (fee 10s).

Personalities

Dr. Lloyd V. Berkner, the new president of the Institute of Radio Engineers, is immediate past president of the International Scientific Radio Union. After graduation in 1927, Dr. Berkner, who is 56, joined the first Byrd expedition to the Antarctic (1928/30) and then served for three years on the staff of the National Bureau of Standards. From 1933 to 1941 he was in the department of terrestrial magnetism of the Carnegie Institution of Washington. In 1941 he headed the radar section of the Bureau of Aeronautics. After holding other Government appointments he became in 1951 president of Associated Universities Inc., New York, an educational institution operating a number of research establishments including the National Radio Astronomy Observatory. A few months ago Dr. Berkner was elected president of the Graduate Research Centre, Dallas.

A. G. Wray, M.A., A.M.Brit.I.R.E., who has been chief of Marconi Instruments' advanced development group since 1956, is appointed deputy chief engineer. A graduate of Emmanuel College, Cambridge, he joined the company in 1944 and in 1952 became company physicist. For the past four years he has been responsible for the design and development of multi-channel microwave test equipment and atomic power instrumentation. Mr. Wray has also been a joint editor of the company's technical house journal, *Marconi Instrumentation,* since 1952.

A. G. Wray.

Marconi Instruments have announced three other engineering appointments. **R. L. Gilbert,** Ph.D., M.A., who joined the company in 1958 after three years as a geophysicist in the Dominion Observatory, Ottawa, becomes advanced product engineering manager. **A. Haviland** and **D. R. Willis,** A.M.Brit.I.R.E., have been appointed Proprietary Engineering Managers. Mr. Haviland has been with the organization since 1931. In 1943 he was made chief of the development test section. Mr. Willis, who has been with the organization 21 years, was for part of the war responsible for the engineering and production of radar test equipment.

N. Elson, technical director of Cossor Communications Co. which he joined a few months ago, has been appointed general manager in succession to **K. P. Wood,** B.Sc., A.M.I.E.E., who has resigned. Mr. Elson was chief engineer of the instrument division of Racal prior to joining Cossor. Other appointments to the boards of Cossor companies are **B. C. Scott** (Cossor Radar & Electronics Ltd. and Cossor Instruments Ltd.) and **J. S. Gilks** (Cossor Communications Co. Ltd.), Lea Bridge Cabinet Works Ltd., and Best Products Ltd.)

N. L. Lupton, M.A., A.F.R.Ae.S., is the new contracts manager of Plessey's Electronics and Equipment Group which embraces the domestic equipment, electronics, and telecommunications divisions at Ilford and the subsidiary Hagan Controls Ltd. In 1941 he joined the Sperry Gyroscope Company as a service engineer and since 1958 has been with Microcell Ltd.

L. Gosland, B.Sc.(Eng.), M.I.E.E., research manager of the British Electrical and Allied Industries Research Association (E.R.A.) has also been appointed to the post of deputy director. He joined the Association in 1925. Mr. Gosland is chairman of the Commission Mixte Internationale pour la Protection des Lignes de Telecommunications et des Canalisations Souterraines (C.M.I.) and also of the C.I.G.R.E.* study committee on radio and telephone interference. The appointment of two assistant directors of the E.R.A. is also announced; they are **C. G. Garton,** M.I.E.E., F.Inst.P., who is head of the Materials Department, and **E. W. Golding,** O.B.E., M.Sc.Tech., M.I.E.E., head of the Rural Electrification Department, and also overseas liaison officer. They will each continue in their present positions. Mr. Garton, who joined the E.R.A. in 1937 after four years with the All-Union Electrotechnical Institute, Moscow, is this year's chairman of the Measurement and Control Section of the I.E.E. Mr. Golding joined the E.R.A. in 1945 prior to which he was senior lecturer in electrical engineering at Nottingham University.

* Conférence Internationale des Grands Réseaux Electriques.

J. A. Mason, C.B.E., M.M., M.I.E.E., C.G.I.A., production director of Automatic Telephone & Electric Co. since 1950, has been appointed deputy managing director. He joined the company as a draughtsman in 1911. After military service in the First World War he went into the company's electrical engineering department where he subsequently became assistant chief engineer. Mr. Mason, who is 63, is also director of the associate company British Telecommunications Research Ltd. He is succeeded as production director by **F. O. Morrell,** B.Sc., M.I.E.E., who has been director (engineering) since 1956.

Barry Rogel, B.Sc.(Eng.), A.M.I.E.E., who led the microwave design team of Wayne Kerr Laboratories, has gone to America to become managing director of a recently formed subsidiary of Rosemount Engineering Company, of Minneapolis. He will, however, act as a consultant to Wayne Kerr and as such joins Dr. A. L. Cullen, Professor of Electrical Engineering at the University of Sheffield, and Dr. V. S. Griffiths, reader in spectroscopy at the Battersea College of Technology.

Anthony S. Pudner, M.B.E., A.M.I.E.E., A.M.Brit.I.R.E., has been appointed an additional assistant engineer-in-chief by Cable & Wireless. He joined the company in 1934 at the age of 17. Four years later he went to the company's Bermuda station as assistant engineer. He went to Korea in 1950 to be assistant engineer in charge of the company's field wireless unit. Since 1958 he has been area engineer, West Indies.

L. A. Sawtell, Comp.Brit.I.R.E., since 1945 manager of the valve division of Mullard's, which he joined in 1929, has retired. Mr. Sawtell, who is a past chairman of the Radio Industries Club, has been over 38 years in the radio industry.

George H. Russell, Assoc.Brit.I.R.E., a former senior development engineer with Bush Radio who has been with Arks Publicity for several years, has joined Taylor Advertising Ltd. as an associate director. Mr. Russell, who has contributed a number of articles to *Wireless World,* handled the publicity for several radio and electronics companies whilst with Arks.

Victor Thomas, press officer for Philips Electrical Ltd. since 1952, has taken up an appointment with N. V. Philips Gloeilampenfabrieken, Eindhoven. Among other duties he will be concerned with the editing of the company's international house magazine *The Announcer,* which is printed in English. He has been with Philips since 1948.

S. E. Allchurch, O.B.E., secretary of the British Radio Equipment Manufacturers' Association since 1946, has been appointed to the newly created post of director of the Association. For the time being he will combine the duties of director and secretary. Before joining B.R.E.M.A. he was assistant director of a department in the Ministry of Aircraft Production concerned with the fitting of radar and communications equipment to Service aircraft.

In announcing in our last issue **B. M. Lee's** appointment as manager of Belling and Lee's industrial group it should have been made clear that he is responsible to, but has not actually joined, the executive board.

OUR AUTHORS

L. Pollack, whose paper on active satellites for world-wide communications presented at the London meeting of U.R.S.I. we reproduce in this issue, has been with I.T.T. Laboratories, New Jersey, since 1943. Mr. Pollack, who is 40, is now project manager of space communication systems and communication systems for anti-submarine warfare.

R. Brown, the first part of whose article on frequency sweep oscillators begins on p. 57, recently joined Leland Instruments where he is responsible for Government contracts and technical liaison with Government departments. Immediately prior to joining Leland he was for four years with Marconi Instruments. After completing his National Service in 1950 he spent five years as a marine radio officer.

OBITUARY

Sir Godfrey Ince, G.C.B., K.B.E., chairman of Cable and Wireless Ltd. and its associated companies since 1956, died on December 20th. He was 69. Sir Godfrey had an outstanding career in the Civil Service from which he retired in 1956. He was Director General of Manpower from 1941 to 1944 when he became permanent secretary to the Ministry of Labour.

W. R. Metcalfe (G3DQ), president of the Radio Society of Great Britain for 1960, died on Christmas Day. He had been a member of the Council since 1955.

NEW YEAR HONOURS

Among the recipients of Knighthoods in the New Year Honours List are the following:—

Gerald C. Beadle, C.B.E., Director, Television Broadcasting, B.B.C.;

Cecil Dannatt, O.B.E., M.C., D.Sc., M.I.E.E., Vice-chairman, Associated Electrical Industries, Ltd., and also a director of a number of companies in the A.E.I. Group;

Edward R. Lewis, chairman, Decca Navigator Company and Decca Radar Ltd.; and

Alfred C. B. Lovell, O.B.E., F.R.S., Professor of Radio Astronomy, University of Manchester and director of the Nuffield Radio Astronomy Laboratories. Professor Lovell is a member of the National Committee on Space Research and is chairman of the U.R.S.I. commission on radio astronomy.

W. H. Stephens, Director-General of Ballistic Missiles, Ministry of Aviation, is appointed a Companion of the Order of the Bath (C.B.). He was head of the Guided Weapons Department, R.A.E., Farnborough, where he later became deputy director (equipment).

Among those appointed Commanders of the Order of the British Empire (C.B.E.) are: **F. E. McGinnety,** M.Sc., M.I.E.E., Director General of Inspection in the Ministry of Aviation, who was at the Signals Research and Development Establishment of the Ministry of Supply from 1929 to 1954; **J. R. Pheazey,** vice-chairman and joint general manager of Standard Telephones and Cables, who has just completed 50 years with the company and is also a director of Kolster Brandes; and **A. J. Young,** B.Sc.(Eng.), M.I.E.E., managing director of the English Electric Valve Company.

Newly appointed Officers of the Order of the British Empire (O.B.E.) include: **H. W. Baker,** Superintendent Engineer, Television, London Studios, B.B.C.; **S. J. Giffen,** senior assistant telecommunications controller, Northern Ireland, G.P.O.; and **C. W. Sowton,** assistant staff engineer, G.P.O., who is secretary of the technical sub-committee of the Television Advisory Committee.

Among the new M.B.E.s are: **R. B. Dickinson,** executive engineer, G.P.O.; **F. J. G. Haines,** engineer-in-charge (sound), Cardiff, B.B.C.; **J. F. Lucas,** principal station radio officer, Government Communications Headquarters; **J. W. Murray,** chief engineer, Nigerian Broadcasting Corporation; and **L. S. Pinder,** chief engineer, Nuffield Talking Book Library for the Blind, who played a major part in the development of the tape-reproducer for the blind.

Recipients of the British Empire Medal include:— **O. C. Baldock,** radio operator, Government Communications Headquarters, Foreign Office; and **W. F. Young,** radio technician, Royal Air Force, North Weald.

E. R. Lewis (Knighthood)

A. C. B. Lovell (Knighthood)

A. J. Young (C.B.E.)

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

L. S. Pinder (M.B.E.)

News from Industry

G.P.C. Record Year.—The Gas Purification and Chemical Co. announce a group profit before taxation of £811,034. This is over £300,000 above the previous year's figure and the highest in the history of the group, which includes A.B. Metal Products, B. & R. Relays, Grundig (Great Britain), E. G. Irwin and Partners, Greencoat Electronics (formerly Staar Electronics) and Wolsey Electronics. Since the a.g.m. the chairman, Vice-Admiral Sir Charles Hughes Hallett, and a director, W. J. Arris, have resigned.

Radio Rentals announce a group trading profit for the year ended last August of £2.3M after allowing £3.4M for depreciation. Taxation absorbed a further £728,000 leaving a net profit of £1,573,987 compared with £1,098,616 the previous year.

Marconi Instruments are to manufacture in this country transistor electronic counters to the design of Computer-Measurements Company, of Sylmar, Cal. The 10-year agreement under which M.I. has world selling rights outside North America and Japan, also provides for the exchange of engineering information.

Blue Spot.—The agreement with A. Prince Industrial Products Ltd. for the marketing in this country of Blue Spot sound and television receivers has been terminated by Blaupunkt Werke G.m.b.H. The sale and service of Blue Spot receivers will now be handled by Bosch Ltd., 205/207 Great Portland Street, London, W.1.

U.K. Agents.—Among the eight "exclusive foreign representatives" appointed by Stoddart Aircraft Radio Co., Inc., of Hollywood, Cal., is Aveley Electric Ltd., of South Ockenden, Essex, for England.

British-made Tektronix 'Scopes.—Livingston Laboratories announce that two types of Tektronix oscilloscopes (515A and 545A) are now being made in Guernsey, Channel Islands, and are therefore duty-free under the Commonwealth Preference regulations.

Mullard's component division has been sub-divided, under its divisional head, A. F. T. Marner, into four commercial product groups. These groups, and the managers, are:—Permanent Magnets (B. C. Foreman); Ferrites (W. A. Everden); Computers (K. R. Patrick) and Radio & Television (W. K. Bailiff).

Furzehill Laboratories Ltd., of 57 Clarendon Road, Watford, Herts., have taken over the production, sales and service of the range of stroboscopes previously manufactured by Watford Instruments under the trade name of "Strobolyser." Paul D. Tyers will continue to be associated with the design of the "Strobolysers."

M.F. beacon/telegraph transmitters have been supplied (in duplicate) by the International Marine Radio Company for each of three new ocean weather ships.

United Mercantile Company Ltd., U.K. distributors of Zenith receivers, have moved to Sovereign House, 13-14 Queen Street, London, W.1 (Tel.: Grosvenor 4901).

Magnavox have opened a service department at 20/22 Corsica Street, London, N.5 (Tel.: Canonbury 5041).

Texas Instruments Ltd. have moved from Dallas Road to Manton Lane, Bedford (Tel.: Bedford 67466).

Ultra-Miles Link.—Ultra Electronics Ltd. have purchased a one-third share in Miles Electronics Ltd. A. V. Edwards and L. R. Crawford, Ultra directors, are joining the board of Miles Electronics. The two companies jointly designed and manufactured the aircraft and radar simulator for the de Havilland Sea Vixen and are now developing similar equipment for the Blackburn Buccaneer.

Derritron.—Three more companies, making a total of 10, have joined the Derritron group which was formed in January, 1960, under the chairmanship of V. G. P. Weake. The newcomers are Beulah Electronics Ltd., Direct TV Windings Ltd., and Direct TV Replacements Ltd. Alfred Rose, who previously headed these companies, will be managing director.

British Electronic Industries Ltd., is the name of the company formed to acquire the shares of Pye Ltd. and E. K. Cole Ltd. The chairman of the company is C. O. Stanley, chairman and managing director of Pye, with Eric Cole as deputy chairman.

Wolsey Electronics have recently entered the closed-circuit television system field. The equipment operates on either a video or r.f. camera output, and in the case of a video output will employ an r.f. modulator to enable standard receivers to be used. A system has been installed at Goodwood Racecourse.

Air Navigation Equipment.—Orders worth over £650,000 have been placed by the Ministry of Aviation with Marconi's for the supply of Doppler navigators and automatic direction finders. The equipment, which includes ancillary gear and spares, is for use in Argosy C. Mk. 1 aircraft of R.A.F. Transport Command.

Telecommunications Test Equipment.—Contracts worth £100,000 have been awarded to Marconi Instruments Ltd. by S.H.A.P.E. for test gear for use on the "Ace High" radar project. It comprises white noise test sets, signal generators, and universal bridges.

EXPORTS

Television transmitting equipment for Mexico and Venezuela has been ordered from Marconi's. The Venezuelan equipment comprises three vision and three sound transmitters and the Mexican eleven Mk. IV camera channels, with associated equipment.

High-altitude u.h.f. airborne emergency transmitter-receivers to the value of £50,000 are to be supplied by W. S. Electronics to the Danish Government. A fully-transistorized power supply and extremely light weight are features of the equipment. It is intended to provide emergency contact between pilot and ground in the event of aircraft electrical-system failure.

Decca weather radar is being installed at five airports in Western Germany. Equipments are nearly complete at Frankfurt and Hamburg, and will, in addition, be installed at Hanover, Munich and Schleswig.

High-power radio communication equipment has been ordered from Marconi's by the British Government on behalf of the Pakistan Posts and Telegraphs Department. The equipment, consisting of two 30-kW h.f. i.s.b. transmitters, their drive units, and five telegraph h.f. receivers, is to be installed near Karachi.

TRANSISTOR SIGNAL GENERATOR

DESIGN COVERING 100kc/s TO 25Mc/s

By C. BAYLEY

MANY advantages are gained from the use of transistors, particularly in test equipment, where the major points are that it can be small, portable and independent of mains supplies, although a mains power unit, simpler than the conventional valve supply, can be used. Lack of dependence on mains, small size and low weight are a great benefit to the field service engineer. Isolation from the mains improves performance as far as both hum and interference are concerned and is also an advantage when working on "live" equipment. Waste power dissipation is very low: the economy in running such equipment is obvious and deterioration of components by heat is reduced to the minimum. Also the equipment is ready for use immediately after switching on—a wait whilst temperatures and thus frequency become stable is not necessary. The radiation from oscillator circuits is reduced considerably and therefore screening precautions might not be so severe.

The signal generator is one of the most commonly used pieces of test equipment and it is one in which the benefits accruing from the use of transistors are most marked. It was thus decided to design a transistor signal generator.

Choice of Basic Circuit

There are many circuits for transistor oscillators, so it would be as well to consider carefully the factors affecting their use in signal generators.

Firstly, transistors are current-operated devices having low impedances, thus matching is more critical than in a valve circuit where the valve is often regarded as having such a high impedance that its effect can be ignored. Most h.f. oscillators use an L-C tuned circuit whose dynamic impedance is high, usually of the order of a fraction of a megohm. Thus a low-impedance transistor, although capable of producing large currents at low voltages, could be so mismatched that it could not drive sufficient current into some tuned circuits to keep them oscillating (Fig. 1 (a)). Improvement of the matching of transistor and tuned circuit can be achieved by reducing the L-C ratio or by tapping the coil, as in Fig. 1 (b).

In the first case, though, the tuning capacitor becomes inconveniently large—too large for a standard variable type to be used—and in the second case the circuit impedance varies too widely to enable a good match to be achieved over the tuning range of the capacitor. The dependence of circuit impedance on tuning capacity (and therefore frequency) is clear from an examination of the expression for impedance at points A and B in Fig. 1 (b): $Z=(L/r-(1/C)+\omega^2L_2$. The approximate formula for the dynamic impedance of the circuit in Fig. 1 (a) is $Z=L/Cr$, i.e., there is no direct dependence on frequency. Thus version (b), although convenient from the point of view of tuning capacitance, has to be limited in frequency range.

Beat Oscillator Techniques

The use of two oscillators whose frequencies beat together to produce the desired output has advantages for lower radio, supersonic and higher audio frequencies. For higher radio frequencies a straight oscillator is preferable; also a lower ratio of maximum to minimum frequency is acceptable, thus the matching problem can be successfully solved by the limiting of the frequency swing.

In the conventional b.f.o. the fixed and variable-frequency oscillators usually operate at frequencies

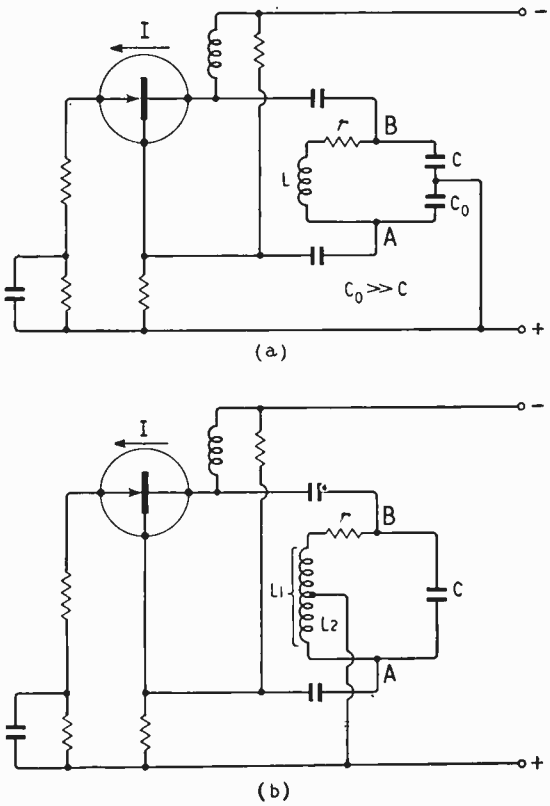


Fig. 1. Two oscillator circuits. In (a) the current I may be insufficient to maintain oscillation, but in (b) I is three or four times greater when $L_1 = 4L_2$.

five to ten times those of the beat. This makes easy the filtering out of the unwanted frequencies after detection of the beat and would also satisfy the requirement that the frequency range should remain small. However, this would, for our purposes, demand the beating of frequencies above a reasonable maximum figure for f_α, the alpha cut-off frequency.

Generally the best solution seems to be to design a b.f.o. for the lower band of frequencies—say 50 to 500kc/s—and above that to use a straight oscillator. For the higher frequencies the desired lower L/C ratio can be obtained conveniently by using the same tuning capacitor. The best choice of b.f.o. frequencies seems to be rather close to the beat frequency, e.g., for an output at 500kc/s the fixed-frequency oscillator (f_1) could be at 1,200kc/s and the variable (f_2) at 700kc/s. As the top limit of frequency f is to be 25Mc/s (for short-wave band coverage) it might be thought that it would be possible to use higher beating frequencies, but this would demand that both oscillators use transistors with high f_α. If, of course, short-wave coverage is not required then this section could be dropped and transistors of lower f_α used. Table 1 lists some high alpha-cut-off transistors.

Naturally the use of low beating frequencies makes their filtering from the output more difficult, but this can be achieved satisfactorily by the proper design of low-pass filters. Unwanted components could occur on some ranges but in practice these are quite harmless.

Further important considerations when choosing an oscillator circuit are good frequency and amplitude stability. To achieve both these ends care must be taken with biasing and stability measures. Looking at the circuit of Fig. 2 it will be seen that the base-biasing resistors, R_1 and R_2 are of much higher values than are commonly used*. High values for these resistors are necessary to prevent excessive damping of the tuned circuit. The collector-to-emitter potential should be chosen as high as possible to reduce internal capacitance and maintain collector current at a low value. This reduces internal power dissipation and, hence, avoids effects due to a rise in temperature. Amplitude modulation is not applied directly to the oscillator because here it can cause frequency modulation.

Some slight modifications from the Colpitts valve oscillator circuit have to be made: for instance, the base-emitter coupling capacitor C_1 has to be several times larger than the collector capacitor, C_2. This is understandable as C_1 has to pass a large current into the tuned circuit whilst C_2 is in a position where the impedance is much higher.

The oscillator output is taken from the tap on the emitter resistor R_3 R_4. Provided that R_3 is high in relation to the impedance at the tap the frequency of oscillation is not affected by changing the load at the tap. However the output is reduced to about 30 to 50mV and an amplifying stage is essential to obtain sufficient input to the attenuator.

The amplifier is a conventional common-base circuit and its output is taken from the step-down transformer to the low-pass filter which matches the 75-Ω attenuator. This attenuator is arranged to give six 20-dB steps of attenuation and "fine" continuous variation of the output over a 20-dB range is obtained by variable negative feedback to the base of the amplifier stage.

If short-wave operation is desired the amplifier transistor would, of course, have to be of the high alpha-cut-off variety. A type with an f_α no lower than 100Mc/s would be suitable. Alternatively the output could be taken directly from the tap on the oscillator emitter resistor but this would preclude the use of modulation, and, of course, result in a much lower maximum output.

Modulation

Three methods of applying modulation to the amplifier were considered:—

1. In a Class-C amplifier high-level modulation can be applied in the common-base or common-emitter circuits by varying the collector supply. This is similar to the Heising method of modulating a valve amplifier.
2. Low-level modulation can be achieved by placing the source in the emitter-base circuit.

* See: The Junction Transistor and its Applications, by E. Wolfendale, pp. 123-135

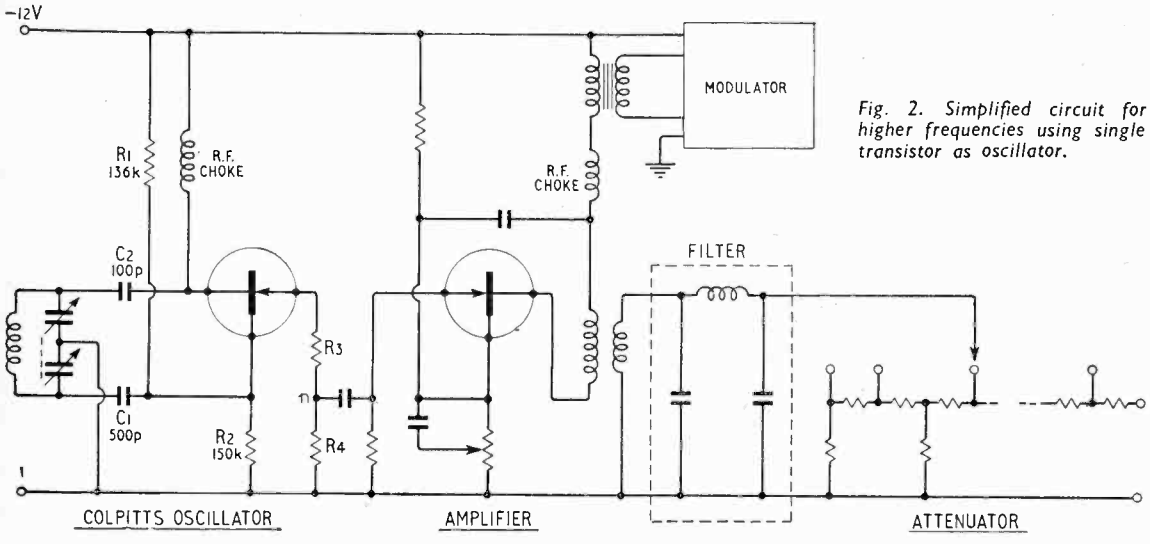


Fig. 2. Simplified circuit for higher frequencies using single transistor as oscillator.

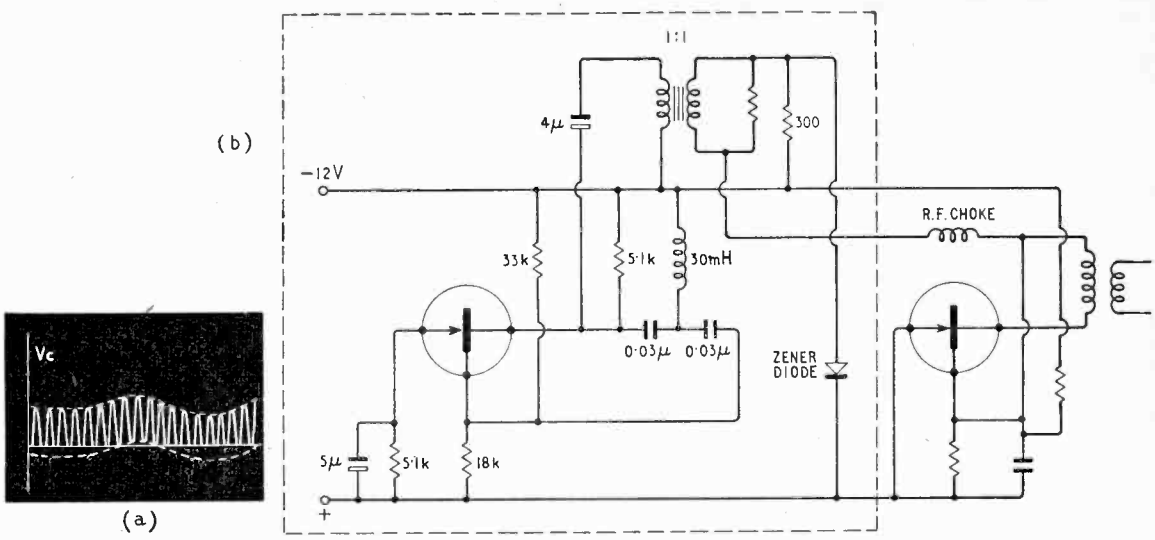


Fig. 3(a). Result of applying modulation by chosen method. Note " clipping " of sine wave. (b) shows simple 1kc/s oscillator and connections to amplifier stage.

3. By adjusting the bias and r.f. drive voltage the modulating current can be made, in an arrangement similar to that described in (2), to change the input impedance of the stage. This is analogous to square-law modulation of Class-B valve circuit.

In our case, deep modulation is not required—30% is normal for a signal generator—and the amplifier does not necessarily have to work in " pure " Class C. The method given in (1) was thus chosen, and Fig. 3(a) shows the output when modulated by a sine wave. In Fig. 3(b) a simple 1-kc/s oscillator is shown. This is a convenient circuit as the 1:1 modulation transformer could be employed as the output transformer of an a.f. stage should modulation from an external source be desired.

It is clear from Fig. 3(a) that distortion of the output takes place and, to avoid the presence of harmonic frequencies in the output some form of filtering is essential. Another tuned circuit ganged with the oscillator could be used but this would demand an extra section on the tuning capacitor. Thus low-pass filters, switched from range to range, are employed.

To obtain proper modulation in the amplifier the initial collector bias has to be chosen carefully. Correct operation is achieved when this is approximately equal to half the supply, i.e. about −6V with a 12-V supply.

TABLE I

Makers	Type	f_α (Mc/s)	Description
Associated Transistors	AP11	30	Germanium alloy p-n-p diffused base
Mullard	OC 170	70	Germanium alloy p-n-p diffused (graded) base
Newmarket	V15/20R	30	Germanium alloy p-n-p drift transistor
Semi-conductors	MA 393	60	Germanium p-n-p " micro-alloy "
Texas Instruments	2N1142	600	Germanium p-n-p diffused-base mesa type
	2N1143	480	Germanium p-n-p diffused-base mesa type
	2S005	30	Silicon n-p-n grown diffused
	2S014	20	Silicon n-p-n grown diffused

B.F.O. Signal Generator

Remembering that a b.f.o. design is advantageous for the lower r.f. bands we may arbitrarily choose the b.f.o. output ranges as within, say, 100 to 500kc/s.

With the variable-frequency oscillator (v.f.o.) ranging from 800 to 1,000kc/s it is possible to achieve the chosen coverage with fixed-oscillator frequencies of 1,100kc/s and 1,300kc/s. Thus the first range is 1,100-1,000=100kc/s to 1,100-800=500kc/s, and this satisfies the requirement that the tuning range of the v.f.o. should be kept small.

The low-pass filters following the frequency-changing circuit have to be multi-range types if it is desired to employ modulation. It would be inconvenient to have a separate switch for these, so the number of positions of the range switch depends on the design of this part of the circuit. Thus our

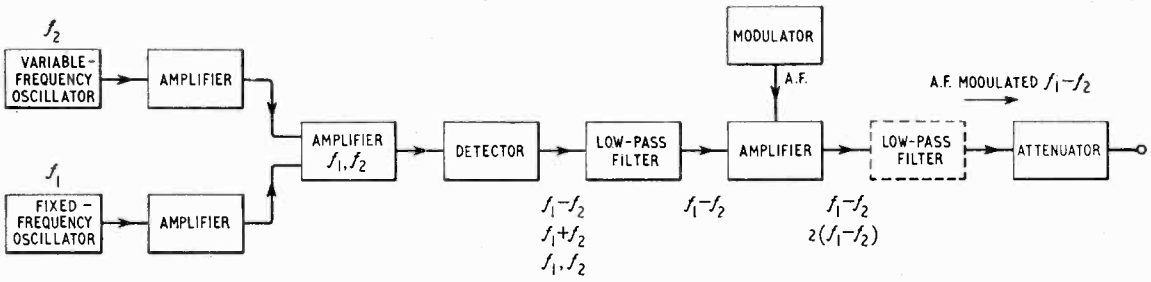


Fig. 4. Block diagram of signal generator when operating as a beat-frequency oscillator.

signal generator when operating as a b.f.o. takes on the outline shown in Fig. 4.

Complete Design

At the left-hand end of Fig. 5 are shown the oscillators: they are basically similar to ensure good frequency stability. The mixing of the beat oscillator outputs is carried out in the triple-wound step-down transformer T_1 (impedance ratio about 3,000Ω to 100Ω), then both signals are amplified by V5. Sum and difference frequencies are produced at the detector V6 which is a mixer-type diode with a low forward resistance and capacitance. The output passes into the first low-pass filter which removes the original fundamental and sum frequencies. S_{1-1} selects the output from either the b.f.o. (V1 to V4) or the v.f.o. (V1). Two positions are provided in the v.f.o. position so that, on short waves, the coupling transformer T_1 and the amplifier V5 are switched out of circuit and are replaced by the short wave coupling transformer T_3.

V7 is the final amplifier, and, it will be remembered, this produces second-harmonic distortion when modulation is applied. Thus another low pass filter follows the output transformers T_4 and T_5.

So that the input to the step attenuator may be set accurately (0.1V r.m.s. is the chosen level) a level-monitoring meter can be connected at this point. For convenience a second gain control R_{21} is fitted for setting-up: this, of course, is done with the normal "fine" output control R_{23} at maximum output.

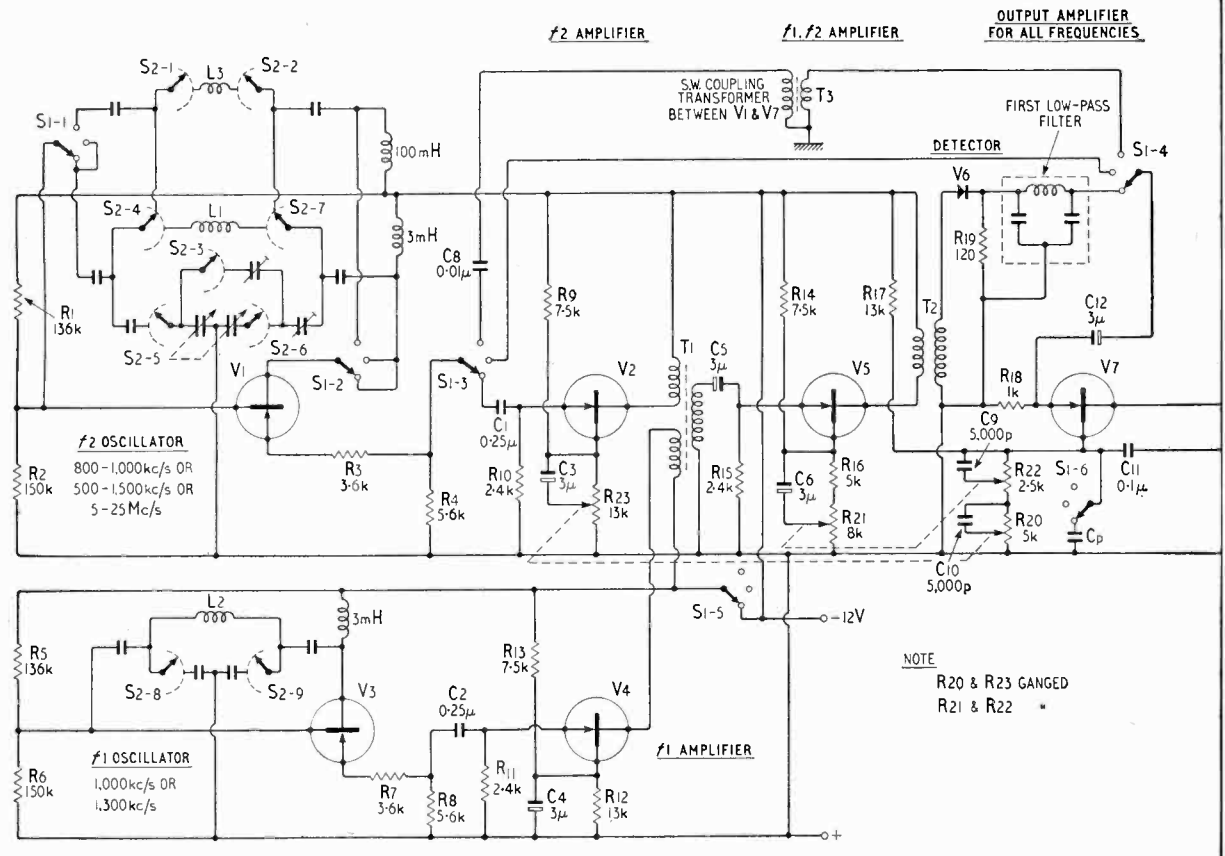


TABLE 2

Oscillator Frequency (kc/s)	Cut-off frequency f_c (kc/s)	Frequency Bands on Tuning Capacitor
800-1,300	650	B.f.o. filter
100-170	185	100-300 kc/s
170-300	320	
300-500	550	300-500 kc/s
500-850	925	500-850 kc/s
850-1,500	1,600	850-1,500 kc/s
5-9 / 8-15 / 14-25 Mc/s	No filter used	5-9 Mc/s / 8-15 Mc/s / 14-25 Mc/s

$L = 10^3 2R_t/2\pi f_c$ mH

$C = 10^6/2\pi f_c R_t$ μF

$R_t \approx 75\Omega$ (terminating impedance).

The range switch S_2 has eight positions, three of which cover the b.f.o. ranges 100 to 170kc/s, 170-300kc/s and 300 to 500kc/s. No change is made in the v.f.o. circuit between the 100 to 170kc/s and 170 to 300kc/s ranges—only the low-pass filters are switched. For clarity the coils associated with the v.f.o. are shown separately in Fig. 6 (a) and that for the b.f.o.—Fig. 6 (b).

For frequencies higher than 500kc/s a straight oscillator is used as the source, so that the supply to the beat oscillator V3 and V4 is interrupted by $S_{1\cdot5}$. Other sections of S_1 change the coupling transformer, r.f. chokes and capacitors to appropriate values for the low, medium and high-frequency ranges. It is not important to use an output low-pass filter on short waves as the harmonics are suppressed sufficiently by stray capacities in the attenuator network. On short waves only V1 and V6 (apart from the modulator) are operating, thus only these two transistors need to be of high f_α type. R_{22} and R_{20} perform the "set level" and "fine output" control functions, but as these are ganged to R_{21} and R_{23} respectively only two knobs are required on the front panel. R_{22} and R_{20} have no effect when the b.f.o. section is in use as they are by-passed by Cp, say 0.1μF, switched in by $S_{1\cdot6}$.

Monitoring Unit

At the h.f. end of the s.w. band the maximum oscillator output falls to about 50mV. Thus, when using the 14 to 25Mc/s band the meter has to give a clear indication at 50mV. At all other frequencies the output is set at 100mV. A sensitive meter (50 or even 25μA f.s.d.) is thus required and two diodes are connected in parallel as the rectifier.

This combination, shunted by a 270-Ω resistor has an impedance of about 150Ω and is substituted for the first 150-Ω shunting resistor in the attenuator so that maximum power is available to work the meter without causing a mismatch. The output level should be set with the step attenuator switched to 1μV and, of course, the "fine" control set to maximum output. For 50-mV level the current flowing through the meter is 4.5μA and for 100mV, 15μA. The frequency response of the unit is practically flat up to 30Mc/s.

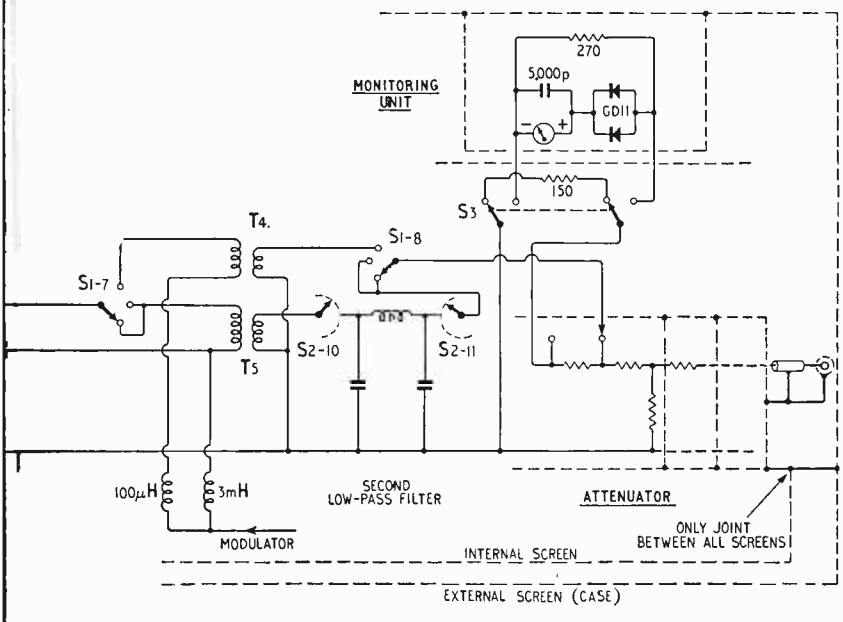
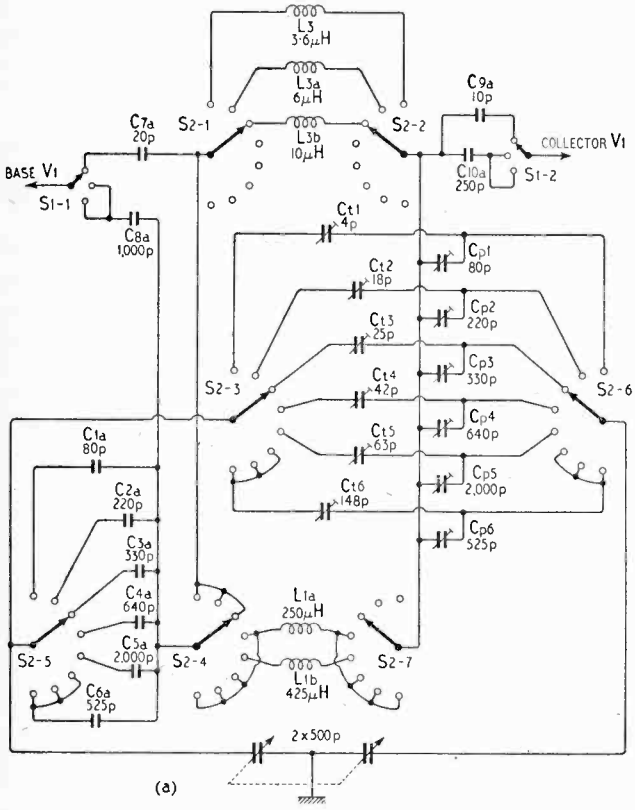


Fig. 5. Signal Generator: Detail of modulator is shown in Fig. 3(b), attenuator, Fig. 8, coil details and switching, Fig. 6(a) and (b); filters, Fig. 7. Transformer details: T_1, $\frac{5}{16}$in dia. former pri $\approx$ 30μH, 100 turns, spaced to 0.5in; sec $\approx$ 3μH 30 turns spaced to 0.5in; dust core of former fully in. T_2, T_5, pri 80mH; sec 3mH; impedance ratio 2000:75. T_3, pri 6.5mH; sec 0.5mH. T_4—as T_1 but without dust core.

Low-Pass Filters

A π-network has been used for the low-pass filters and the terminating impedances are, for the first filter 50 to 150Ω (input impedance of V7) and for the second 75Ω. Thus the value of 75Ω can be assumed for both filters; but it is advisable to check the input impedance of V7 under operating conditions. Table 2 and Fig. 7 show data needed for the calculation of the values for the low-pass filters, f_c being the cut-off frequency. On the lower ranges, using the b.f.o., the highest frequency to be passed by the first filter is 500kc/s and the lowest to be cut is 800kc/s, thus 650kc/s is a suitable frequency for design purposes. The other filters are the second or output filters, which remove the second harmonic generated by modulation; consequently these have to cut off below twice the lowest frequency on each range and this limits the ratio between mini-



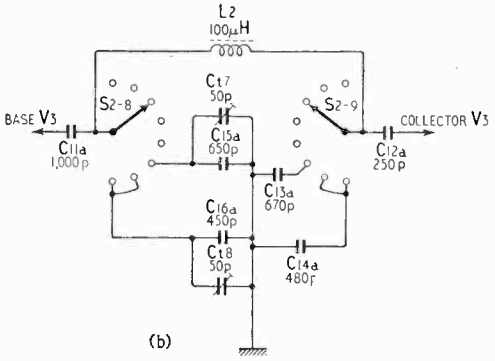


Fig. 6 (a). Variable-frequency oscillator (f_2) coil switching; (b) beat frequency oscillator (f_1) coil switching.

mum and maximum frequencies to less than 1:2. Thus the first b.f.o. range has to be divided into two, i.e., 100-170kc/s and 170-300kc/s and provided with the appropriate filters.

Some adjustment of the filters may be necessary after construction; for instance, if it is found that a filter is reducing output at the high-frequency end of its band, then the inductance of the coil should be reduced. This obviously calls for adjustable iron-dust cores, and, to achieve high efficiency, Litz wire and low-loss capacitors, such as polystyrene-dielectric types, should be used.

It will be noticed that the range switch (Figs. 5 and 6) has eight positions, although seven continuous-tuning ranges are provided—this extra position changes the first low-pass filter halfway through the lowest-frequency tuning range.

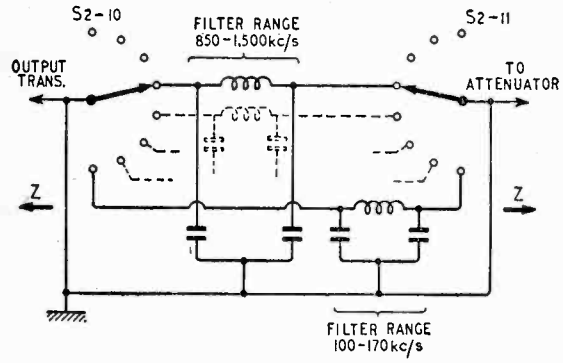


Fig. 7. Low-pass filter switching.

Attenuator

100mV is usually sufficient signal for testing purposes, and it is convenient to use 20dB steps, thus the attenuator steps run: 100mV, 10mV, 1mV, 100μV, 10μV, 1μV.

Fig. 8(a) shows the attenuator circuit and the way in which the values given for R_1 and R_2 are calculated. The use of a single-wafer switch would be convenient, but the capacities between the rotor and stationary contacts would shunt the attenuator resistors and render the whole useless for the higher ranges. Thus several wafers, individually screened and connected so that stray capacities do not bypass the resistors, have to be used and Fig. 8(b) shows how these are arranged. Assuming that the stray capacities C_p are about 0.1pF and the capacity to earth, C_s, is 3pF, the leakage attenuation will be 30 times per stage, i.e., three times the loss in the resistor. At the high-level end of the attenuator C_s is deliberately increased by adding small capacitors to improve the performance further.

The accuracy of attenuation should be reliable down to say 10μV at 5Mc/s. Outside these limits the screening of the oscillator must be very good if the calibration is to be within ±10%. The transistor signal generator has a very definite advantage here as no ventilation is needed (it is always difficult to screen holes!) and the power supply (battery) can be screened with the generator. Even so, careful construction is necessary.

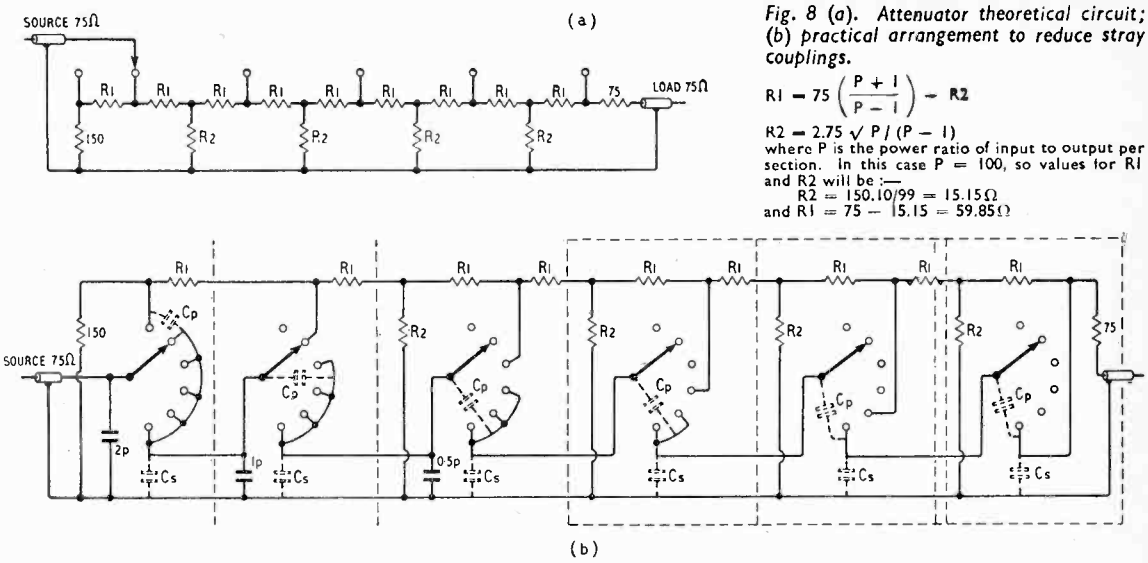


Fig. 8 (a). Attenuator theoretical circuit; (b) practical arrangement to reduce stray couplings.

$$R1 = 75\left(\frac{P+1}{P-1}\right) - R2$$

$$R2 = 2.75\sqrt{P}/(P-1)$$

where P is the power ratio of input to output per section. In this case P = 100, so values for R1 and R2 will be :—

R2 = 150.10/99 = 15.15Ω

and R1 = 75 − 15.15 = 59.85Ω

Construction

The front-panel controls are:—

1. Tuning (for ranges see Table 2).
2. Range switch (S_2).
3. Function switch (b.f.o., m.w., s.w.) (S_1).
4. Monitor meter and switch (S_3).
5. Level set (R_{21} and R_{22}, ganged).
6. Coarse attenuator (20-dB steps).
7. Fine attenuator (20-dB variation) (R_{23} and R_{20}, ganged).

Fig. 9 shows a suggested layout and the position of internal screens. It is essential to avoid loops or double paths between points on the screens; thus the internal screens are insulated from the case proper and are connected to the case and each other at only one point—the earthy connection of the output socket. The monitor or level-set meter circuit is enclosed in a screen which is secured only to the front plate, this forming its sole "earth" connection. The tuning dial should be outside the case, the front panel continuing behind it. Similarly no cut-outs should be made in the internal screening. The components are mounted on tags on a sheet of insulating material placed behind the front piece of the internal screen: the wiring should naturally be point-to-point, as short as possible, and in general follow roughly the theoretical circuit.

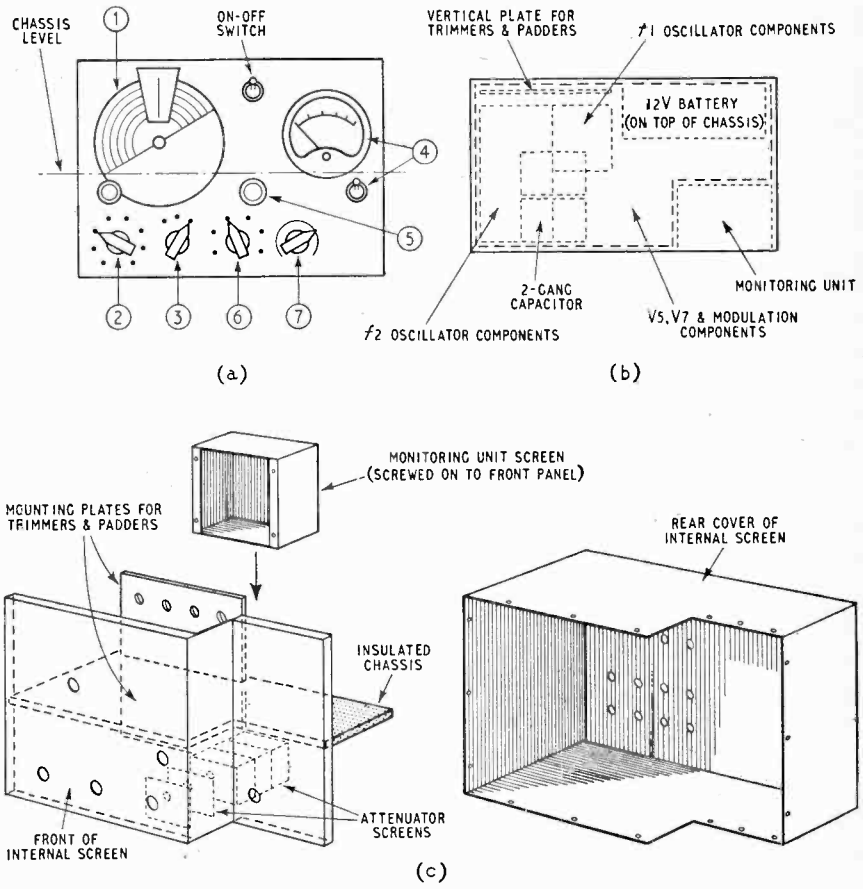
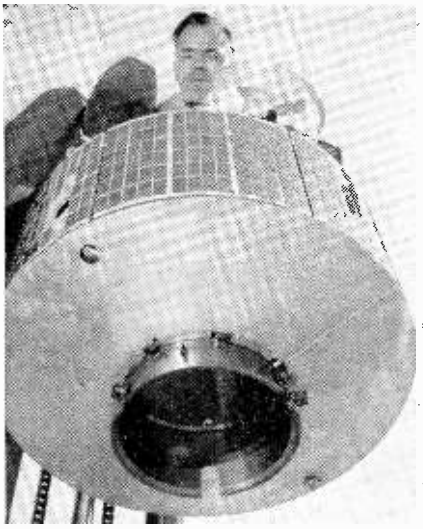
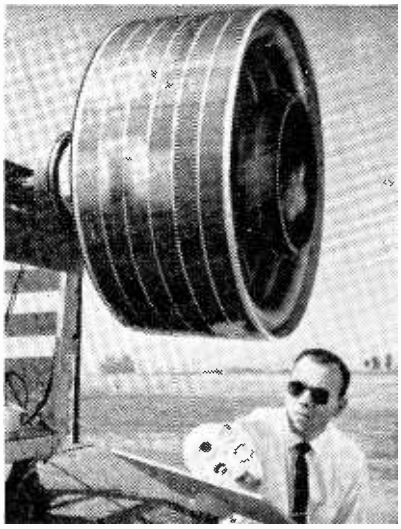


Fig. 9. (a) Front panel; (b) layout; (c) screening arrangements.





(Left) The Hughes spin-stabilized communication satellite is powered by 2,700 solar cells and is seen (right) undergoing centrifugal tests.

"FIXED" SATELLITE

HUGHES Aircraft Company in the United States have developed a communication satellite designed to orbit at a radius of 22,300 miles, and so to appear "fixed" above any selected point on the earth. Over the mouth of the Amazon, for instance, it would be "visible" to ground communication stations throughout most of North and South America, Western Europe and the Western half of Africa. The new design is 29 inches in diameter and weighs only 32 pounds, of which a mere 5 pounds is accounted for by the "electronics." It can be launched economically by a Scout rocket and weight has been reduced by adopting spin stabilization, with the axis parallel to that of the earth. Auxiliary nitrogen jets are used for final trim.

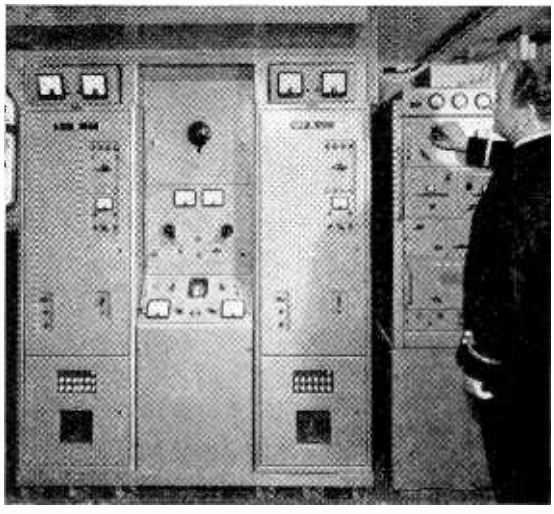
Since a pencil beam is not feasible with spin stabilization the aerial system is arranged to give a circular radiation pattern. The repeater consists of a transistorized u.h.f. receiver and L-band (2kMc/s) transmitter using a travelling-wave tube with a power output of 2.5 watts. Single-sideband is used to increase the number of available channels and the repeater also serves as a command receiver and telemetering transmitter.

Wideband Transmitter Output Amplifier

PART of the Marconi radio equipment installed in the G.P.O.'s cable-laying ship H.M.T.S. "Monarch" consists of two wideband transmitter output amplifiers, Type NT203, covering 1.5Mc/s to 24Mc/s and which do not require retuning whenever the transmitting frequency is changed. These can be used singly in conjunction with suitable drive units, such as the low-level drive stages of the NT201 independent-sideband transmitters included in the "Monarch's" equipment, or in parallel to give a peak envelope power output of 2.8kW (s.s.b. operation).

The NT203 is a linear distributed amplifier consisting of a penultimate stage and a power output stage. The former has 9 pairs of E180F valves in push-pull with anode and grid circuits consisting of "lumped-impedance" type transmission lines, while the final amplifier has 8 push-pull pairs of 4X250B air-cooled tetrodes, also with transmission-line circuits. The output impedance is 50Ω.

Although no tuned circuits are employed the discrimination against second harmonics throughout the frequency band covered is said to be generally better than −40dB and inter-modulation products are of about the same order. Included in these equipments are p.e.p. output indicators, feeder s.w.r. meters and facilities for remote control. Further details can be obtained from Marconi's Wireless Telegraph Co., Ltd., Chelmsford.



Marconi Type NT203 transmitter amplifiers in G.P.O. cable-laying ship "Monarch."

Electricity Direct from Heat

By "CATHODE RAY"

As I said only the time before last, a main aim of power engineers is to generate electricity direct from heat, instead of going through the tiresome sequence of using the heat to boil water and making the steam impinge upon blades in a turbine, causing it to move strong magnets past an array of conductors. This procedure is particularly irksome in nuclear power stations, where it looks incongruously old-fashioned alongside the modernity and scientific elegance of the nuclear part of the system. I am sure many people who know roughly how electricity is generated in ordinary fuel-burning stations imagine that steam-raising and turbines have been abolished in nuclear stations, and are surprised when they find them still in use. Even boilers are there, only they are called "heat exchangers."

Now I know that this sort of thing is none of our business, but—transistors notwithstanding—we rely upon it for most of our business. Besides that, we are finding ourselves moving closer to the successors of the old heavy electrical power engineers as we both converge towards a common centre—atomic physics. At the moment, the generation of electricity direct from heat looks like having more impact at first on our light electronic applications than on large-scale supplies.

The thing itself is nothing new. My last two instalments have been on undesired electrical manifestations of heat—as "noise" in valves and transistors. But electricity has been usefully generated direct from heat for ages. The fact that heating a joint between wires of different metals generated an electric current was discovered by Seebeck as long ago as the year Napoleon Bonaparte died. That electricity can be generated in a single piece of metal by heating one end of it (Thomson effect) is less familiar. But I suppose we all know that an ordinary diode valve acts as an electric generator when its cathode is heated. We may not all know that we know it, but it follows from the familiar fact that the characteristic curve of a diode extends slightly into the negative voltage region, as in Fig. 1(a). A load line can be drawn from the zero voltage point, representing a resistance R connected to the diode without any applied voltage; and the point at which it cuts the curve marks the current that will flow (I_0) and the voltage (V_0) across R. As the circuit diagram (b) shows, the generator of this current is indeed the diode, and of course its power output is I_0V_0 watts.

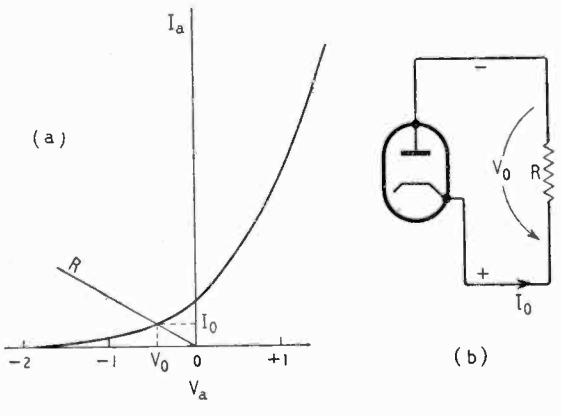


Fig. 1 (a) Enlarged view of the part of a diode characteristic curve near zero anode voltage, showing that some current flows even when the voltage is negative. (b) Basic circuit of a diode as a heat-to-electricity converter, the load resistance R being represented in (a) by the line marked R.

The issue here is perhaps confused by the fact that the heating of the cathode, without which no anode current would flow, is invariably done electrically. In the days when the cathode was always a directly-heated filament, there was some excuse for assuming that this anode current was somehow directly due to the filament battery. With an indirectly-heated cathode, that is impossible, and precisely the same result would be achieved in the anode circuit however that cathode was heated, so long as it was brought to the same temperature. It could for example be done with a bunson burner, or by focusing the sun's rays on it with a lens.

The fact that (purely for convenience) cathodes are heated electrically does at least mean that the input and output power are both of the same kind so that it is easy to calculate the efficiency. And it is not impressive. Typically, for an input of 1.4V, 0.15A (210,000 microwatts) the output might be 0.5V, 0.5μA (0.25 microwatt), or an efficiency of 0.00012%. Even heat from the sun is not so plentiful—in Britain, anyway—that it can be thrown away like that. All the same, the principle is established, and one must remember that normally this generator effect is discouraged by the valve designer. It is a major nuisance in low-reading valve voltmeters, because it shifts the zero to an extent that varies steeply with the cathode temperature. Can this despised weed be cultivated into a valuable plant?

Intensive cultivation has certainly been going on, and reports emerge from time to time claiming progressively higher efficiencies. Whatever I quote will probably be out of date by the time you read it, but an experimental efficiency of 12% has been claimed and 30% confidently predicted.

Even granting these figures are reliable, some readers (aware that electric generator efficiencies are in the upper nineties) may still not be impressed with their practical value, remarkable though the progress must be admitted to be. If so, then they must be confusing the efficiencies of the electrical machines alone (i.e., mechanical to electrical) with the overall efficiencies of generating stations, and the latter are subject to a serious limitation at the heat-to-mechanical stage. Any sort of heat engine is presented with a fluid, such as steam or burnt gas or oil, at a relatively high temperature. The energy the fluid possesses by virtue of this temperature drives the engine, and at

the exhaust the fluid is cooler and therefore has less energy. The difference is energy available for useful mechanical work. Naturally there are some losses, such as heat radiated from the engine and mechanical work lost in friction. But the efficiency of the engine, reckoned as the ratio of useful work to the drop in fluid energy between inlet and exhaust, can be quite high. This basis of reckoning takes no account of by far the biggest loss of energy—that thrown away in the fluid at the exhaust. The greater the ratio of maximum to minimum absolute temperature, the greater the amount of mechanical work theoretically

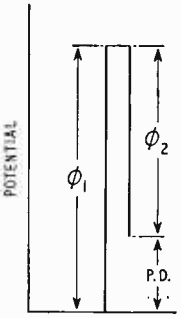


Fig. 2. When electrons pass from a conductor having a work function ϕ_1 to one with a work function ϕ_2, a potential difference is set up between them equal to ϕ_1-ϕ_2.

available. So in power stations the temperature at which the steam enters the turbines has been pushed steadily higher as engineering techniques have progressed. But even in the most modern power stations only about one-third of the heat energy of the fuel is utilized And of course the overall efficiency of small electric generating units, such as those used in country houses, is far lower. So the 12% of the "thermo-electron engine" begins to look more significant.

Note the rather surprising name, for a device with no moving parts—"engine." This has been given to it by Dr. Kaye and Dr. Hatsopoulos of U.S.A., leading workers in this field. They did so because they regard it as essentially a heat engine, like a steam or petrol engine. Just as steam flows from a hot body (the boiler) to a relatively cold body (the condenser) and back as water, so an electron "gas" flows from the hot cathode to the relatively cold anode and back via the load circuit. Only in doing so it gives (instead of mechanical energy) electrical energy. This analogy could no doubt be profitably followed into greater detail if we were mechanical engineers, well up in the theory of thermodynamics and heat engines. But I for one am not, so it would be a case of explaining the obscure in terms of the still more obscure. I just drop the hint in case any A.M.I.Mech.Es reading this would like to approach from that angle. As for the rest of us, we would probably be safer to stick to our electronics.

One of the facts thereof is that any electron requires a certain amount of energy to make it emerge from a conductor. This energy is curiously named the "work function" and denoted by ϕ, and is conveniently specified in electron-volts (eV) because that indicates the potential difference in volts that has to be overcome. If two pieces of exactly the same metal are brought into contact, their work functions—being the same—cancel out when an electron current flows out of one into the other. So (apart from any resistance drop) there is no difference of potential between the two sides of the contact. If however two metals with different work functions are brought into contact, a potential difference will be set up between them, equal to the difference between the work functions, as shown in Fig. 2. If you attempt to measure this with a voltmeter you will not succeed, even if you take the precaution of using a valve voltmeter drawing negligible current. That is because somewhere in the circuit there is bound to be at least one other junction between different metals, the net work function of which will cancel out the p.d. set up at the first junction.

Fig. 3 is a potential diagram for a diode connected as in Fig. 1(b). Beginning at the cathode, there is first a p.d. due to the cathode work function, ϕ_K. Because the direction of the electrons at the anode is inward, instead of outward as at the cathode, ϕ_A is set off downwards. But not from the level where ϕ_A left off. There is the p.d. caused by heating the cathode, which gives many of the electrons greater energy than is barely necessary to emit them. They are therefore able to climb a potential hill between ϕ_K and ϕ_A. In an ordinary diode the space charge due to the electrons between the electrodes makes this hill steeper, so that the number with enough spare energy to climb over it is a mere trickle—often less than 1 μA.

The difference of potential between cathode and anode is marked V_A, and this is the voltage available for driving the anode current through a load. To make it as large as possible, not only should the difference between cathode and anode temperatures be as large as possible but ϕ_K should be as much larger than ϕ_A as possible. And the space-charge hill (δ) should be reduced—preferably eliminated altogether. Unfortunately, increasing the current increases it! So the cure must be pretty drastic.

In a vacuum diode, the obvious but by no means easy way is to get rid of the gap. No space, no space charge. Of course, there must be some gap, otherwise cathode and anode would be at the same temperature and all one would get would be the thermo-electric e.m.f. Experimentally, it has been made as small as 0.01 millimetre—an impressive achievement with an emitting surface.

Another way in which the "engine" differs from an ordinary diode is that for the latter one wants as large an emission at as low a temperature as possible, an aim that is promoted by using an oxide coating to reduce ϕ_K. But here one wants a high temperature, which looks after the emission without the need for a low ϕ_K. So tungsten, which has a high ϕ and high melting point, is indicated.

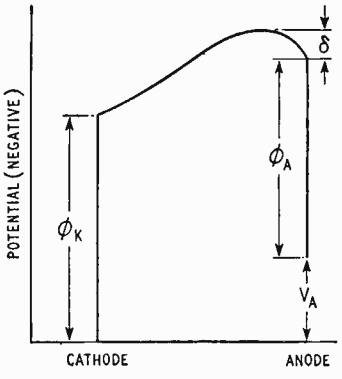


Fig. 3. In a diode the cathode and anode have their work functions, ϕ_K and ϕ_A; there is also a p.d. due to the heating of the cathode. The net p.d. between anode and cathode is marked V_A. A crowd of electrons between cathode and anode constitutes a space charge, which raises a potential barrier δ, severely restricting the flow of current.

There are obvious difficulties in maintaining such a minute gap, especially with such large temperature changes, and alternative solutions have been looked for. One of them is the control of the electrons by a third electrode, as in Fig. 4. Although the names "cathode" and "anode", meaning the electrodes where the electrons respectively leave and arrive, are correct by definition even when the anode is negative relative to the cathode, the inventor of this tube evidently felt they weren't altogether appropriate and substituted the transistor terms "emitter" and "collector". The accelerating plate is held at a positive potential of the order of 100V. By itself this would obviously draw off all the electrons and cause a heavy current to flow through the battery—not at all what is wanted. So a permanent magnet is also fitted, to provide a magnetic field B, at right angles to the electric field E. Directly the electron starts off towards the positive plate, it crosses the magnetic field, and in accordance with the right-hand rule is whisked around into a curved path that takes it (if everything has been correctly calculated) to the collector, and thence through the load R to the starting point. So, although a relatively high voltage is needed for the accelerator, there should be no current in that circuit and therefore no expenditure of power in providing the two fields.

It has been calculated that a device of this kind is potentially capable of a higher efficiency than the diode "engine", but a snag is that if the current density in the tube is large the field strengths have to be large—perhaps impracticably so.

I am more impressed with the possibilities of a third variety, which is analogous to the gas-filled diode, the great advantage of which is the neutralizing of the negative space charge by positive gas ions, so that the voltage drop between cathode and anode is greatly reduced. This, of course, is just the sort of thing we want, and allows of a reasonable engineering clearance between cathode and anode. In fact, it can be more than that, allowing the designer better scope for keeping the heat where it is needed.

In order to be of any use for neutralizing the electronic space charge, the gas atoms have to be ionized, by knocking away at least one electron from each. In the ordinary "soft" rectifier this is done by the applied anode voltage accelerating the emitted electrons to a velocity that renders them capable of inflicting this bodily harm on the gas atoms. But in the "engine" there is no applied voltage, and the velocity of emission is not enough. One idea is to provide an auxiliary ionizing electrode held at an appropriate voltage. But there are obvious objections to that. It has been found possible to ionize them with the work function voltage of the cathode, if that exceeds the ionizing voltage of the gas. With most combinations it doesn't, but with the exceptionally high work function voltage of tungsten (4.52V) and the exceptionally low ionizing voltage of caesium vapour (3.89V) it does. The voltage is brought to bear when the caesium atoms hit the cathode.

Besides performing this essential duty, the caesium has the convenient effect of reducing the work function of the anode to 1.81V. So the difference between ϕ_K and ϕ_A is exceptionally large, and consequently so is the output voltage—in an experimental "engine", 2.5V at 1A. This quite high output current required a very high cathode temperature, 2,910°K (=2,637°C), and yielded an efficiency of 10.4%.

In this experiment, with $2\frac{1}{2}$ watts output, the load resistance was 2.5Ω. Much higher power would mean correspondingly lower load resistance. Even in these days of transistors there isn't very much call for such low-voltage d.c. as that. It is possible to step up the voltage to some extent by arranging several diodes in series. But often one wants a.c. A very ancient joke was to send some sap to buy an a.c. battery. One might think it equally naïve to ask for an a.c. version of the kind of current generator we have been considering. But their developers have no such inhibition and have pointed out that by suitably modulating their output in accordance with known techniques they can be made to provide a.c.

In experimental work so far reported, the cathodes have for convenience been heated electrically, the idea presumably being to established the essential principles before complicating the issue by the practical problems of applying non-electrical heat. That these problems are rated by the developers as mere routine can be guessed from the confidence with which they have announced that thermo-electron engines can be built to use conventional, nuclear or solar heating. In view of the exponential relationship between output and temperature (this is yet another place where $e^{1/kT}$ comes in; see "k" in the last November issue) I would expect control of temperature to sufficiently narrow limits to be quite a formidable problem on its own. But they know more about what they are doing than we do.

The thermo-electric effect has already been mentioned. Has it been considered as a source of power, as distinct from instrumental applications such as thermometry? It has not only been considered but actually used, I believe on a commercial scale, a good many years ago. One form, if memory serves me (if it doesn't, "Free Grid" will no doubt come to the rescue) was seen in this country, for bringing the offerings of the B.B.C. to the considerable proportion of British citizens who at that early date had a gas supply but no electricity. Another recollection of about the same period concerns a paraffin powered radio for bringing news of the exploits of stahkanovites and similar inspiration to dwellers in the remoter parts of the People's Republics. There would seem to be scope for more and smaller

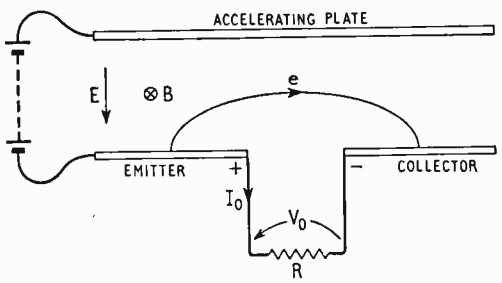


Fig. 4. In this diagram, E represents an electric field from accelerator to emitter, and the conventional symbol marked B is the rear of an arrow pointing into the paper, indicating the direction of a magnetic field. Under the influence of these fields, electrons leap across to the collector without causing space-charge effects.

devices of this kind now that transistors have displaced valves, for situations (if any) where batteries are not readily obtainable. (What about a combination radio and petrol lighter?) Compared with thermo-electron engines, they are less efficient at high temperatures, say about 1,000°K, but more efficient at lower temperatures. Their maximum efficiency is lower. And the voltage per thermo-junction is much lower even than that per diode, but it is rather easier, I would think, to arrange a lot of them in series, as in fact is usually done.

Development of semiconductors is having its impact on thermo-electric devices, as on so much else, but that is a subject (and a very involved one) of its own.

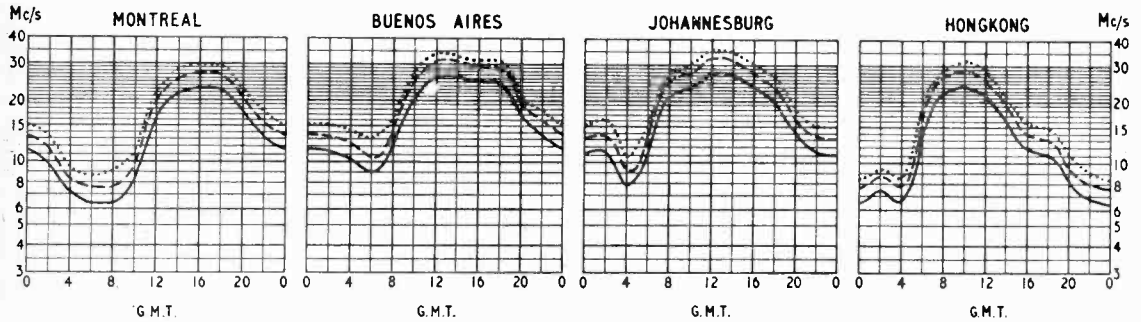
Another kind of generator altogether is the magnetohydrodynamic, considerately abbreviated to mhd. It makes another whole subject, but perhaps I can just indicate the broad idea by saying how it compares in principle with the conventional power station. In a turbo-generator set, a fluid (steam) is used to generate mechanical energy, which in turn generates electrical energy by causing relative motion between conductors and magnetic fields. In the mhd generator these two stages are telescoped into one by using a conducting fluid. The possibilities would seem to be very big indeed. But a great deal of development will be needed before they can displace such highly developed and well established units as turbo-generators.

Another kind of device that is sometimes included under our title, though it would be more correct to call it a generator of electricity *instead* of heat, is the fuel cell. If a supply of hydrogen gas is ignited it will burn, just like commercial gas, by combining with the oxygen of the air to form water vapour. This is simply a rearrangement of the electrons in the hydrogen and oxygen atoms. When rearranged, their total energy at their original temperature is less, so the surplus is given off as heat. However, by arranging a sort of middleman to keep the two parties to the transaction separate, this surplus energy can be made to come in potential form, as an excess of electrons at one electrode and a deficiency at another, these electrodes therefore becoming negative and positive respectively.

This is precisely what happens in an ordinary chemical battery cell, the only difference in a fuel cell being that the materials can be fed in continuously instead of being used up irreplaceably. In the Bacon cell—which we heard a lot about, over a year ago—hydrogen and oxygen are fed in through porous electrodes in a solution of caustic potash, and the chemical reactions cause electrons to accumulate on the hydrogen electrode and be withdrawn from the oxygen electrode—which therefore becomes about 1 volt positive. The efficiency is much higher than in the best heat engine, and the possibilities are tremendous.

All this may seem to have been a maximum hotch-potch of information for a minimum of accomplished practice. We have so often been let down by popular news of what was "just round the corner." And however promising the experimental results, the new methods of generating electricity will have a tough fight before they can displace the firmly established methods. Perhaps at first they will be limited to exotic applications such as satellites. But I shall be surprised if some of the conventional sources of electricity are not seriously challenged before many more years have rolled.

SHORT-WAVE CONDITIONS *Prediction for February*



THE full-line curves indicate the highest frequencies likely to be usable at any time of the day or night for reliable communications over four long-distance paths from this country during February.

Broken-line curves give the highest frequencies that will sustain a partial service throughout the same period.

•••••••••• FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE FOR 25% OF THE TOTAL TIME

— — — PREDICTED MEDIAN STANDARD MAXIMUM USABLE FREQUENCY

——— FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE ON ALL UNDISTURBED DAYS

The Bootstrap Follower

2.—MEASUREMENTS IN PRACTICAL CIRCUITS

By G. W. SHORT

IN the first part of this article the properties of the "bootstrap follower" were discussed and a high-gain cascade amplifier combination of a pentode and bootstrap follower was analysed. We now pass to a consideration of practical design details and some measurements of performance.

Effect of Output Capacitance.—The effect of the capacitance c_{s2} across the output of the amplifier has so far been ignored. One reason for this is that c_{s2} is unknown—it depends on what you connect to the amplifier. Another is that the effect is complex, because c_{s2} affects the load seen by the pentode. Clever people could no doubt calculate the performance with c_{s2} included, but the writer gave up at this point, and made some measurements instead.

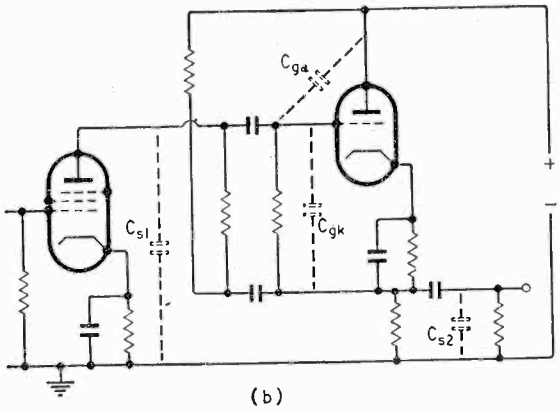


Fig. 8(b).—Bootstrap follower combination showing stray capacitances. (Repeated from Part 1 of this article).

The circuit used is shown in Fig. 9, which is based on Fig. 8(b). Care was taken to keep the anode strays of V1 down to a minimum. R_4 and R_5 were connected "close up," coupling capacitor C_2 was a small type (TCC Metalmite) and the valve holders were just far enough apart to accommodate it. A small earthed screening plate was put between the grid and anode tags of the triode valve holder, which are adjacent. The rest of the circuit was arranged so that it could quickly be changed from a bootstrap follower amplifier to a cascade amplifier and vice versa. For the cascade amplifier, C_3 was disconnected, R_8 was shorted, and R_6 was unshorted. The output was taken to a voltmeter via another bootstrap follower stage, made up from the other section of the ECC81 double triode. The meter was calibrated by applying the output of the audio oscillator used for measuring frequency responses directly to this second bootstrap follower stage.

The cascade amplifier had a gain of 6000 at 1 kc/s, and a — 3dB bandwidth of about 10 kc/s. The gain of the bootstrap follower amplifier at 1 kc/s was 1700. Some reduction was to be expected, because, first, in the circuit used only half the pentode load is subject to impedance multiplication, and, second, the triode gain (V_{ou}/V_{gk}) is reduced because the load is halved. Despite the lower gain, the high-frequency response was poorer than that of the cascade circuit (see Fig. 10) because of the ill effects of c_{s1}. This stray capacitance is made up of the output capacitance of the EF86 (5.5pF) plus strays, which might be expected to add up to 10 pF in a carefully wired-up circuit. In the cascade circuit, the triode should have a gain of 38, and in the bootstrap follower circuit a gain of 32. The value of c_{ga} is 1.6 pF, while c_{gk} is 2.2 p.F. These values yield a calculated ratio of gain-bandwidth products of 6, which agrees with the measurements (ignoring the l.f. responses).

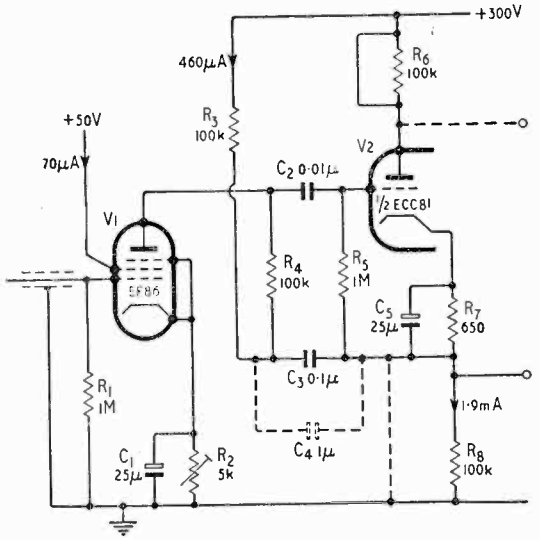


Fig. 9. —Practical pentode—b.f. combination circuit, based on Fig. 8(b). This can be turned into a cascade amplifier by disconnecting C_3, shorting R_8, and unshorting R_6. R_2 was adjusted to provide 1.5 V bias for V1.

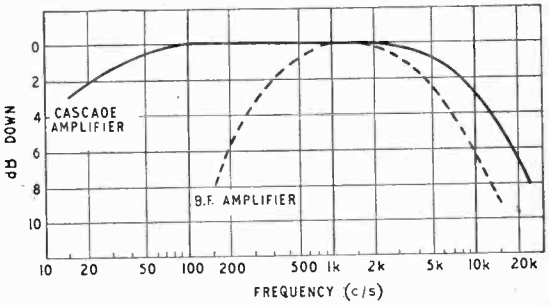


Fig. 10.—Frequency responses of the cascade and bootstrap follower amplifiers.

The effect of a capacitive triode load is shown in Fig. 11, which shows how the cut-off frequency (— 3dB) varies with this capacitance. As might be expected, the effect is worse for the cascade amplifier, which has a higher output resistance, but it is not very serious for normal values of load capacitance.

Low-Frequency Response.—The falling-off of l.f. response in the cascade amplifier due to the 0.01μF, 1 MΩ interstage coupling should produce a 3dB loss at about 16 c/s, and this will be made slightly worse by the triode cathode-bias circuit. The measured response agrees with this. In the bootstrap follower amplifier, however, the lower cut-off frequency is about 330 c/s, which is twenty times greater.

Why should there be such a great discrepancy between the two circuits? The obvious difference between them is that the bootstrap follower amplifier

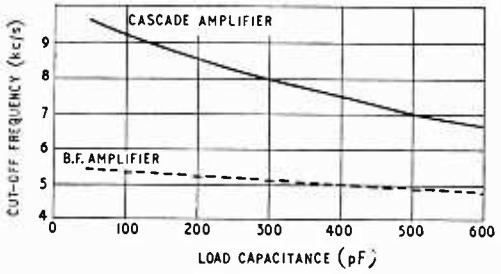


Fig. 11.—Effect of load capacitance on upper cut-off frequency.

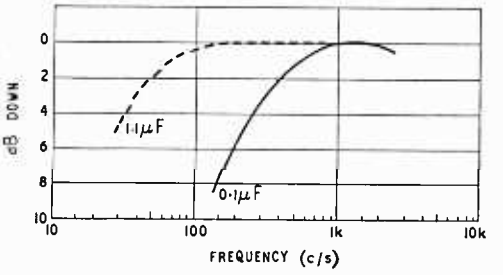


Fig. 12.—Effect of lower coupling capacitance on l.f. response of bootstrap follower amplifier.

has *two* couplings, C_2R_5 and C_3R_3, instead of one. In Fig. 9, these have equal time-constants, so on the face of it one would expect merely a further 3dB loss at 16 c/s compared with the cascade amplifier. Indeed even this would be pessimistic, since R_5 is impedance-multiplied to about 33 MΩ in the bootstrap follower.

It seemed reasonable to leave the upper coupling network C_2R_5 as it was, and make measurements with an increased C_3R_3. An extra 1μF capacitor C_4 was strapped across C_3 and the response measured again. The result, shown in Fig. 12, was to bring down the cut-off frequency to 40 c/s, which is a marked improvement, though the cascade amplifier is still superior. The best thing to do would be to make C_3 infinitely large by connecting the lower end of R_4 directly to the other end of R_a. This kind of direct connection is used in Bailey's circuit.* Unfortunately, a direct coupling of this kind puts the two valves in series across the h.t. line and so imposes restrictions on their d.c. operating conditions. The h.t. voltage must be shared between the two stages, and the anode currents of the valves must be equal. An a.c.-coupled circuit is more versatile in this respect and, fortunately, adequate l.f. response can be ensured by using a suitable electrolytic capacitor for the lower coupling. A small leakage current is permissible since it does not seriously affect the operating conditions of the triode.

In a circuit like that of Fig. 9, there are signal-voltage drops across C_2, R_7 and C_5, and C_3. All of these reduce the voltage fed back to the lower end of R_4, and so reduce the amount by which R_4 is multiplied by bootstrap action. If, for example, the transmission of each coupling were 0.9, then the overall transmission would be 0.9 cubed or 0.73, which would result in nearly 3dB loss of gain. At lower frequencies the transmission of each coupling would be smaller and the situation would get rapidly worse. The loss of l.f. signal across the triode cathode-bias network is particularly bad, since any signal-frequency voltage lost here reduces the impedance multiplication of the grid resistor R_5, which in turn reduces the response of the C_2R_5 coupling; so once the rot sets in it spreads rather rapidly. Moreover, it is only the in-phase part of the fed-back voltage which produces impedance multiplication. Because of this, in a CR network such as C_3R_3, the effective part of the output voltage is $1/(1 + X^2/R^2)$ times the input, X being the reactance of the capacitor. Thus when X = R, which is the normal condition for a 3dB loss, the actual loss is 6dB.

Single-Ended Bootstrap Follower Amplifiers.—The foregoing results show that, as a single-ended amplifier, the pentode-bootstrap follower combination is inferior in gain to a normal cascaded amplifier. Another disadvantage is that it cannot deliver as great an output voltage.

There may be circumstances in which these disadvantages are unimportant, and there may be reasons why the bootstrap follower combination is still an attractive proposition. Possible grounds for preferring the bootstrap follower combination to a normal cascade amplifier are component economy, stability, and greater suitability for use in feedback circuits. Let us see if there is a niche in which the bootstrap follower circuit fits.

An examination of Fig. 9 shows that, in this particular bootstrap follower combination, there is no component economy compared with a cascade amplifier. Indeed, one extra resistor and one extra capacitor are required. To reduce the number of components some degree of direct coupling must be resorted to. A completely direct-coupled circuit would look very like Fig. 7 (Part 1). The trouble with this is that the pentode load R_a is also the cathode-bias resistance for the triode. It must therefore be small (no more than a few thousand ohms) and the gain is therefore small. Readers will recognize this kind of circuit as one variety of "single-ended push-pull" output stage. In a power output stage one does not look for high gain so much as high output power, and the comparatively low gain is not important. Somewhat similar arrangements have also been used in video-frequency amplifiers which must work into low-impedance loads. The load R_l is connected via a block-

* *Wireless World*, January, 1960

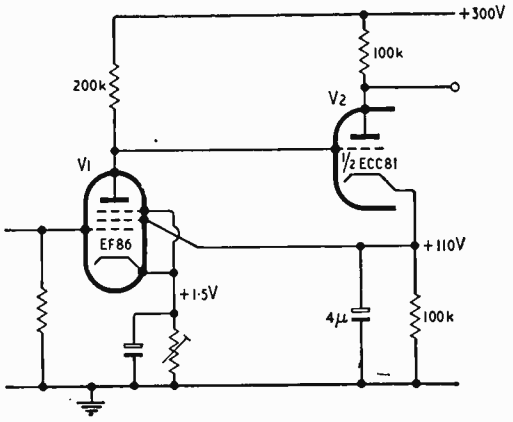


Fig. 13.—Partially direct-coupled cascade amplifier designed for economy in components.

ing capacitor, or returned to a tap on the h.t. supply such that there is no direct current through it.

A circuit which is not completely direct-coupled and is capable of furnishing much more gain has already been mentioned in connection with low-frequency response. Naturally, it uses fewer components than an a.c.-coupled circuit. But if direct coupling is to be permitted, one must compare like with like: that is to say, one must compare a bootstrap follower combination having some degree of direct coupling with a cascade amplifier also with some degree of direct coupling. Such a cascade amplifier is shown in Fig. 13. Astute readers will realize that the circuit of Fig. 9 can be converted into that of Fig. 13 with the minimum of trouble on the part of the experimenter! With this circuit the gain was about 8000, with an upper cut-off frequency of 8.5 kc/s. The lower cut-off frequency was 110 c/s: this indicates that the triode cathode capacitor was too small. Although this circuit is very economical in components, it does not represent quite the limit in economy. With some combinations of valves it should be possible to do without the triode cathode resistor. To be able to do so, the anode current of the triode must be the same as the screen current of the pentode, and the pentode must be capable of working satisfactorily with a screen voltage slightly in excess of its anode voltage. The best bet is to use a high-slope pentode such as the EF91, but unfortunately this kind of valve is not really suitable for use in low-level a.f. stages, because of hum and microphony. In general, it is much better to use a proper audio valve like the EF86 and stand the expense of the one extra resistor.

Readers who like using unorthodox-looking circuits may care to experiment with a combination of valves such that the screen current of the pentode is *greater* than the anode current of the triode. The triode cathode resistor must then be returned to h.t. positive.

The bootstrap follower combination does possess one characteristic which sometimes makes it more suitable than a normal amplifier. This is that there is only one phase reversal, so that the input and output voltages are in anti-phase. This can be useful in feedback circuits for getting the polarity right.

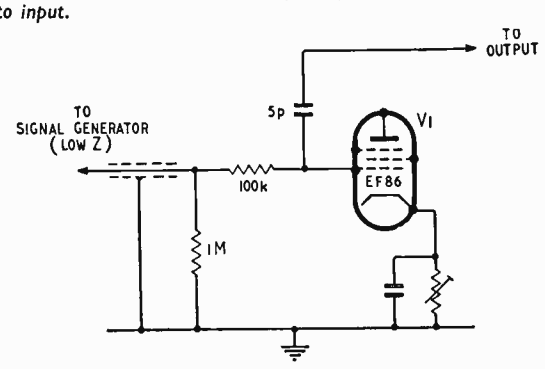
In certain circumstances, the bootstrap follower combination may produce less phase shift than a cascade amplifier. This is because the triode has a lower output resistance in the bootstrap follower circuit and so the high-frequency phase shift caused by capacitance across the output will be less than in the triode stage of the cascade amplifier. The writer suspects, however, that claims about reduced phase shift for this kind of circuit are usually based on an assumption that the output resistance of the triode is as low as that of a true cathode-follower. If this were so, then for audio applications the high-frequency phase shift introduced by load capacitance would be negligible. Unfortunately, as we have seen, this is not true of circuits in which the triode is driven from a high-impedance source, and these are the very circuits which produce high gain. In such circuits there are two important h.f. cut-offs, as in a cascade circuit. While Fig. 11 suggests that there may well be more h.f. phase shift in the cascade circuit, one could always reduce it in the latter by using a smaller triode load and possibly still end up with a high overall gain.

On the matter of stability, it is obviously true that stray coupling from output to input of the bootstrap follower combination is not likely to cause oscillation, since it completes a negative feedback loop. Such coupling could only give trouble of this kind if phase shifts elsewhere in the loop were large enough to bring the total phase shift to 180°. It does not follow that the effect of stray coupling is harmless. Since such a coupling takes place by way of a capacitance of, at the most, a few pF, it is in itself frequency-selective and introduces considerable phase shift. It can therefore affect the frequency response considerably.

To illustrate this the frequency response was measured with a 5-pF capacitor connected from output to input. Measurements were made on the Fig. 9 bootstrap follower combination with the input circuit modified as shown in Fig. 14. Since the 1-MΩ grid resistor was virtually shorted by the signal generator, the effective signal-source resistance was 100 kΩ.

The effect of the 5-pF feedback capacitance was to change the frequency response to that shown by the solid-line curve of Fig. 15. The gain at the peak was 1200, and the response was 3dB down at about 1.5 kc/s. Even this is better than might be expected on simple theory. If one regards the boot-

Fig. 14.—Modification of bootstrap follower amplifier input circuit to measure the effect of stray coupling from output to input.



strap follower combination as a sort of composite single-valve amplifier, then the 5-pF capacitance is its anode-grid capacitance and gives rise to Miller effect. Since the gain without feedback was previously found to be 1700, a 5-pF capacitance must look like 8500 pF between the input grid and earth, and with this value of capacitance one would expect a 3 dB drop at about 200 c/s.

The 100-kΩ grid stopper by itself, without the 5-pF feedback capacitance, has some effect on the high-frequency response. This is shown by the dotted-line curve of Fig. 15.

Bootstrap Follower Phase Splitters.—In general, then, the single-ended bootstrap follower combination is inferior to ordinary cascaded stages. In phase-splitting circuits of the "concertina" type, however, it can be used with advantage to obtain a higher overall gain than one would get from a straight pentode followed by a normal triode concertina phase-splitter.

Fig. 16 shows the frequency response of a modified Fig. 9 circuit. The modifications consisted of adding a 50-kΩ anode load resistor and using a 4-μF electrolytic capacitor for C_3. The gain to either output was 1250. The deterioration in h.f. response is probably the result of Miller effect in the triode, which approximately doubles the effect of the grid-anode capacitance.

This type of circuit is clearly very useful. The h.f. response could be improved by reducing the load of the pentode. The gain would fall, but it would still be greater than that of a normal circuit with no impedance multiplication. One way of reducing the gain is simply to remove C_5. This reduces the impedance multiplication and introduces some local negative feedback. Another method is to reduce R_4, and yet another is to use a low-μ triode for V2.

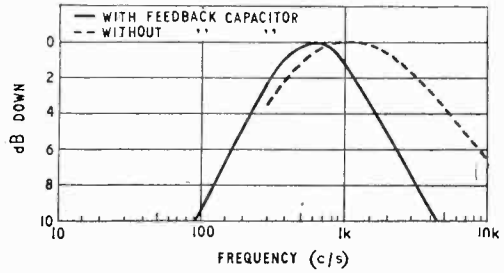


Fig. 15.—Effect of 5pF coupling capacitor (solid line). The dotted line shows the response without the capacitor but with a 100-k Ω grid stopper.

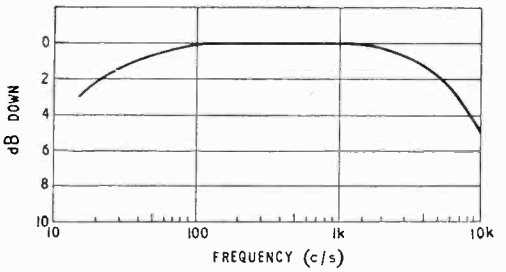


Fig. 16.—Frequency response of bootstrap follower phase-splitter combination.

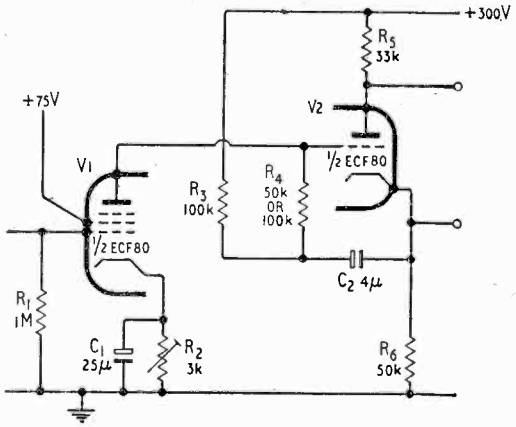


Fig. 17.—Experimental high-gain phase-splitting circuit using a triode-pentode valve. R_2 was adjusted to provide a bias of 1.5V. R_4 is the only component which adds stray capacitance to the sensitive part of the circuit.

In many cases, an impedance multiplication of 10-20 will be as much as can be made use of without running into h.f. response difficulties, and almost any triode will provide this amount. It then becomes an attractive proposition to use a triode-pentode of the television frequency-changer type as a single-valve bootstrap follower phase-splitter combination, to give high gain together with adequate bandwidth.

Whichever circuit is used, care should be taken to minimize the wiring stray capacitance in the pentode anode and triode grid circuit. The best way of doing this is to connect these two electrodes directly, since a short piece of wire has a lower capacitance to earth than a coupling capacitor. In addition, the number of components in the vulnerable part of the circuit should be kept as small as possible, since each one adds its quota of stray capacitance. The components should be soldered to the valve-holder tags, using short leads, and not mounted on tag boards some distance from the valve holders.

These considerations lead to the kind of circuit shown in Fig. 17. With $R_4 = 50$ kΩ, this had a gain of 750 to each output, 3 dB down at 14 c/s and 30 kc/s, and provided about 25 V peak from either output into a 300-kΩ load. With $R_4 = 100$ kΩ, the gain was 1000, the bandwidth was 15 kc/s, and the peak output was about 35V. No attempt was made to optimize component values (this applies to all the circuits used in making measurements for this article) and it may well be possible to do a bit better than this.

A valve designed for r.f. applications is not likely to have very low hum and microphony, but it should still be possible to use such a valve where the signal level is fairly high. The usual high-slope output pentodes require round about 10V grid drive, so that the input to a typical pentode bootstrap follower phase-splitter would be about 10 mV. This is a bit too low for comfort, but in many amplifiers 20 dB of negative feedback is used, and the required input would then be 100 mV. Under these conditions one might hope to get away with it. However, the writer would like to emphasize that the circuit of Fig. 17 has not been tried out by him in an actual audio amplifier. It may be full of hidden snags, and, as this article has endeavoured to illustrate, with these types of circuit you can't be too careful.

Symbolic Circuit Description

A USEFUL FORM OF SHORTHAND FOR COMPLEX SYSTEMS

By P. RAILTON and H. JEFFERSON, M.A.

THE increasing complexity of electric and electronic circuits has brought in its train an increasing mass of paper describing the operation of the circuits. Where the descriptions are intended to be used for maintenance and fault-finding they are of necessity detailed and as the equipment grows in size the study of the handbook becomes itself a task of formidable proportions. This is especially true of switching circuits. In the linear circuits, amplifiers, modulators and the like, there is commonly a single path to be followed throughout the units of the system with perhaps an entrant side chain from an oscillator to a modulator or a separation into a number of parallel and similar tracks at a filter system. In switching circuits we no longer have this simplicity. The operation of a relay may close six circuits and open half-a-dozen more. Sometimes, though this is usually deprecated, two circuits may race against each other and the designer's skill becomes his skill as a handicapper. As each stage in the operation is completed a whole new set of functions is initiated. All this must be described.

To facilitate the understanding of repetitive but non-linear circuits a practice has developed of showing a small diagram at important points of the circuit diagram to indicate the waveform which will be seen on an oscilloscope connected to any of these points. This practice, not surprisingly, is very frequently adopted by the manufacturers of oscilloscopes, but it has also been found useful by others whose judgment can be assumed to be free of any trace of special interest. It is a clear admission that a lengthy description of the functioning of the device is not really sufficient.

An interesting method of dealing with the circuit description of switching circuits has been suggested by M. M. Bonell in the official journal of the Spanish Posts and Telecommunications, *Revista de Telecomunicacion* (Vol. 12, No. 53, pp 2-7, September 1958). The author is concerned with the functioning of automatic telephone exchanges and his paper is devoted to a description of a symbolic method of cataloguing the stages involved in setting up a call. He claims that on four pages of normal size he has provided all the information normally requiring a book of more than one hundred pages. Obviously the information has become much more accessible: at the same time it has become easier to understand and in consequence easier to remember.

Bonell's diagrams appear tc be of much wider application than he suggests and they deserve wider publicity. This article has been prepared to ensure the latter and to encourage the former. Its merits are those of Bonell, its defects must be attributed to the authors.

In order to demonstrate the method we have

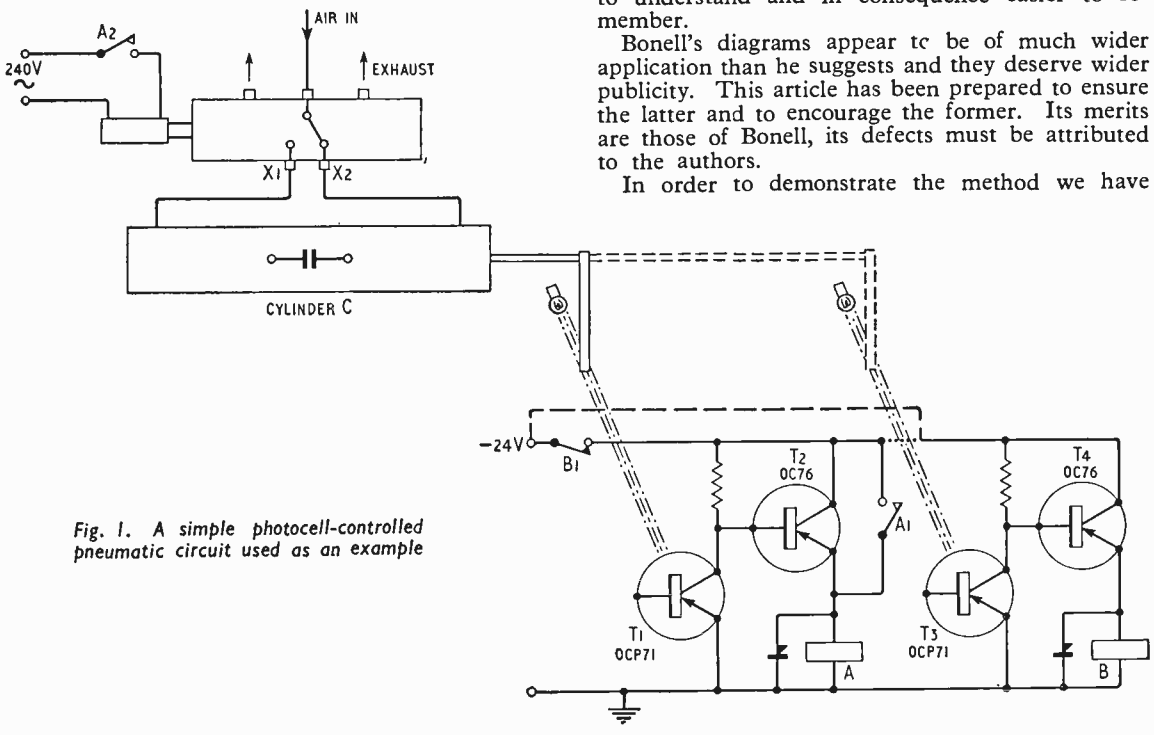


Fig. 1. A simple photocell-controlled pneumatic circuit used as an example

devised a simple reciprocating circuit in which air pressure is used to drive a shutter to the point at which it intercepts the light falling on a photo-transistor. A second transistor then operates a relay to reverse the motion which continues until the shutter reaches a second light beam. The complete arrangement is shown in Fig. 1. It will be seen that in this relatively simple system we have on-off

(1) *When first switched on with the piston in some arbitrary central position light will fall on both phototransistors which will then conduct, cutting off the second transistor of each pair. Neither relay will be operated. The air valve X will not be energized so that pressure will be applied through the path X2 to the cylinder and the piston will be driven to the left.*

(2) *When the piston has travelled far enough to the left the shutter will intercept the light falling on the normally conducting phototransistor T1. In consequence T1 will be cut off, bringing the normally non-conducting transistor T2 into conduction and operating relay A. The —24 volt supply for this action is provided through the normally closed contact B1.*

(3) *Relay A now locks on through its own holding contact A1.*

(4) *Contact A2 is operated and applies the 240 v a.c. mains supply to the solenoid of air valve X.*

(5) *When the solenoid is energized air pressure is applied through the path X1 to the cylinder, while the other end is opened to atmosphere through X2. The piston is driven to the right.*

(6) *As soon as the piston moves light again falls on the photo-transistor T1, cutting off the transistor T2 but leaving A operated through the holding contact A1.*

(7) *On the completion of its stroke the piston causes the shutter to intercept the light reaching phototransistor T3. As in step 2 transistor T4 conducts and relay B is operated.*

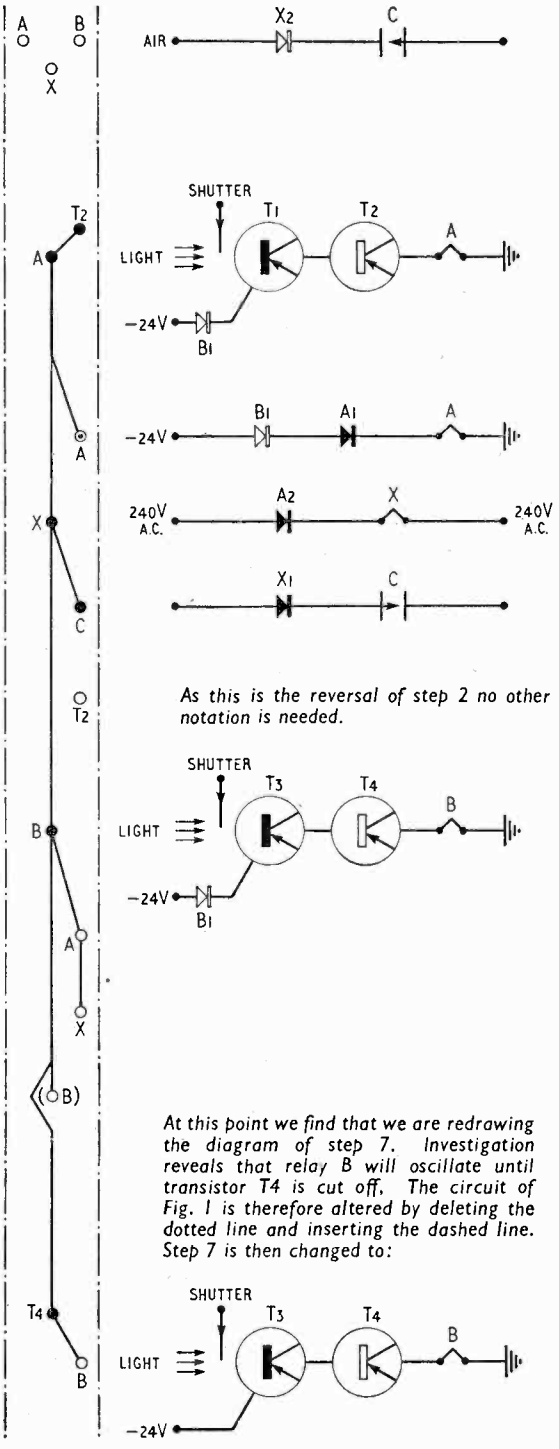
(8) *The operation of B opens contact B1 so that relay A releases.*

(9) *The release of relay A opens the holding contact and also contact A2, so that X releases.*

(10) *The operation of contact B1 also releases B*

(11) *The release of B closes contact B1.*

With the change thus made necessary steps 10 and 11 disappear. A new stage in the centre indicates the re-illumination of T3 and consequent events.



As this is the reversal of step 2 no other notation is needed.

At this point we find that we are redrawing the diagram of step 7. Investigation reveals that relay B will oscillate until transistor T4 is cut off. The circuit of Fig. 1 is therefore altered by deleting the dotted line and inserting the dashed line. Step 7 is then changed to:

The system is now in the origina' state with relays A and B and solenoid X all de-energized. This is the opening condition of step 1 and the cycle will now be repeated

Key to Symbols


Contact normally made or air path normally complete


Contact made or air path completed when device is energized


Relay or solenoid coil


Non-conducting transistor


Conducting transistor

● Relay energized

○ Relay de-energized

◉ Relay held

actions in light paths, air paths, electric circuits through transistors and electric circuits through relay contacts. It is now necessary to describe in detail the functioning of the circuit. This is done in the table, which contains in parallel columns the conventional description in words and the symbolic description of the Bonell diagram.

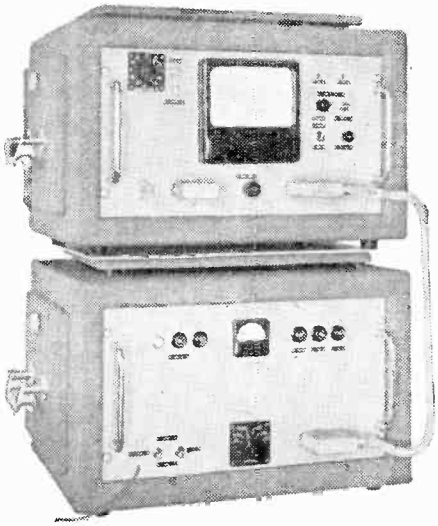
As will be seen the Bonell diagram is in two parts, the one on the left indicating the successive operations, for example the energizing of relay A in step (2), while on the right the skeleton of the circuit which produces the operation is given in a form which tells us what happens without excessive detail. We do not, at this stage, require to know just how much light must be cut off from the phototransistor in order that the second transistor emitter current will rise to the operate current of the relay. This is a matter which must always be referred back to the original and detailed circuit.

The preparation of the Bonell diagram is in itself a useful tool in the detection of circuit errors. Such an error which results in a race between the piston movement and relay B has been introduced into the symbolic circuit, in order that it might be detected at step (10). It is probably always more difficult to gloss over racing sequences and similar circuit aberrations in a highly formalized language, which is what the diagram in fact is, than in a flow of words.

In the manuscript a conservative estimate is that the Bonell diagram occupies only one-third of the length of the conventional description. This is a much smaller improvement than is claimed by Bonell. There are two reasons for this: the circuit itself is simpler than Bonell's circuits and the conventional description is rather abbreviated. For example, in step 3 no mention is made of the -24V supply, nor of the fact that the normally made B1 contact is in the holding path of relay A. This sort of abbreviation becomes much less pardonable in complex circuits.

The symbols used for relays are those introduced by Bonell, while the others are those which we have found convenient. It is, of course, vital to the success of a symbolic form such as this that a uniform system should be adopted and that once adopted it should be protected from the hands of the improvers who can produce a maximum of confusion for a minimum of merit.

Permanent Noise Factor Measurement



A METHOD of centimetric radar receiver noise measurement, which provides a permanent meter indication of noise factor under true working conditions has been developed by C.S.F. (Compagnie Générale de Télégraphie Sans Fil, 79, blvd. Haussmann, Paris 8).

The limited output of a noise discharge-tube, pulsed at half the recurrence frequency of the radar equipment, is fed to the transmission waveguide via a directional coupler. The noise pulses are employed as a standard, and are delayed to avoid interference from clutter.

The amplitude of the receiver output is proportional, during "even" pulses, to receiver noise added to that of the noise diode, and to receiver noise alone during "odd" pulses. The two outputs are compared in a differential amplifier, the output of which is proportional, after standardization, to the difference in amplitude of the two inputs. A meter connected to the output of the amplifier gives noise factor in decibels.

An additional rack enables measurement of noise factor to be made on one or more radars, readings being presented on separate meters.

CLUB NEWS

Bradford.—"Transistors, Pirates, and Direction Finding" is the title of the talk to be given by A. R. Bailey (G3IBM) at the February 14th meeting of the Bradford Amateur Radio Society. The club meets on the second and fourth Tuesdays of each month at 7.30 at Cambridge House, 66, Little Horton Lane, Bradford 5.

Cleckheaton.—Dr. N. H. Chamberlain, of Leeds University, will deal with industrial electronics in a lecture to the Spen Valley Amateur Radio Society on February 1st. Meetings are held on alternate Wednesdays at 7.30 at the Labour Rooms, Cleckheaton.

Halifax.—Transistors is the subject of the lecture to be given by E. C. Bell, of Bradford Technical College, at the February 7th meeting of the Halifax and District Amateur Radio Society. Meetings are held at the Sportsman Inn, Ogden, at 7.30.

Leeds.—The February programme of the Leeds Amateur Radio Society includes a transmitting evening (1st) and a lecture by D. Watson on amateur television (15th). The club meets each Wednesday at 7.45 at 3 Woodhouse Square, Leeds 3.

Elements of Electronic Circuits

22.—Multiplication and Division

By J. M. PETERS, B.Sc. (Eng.), A.M.I.E.E., A.M.Brit.I.R.E.

ARITHMETIC multiplication and division form an important part of mathematical operations on wave-forms and a variety of methods for achieving these functions have been devised.

Multiplication

Three common methods of achieving multiplication use the characteristics of valves, "take logarithms" almost as one would using log. tables or employ a pulse generator of variable width and amplitude.

Valve Characteristics.—If it is desired to achieve multiplication with valves at least two inputs should each, independently, be proportional to the output. With a triode, this means that the anode characteristic (I_a/v_a) must be linear. In other words the output current must be proportional to the anode voltage and the grid voltage:

$$I_a = k v_a v_g$$

Although this relationship is very difficult to achieve in practice, if some types of output tetrodes or pentodes strapped as triodes are used and the range of variables is restricted, an output approximately proportional to the product of two input voltages may be obtained. Fig. 1(a) shows a circuit using two tetrodes strapped as triodes. V2 is a cathode follower with V1, the multiplier valve, as the cathode impedance. $v_{k2} = v_{a1} = v_2$ by cathode follower action. As the valves have been arranged to have linear I_a/v_a characteristics, variation of v_2 causes a linear variation in current through the valves; as does v_1. Thus the common valve current I_a and consequently v_{out} is proportional to $v_1 v_2$.

A similar method uses a multi-grid valve, with the voltages to be multiplied applied to different grids (Fig. 1(b)). This is the process commonly known as "multiplicative mixing" nearly always used in a.m. superheterodyne radio receivers, where the anode current $= k v_{g1} v_{g3}$. Here v_{g1} is the signal voltage applied to the first (control) grid and v_{g3} is the local oscillator voltage applied to the third grid of the mixer valve.

A similar process occurs in amplitude modulation where the carrier amplitude after modulation is proportional to the modulating signal and to the amplitude of the carrier input.

Logarithmic Devices.—Let us consider the expression $\log a + \log b = \log ab$. Some forms of diode can be operated under conditions which produce a practically logarithmic voltage/current characteristic; hence this can lead to their use for multiplication purposes. After converting the inputs, the two logarithms are added and the antilogarithm derived, either directly from an exponential characteristic or by methods which involve the use of feedback circuits. Rectifiers of the copper-oxide type have a forward-impedance law which is approximately logarithmic (of the form $v = R \log I$) and can be used for multiplication. Fig. 2 shows a simple circuit employing a rectifier.

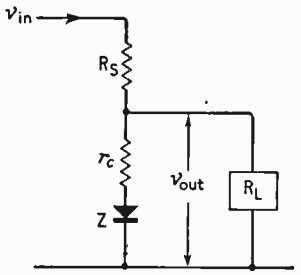


Fig. 2

- Z— the dynamic-forward or "characteristic" resistance of the rectifier.
- r_c— the ohmic resistance of the rectifier—this represents the resistance of the assembled component parts of the device and is quite small.
- R_S—the resistance of the source—this is made large compared with Z.
- R_L—the load resistance which is also made large compared with Z.

An improvement on this simple circuit is the non-linear bridge circuit employing identical rectifiers (Fig. 3). First of all let us consider what happens when R_1 and R_2 are fixed and R_3 and R_4 are varied. For low values of R_3 and R_4 it is possible to balance the bridge, i.e. $v_{out} = 0$. As the values of R_3 and R_4 are increased the

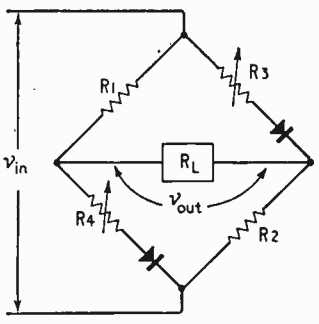


Fig. 3

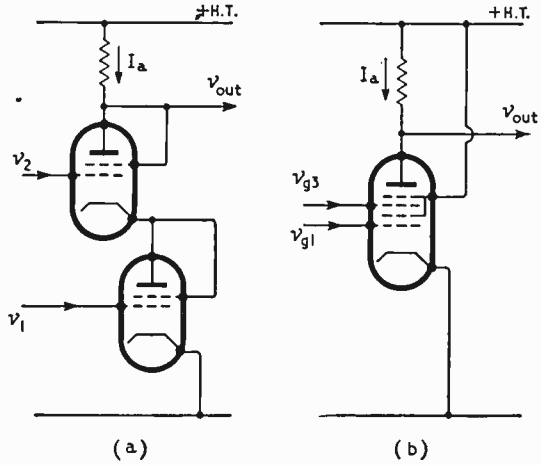


Fig. 1

input voltage v_{in} must be made larger in order to balance the bridge. Ultimately a condition is reached when v_{out} can no longer be zero, regardless of the value of v_{in}, and when $R_3 = R_4 = R_1 = R_2$ the output current (and hence v_{out}) rises logarithmically with an increasing v_{in}.

Variation of Waveform.—The average value of a waveform is proportional to the product of its amplitude and duration, provided that the negative excursion is clamped to zero. This is pressed into service by making the amplitude of the waveform follow one input and the duration the other. Methods based on this principle are quite often used in computers with a comparatively high degree of accuracy.

Division

Naturally, circuits carrying out this function are sometimes required and the simplest of these need not use valves or semi-conductors.

Passive Circuit Elements.—A very common example of potential division is the arrangement of resistors, capacitors or inductors in simple potential-divider configurations. The volume control is perhaps the most familiar divider; with this the input represents one variable, the rotation another. Of course, for "mathematical" use the potentiometer must have an accurately-known law.

Logarithmic Division Devices.—The expression $\log a - \log b = \log (a/b)$ enables us to use the logarithmic devices which were described in the section on multiplication.

Suppose we wish to find the quotient of two voltages $v_1 \div v_2$. We apply these voltages to two non-linear bridges and connect the bridges in series. The output currents are fed to a meter which records their difference $I_1 - I_2$. Then since $I_1 = k \log v_1$ and $I_2 = k \log v_2$, $I_1 - I_2 = k \log v_1 - k \log v_2$ which by definition is $k \log (v_1/v_2)$ therefore the difference in output currents is proportional to the logarithm of the ratio of the two inputs.

Feedback Techniques.—With the aid of a high-gain amplifier together with a subtractor circuit it is possible to convert any multiplying circuit into a dividing circuit. Let us examine the block diagram of Fig. 4.

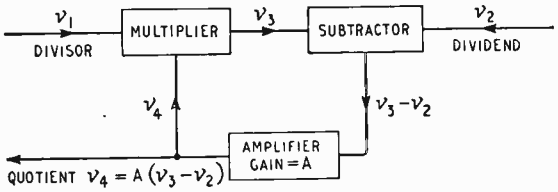


Fig. 4

It is required to derive the result $v_4 = v_2/v_1$. The equations to be considered are :—

$$v_3 = kv_1 v_4 \quad \text{(1) (from the multiplier)}$$

$$v_4 = A(v_3 - v_2) \quad \text{(2) (from the amplifier)}$$

substituting in (2) for v_3 we have

$$v_4 = A(kv_1 v_4 - v_2)$$
$$v_4 - Akv_1 v_4 = -A v_2$$
$$v_4 (1 - Akv_1) = -A v_2$$
$$v_4 = A v_2/(Akv_1 - 1)$$
$$= v_2/(kv_1 - 1/A)$$

If we make the gain (A) of the amplifier very high 1/A becomes very small. Then $v_4 = v_2/kv_1$ which is the required ratio (k can be made equal to one).

TECHNICAL NOTEBOOK

Tunnelling through Insulators has recently been demonstrated by Ivar Giaever of the American General Electric Research Laboratories. The quantum tunnelling process by which electrons can pass through an energy barrier which they have insufficient energy to surmount has already been demonstrated and made use of in semiconductor tunnel diodes, but had not so far been observed in insulators. In Giaever's experiments the insulator was only ~ 10-100 atoms thick and was sandwiched between two metal plates. Giaever also found that, if both of the metals were made superconductive, then the tunnelling voltage/current characteristic exhibited a negative-resistance region. Since superconductivity can be removed by applying a magnetic field, this offers a method of controlling the characteristics of such a device. It could in fact be made to function as a capacitor, resistor, diode, negative-resistance diode, switch or triode. The device can be made simply by depositing the metal and insulating layers on a suitable substrate. It could thus be made extremely small and with a very low power consumption and dissipation. Since the tunnelling current depends on the electron density in the energy levels in the two metal plates, information about these levels can be obtained from measurements of the tunnelling current.

Photographic Memory has been recently developed by Bell Telephone Laboratories for an experimental electronic telephone switching system. In this memory switching instructions and directory information are permanently stored in the form of many small clear spots in an otherwise opaque photographic film. Each store contains over 2×10^6 spots or "bits" of information. This is read out by a flying-spot scanner, a 68-bit word taking only 2.5μsec to read. The flying-spot electron beam is also used to initially develop the film by stopping the beam briefly at positions where a spot is desired. A photographic emulsion is used which is fast enough to be exposed when the beam is stopped, but slow enough not to be exposed by a moving beam. Two million spots can be exposed in about ten minutes in this way. The photographic developing process—which may involve as many as fifteen steps and which takes in all about half an hour—has been made completely automatic in this equipment.

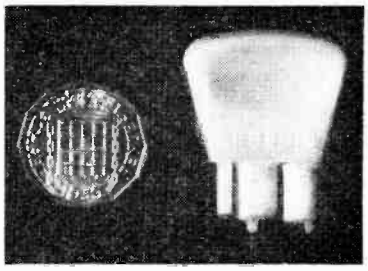
Thermoelectric Cooling Unit—the BT4—has been introduced by Salford Electrical Industries. This unit utilizes the Peltier effect in which heat is absorbed or generated when an electric current is passed across the junction of two dissimilar metals or semiconductors. (This effect occurs only at the junctions, and is in addition to the normal Joule electrical heating in the metals or semiconductors.) In this unit four pairs of junctions formed between p- and n-type bismuth telluride are used since this semiconductor exhibits a

large Peltier effect. In use the unit is clamped between the object to be cooled and a heat sink (for absorbing the heat produced from four of the junctions). The cooling power increases with decreasing temperature difference between pairs of junctions up to a maximum, for this unit, of about 3W for a 10°C junction temperature difference. The cooling power can also be continuously varied or even reversed simply by varying the value or direction of the input current, so that such units can readily be incorporated in automatic control systems. Other advantages of this cooling unit over conventional units are that the actual junctions occupy only about a $\frac{1}{2}$-in cube, it is silent and reliable (since no moving parts are used) and finally, it is unaffected by vibration or attitude.

Microwave Modulator using n-type germanium diodes has been developed by E. T. Harkless and R. Vincent of the Bell Telephone Laboratories. The operation of the device depends on the fact that such diodes, when suitably mounted in a waveguide, can be changed from nearly perfect absorbers to almost complete reflectors simply by switching the d.c. bias on them. The modulator uses a pair of such suitably-mounted diodes combined with a hybrid junction. With a reverse bias of about 7V on the diodes they reflect nearly all of the radiation incident on them and the microwave signal is transmitted with an attenuation of only 1 to 2dB. When the bias is switched to about 40mA in a forward direction nearly all of the radiation incident on the diodes is absorbed and the microwave signal is attenuated by 30 to 40dB. In this way up to 1W of 35kMc/s radiation has been successfully switched on and off at a repetition rate of 10Mc/s and with pulse rise and fall times of less than 2mμsec. Pulse lengths as short as 5mμsec have also been achieved.

High-Voltage Line Fault Locator introduced by Ferranti detects faults by means of the signal reflections these faults produce. The locator produces signals at a frequency of 1Mc/s in the form of 400V peak-to-peak 5μsec pulses spaced at 5msec intervals. These pulses are capacitively coupled to the 132 or 275kV high-voltage line. Any discontinuity in the electrical characteristics of the line due to a fault or the proximity of a tower then produces reflections of the pulses which are detected in the locator. The reflections produced by faults are larger and so may be distinguished from the reflection produced by towers. The delay between a pulse and its reflection determines the distance along the line to the discontinuity to an accuracy of 1% or 3000 ft, whichever is the greater, and faults can be detected at distances from 1 to 100 miles. This new locator should replace the old time-consuming method of visually searching the line for faults.

Tape Cleaning Attachment for use with the Grundig TK24 four-track recorder on fast forward or rewind is shown (with a threepenny bit to indicate its size) in the photograph. The attachment has three prongs which are fitted into three corresponding holes on the tape deck when it is desired to clean the tape. Dust and other foreign particles are removed from the tape as it bears on the felt pads which cover two of the attachment prongs. Such cleaning



reduces the number of "drop outs" and this can be particularly beneficial with four-track reproduction.

TRANSISTOR BATTERY TAPE RECORDER

MARKETED in this country by E.M.I. Sales and Service, the German Protona "Minifon Attaché" dictation tape recorder measures only 7in by 4in by $1\frac{3}{8}$in and weighs only 2 lb 6 oz. With the tape magazine used with this recorder, an overall playing time of 2×15 minutes can be obtained. The response is within ±3dB from 200c/s to 3000c/s at the single tape speed used ($1\frac{7}{8}$in/sec). Fast rewinding is at 30 times this record/playback speed. A useful dictation facility is that the last few syllables can be repeated. This recorder is transistorized and runs from a 12V battery.

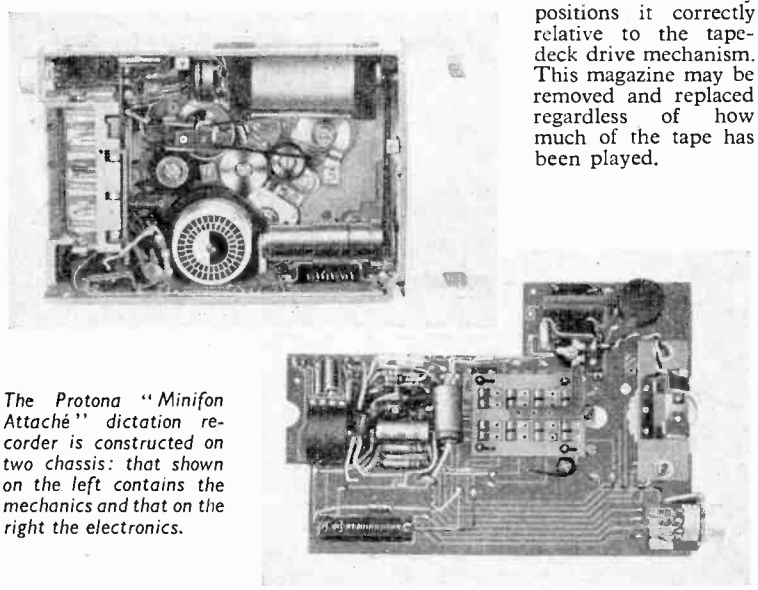
A 34kc/s bias and erase supply is provided from a single OC308 transistor. A permanent magnet can also be used to erase both tracks simultaneously while fast winding.

As the battery supply runs down, the motor speed and amplifier supply voltage are kept constant by means of an electrical centrifugal governor and transistor voltage stabilizer respectively. The transistor stabilizer also suppresses electrical motor noise.

To reduce possible sources of flutter, a structure consisting of two heavy cylinders joined by a spiral spring is used to connect the motor transmission belt to the capstan. The capstan is not connected to the tape take-up and supply spools during recording or replaying; the supply spool is instead driven by the motion of the tape past the capstan. Take-up tape tension is provided by connecting the take-up spool to the supply spool by means of a slipping clutch and belt of suitable transmission ratio. For fast forward or rewind the capstan is connected to the take-up or supply spool via one or two idler wheels respectively.

The motor is automatically stopped at the end of each reel by cutting off an OC307 transistor which is in series with the motor battery supply. This is done by using the metal foil on the end of the tape to join the emitter and base of the OC307.

The tape is housed in a magazine which automatically positions it correctly relative to the tape-deck drive mechanism. This magazine may be removed and replaced regardless of how much of the tape has been played.



The Protona "Minifon Attaché" dictation recorder is constructed on two chassis: that shown on the left contains the mechanics and that on the right the electronics.

LINEAR PASSIVE FOUR-TERMINAL NETWORKS

USE OF SUPERPOSITION AND RECIPROCITY TO DETERMINE ELECTRICAL CONSTANTS

By G. de VISME*, B.Sc.

ASSOCIATED with linearity, either in the field of mechanical, electrical, magnetic, or even electromagnetic systems, there are two quite fundamental and—but for special cases—unprovable axioms: Superposition and Reciprocity.

The first principle asserts that the effect of a number of independent causes acting together within a linear system is the sum of the effects produced by each cause acting on its own.

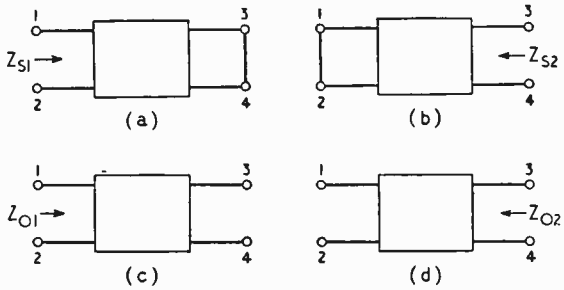


Fig. 1. Definition of short-circuit and open-circuit impedances of a four-terminal network.

The second principle states that if a cause at one point in a linear system produces an effect at another point, then the same cause acting at the second point produces the same effect at the first. In a sense, this principle expresses the fact that a linear system behaves in the same way in both directions.

The linear passive four-terminal network is a very important type of linear network. It can be represented as a box with four terminals, 1, 2, 3 and 4, between which some form of coupling exists. The box itself contains no separate sources of voltage or current, and the elements coupling the four terminals are all linear.

Using only the principles of superposition and reciprocity, and without specifying the contents of the box, we derive the coupling between any two pairs of terminals in terms of externally measurable properties of the four-terminal network, namely the open- and short-circuit impedances measured across these two pairs of terminals.

Define short-circuit and open-circuit impedances Z_{S1}, Z_{S2}, Z_{O1} and Z_{O2} as in Fig. 1(a), (b), (c) and (d).

1. Let us short-circuit terminals 3 & 4 and connec, to terminals 1 & 2 an a.c. generator of zero impedancet whose voltage is representable by the complex number V_1.

Sinusoidal currents, representable by complex numbers I_1 and I'_1, will flow in the left-hand and right-hand circuits respectively, as in Fig. 2.

The signs and arrows in this diagram, as in all subsequent diagrams, indicate the positive directions of voltages and currents.

We have therefore, by definition,

$$V_1/I_1 = Z_{S1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (i)$$

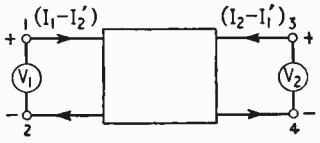
The ratio V_1/I'_1 also has the dimensions of impedance; let us call this ratio Z_{T1}.

2. Now let us short-circuit terminals 1 & 2 and connect to terminals 3 & 4 an a.c. generator of zero impedance, whose voltage is representable by the complex number V_2.

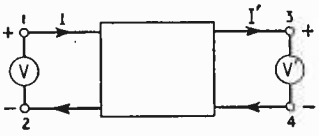
Sinusoidal currents, representable by complex numbers I_2 and I'_2, will flow in the right-hand and left-hand circuits respectively, as in Fig. 3.

As before, we have, by definition,

$$V_2/I_2 = Z_{S2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (ii)$$



Left: Fig. 4. Superposition of Figs. 2 and 3.



Right: Fig. 5. Relabelled version of Fig. 4.

And we may define an impedance Z_{T2} equal to V_2/I'_2.

The principle of reciprocity then requires that $Z_{T1} = Z_{T2} = Z_T$, say. Thus we have

$$V_1/I'_1 = V_2/I'_2 = Z_T \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (iii)$$

3. Suppose we now connect the generators V_1 and V_2 at the same time to terminals 1 & 2, and 3 & 4 respectively. Then the principle of superposition requires that the currents flowing in the left-hand and right-hand circuits be respectively $(I_1 - I'_2)$ and $(I_2 - I'_1)$, as in Fig. 4.

For convenience, let us relabel the voltages and currents, calling V_1 V, V_2 V', $(I_1 - I'_2)$ I, and $(I'_1 - I_2)$ I', as in Fig. 5.

*Squadron Leader, Royal Air Force Technical College, Henlow.

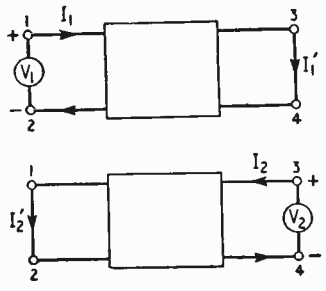


Fig. 2

Figs. 2 and 3. Four-terminal networks with one pair of terminals short-circuited and a generator connected to the other pair.

Fig. 3

Then,

$I = V/Z_{s1} - V'/Z_T$, from (i) and (iii) ..... (iv)

$I' = V/Z_T - V'/Z_{s2}$, from (ii) and (iii) ..... (v)

These equations are entirely general, irrespective of the values of V and V'. They relate the currents flowing in the input and output circuits with the voltages *actually present* across terminals 1 & 2 and 3 & 4.

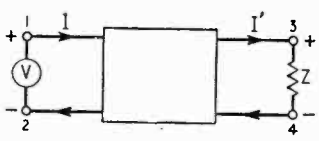
Suppose we now adjust the voltage of the generator across terminals 3 & 4 so as exactly to prevent any current from flowing in the right-hand circuit. To do this we have to make $V' = (Z_{s2}/Z_T)V$, from (v).

As a result, V/I becomes

$$\frac{V}{(V/Z_{s1}) - (Z_{s2}/Z_T)V/Z_T}, \text{ from (iv)}$$

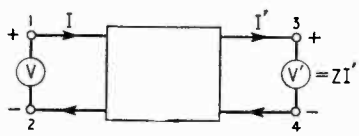
$$= Z_{s1}Z_T^2/(Z_T^2 - Z_{s1}Z_{s2})$$

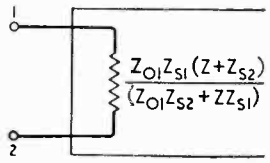
As far as the network is concerned, it is conscious only of an open circuit across terminals 3 & 4 and



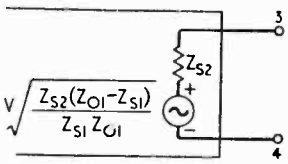
Left: Fig. 6. Four-terminal network terminated in an impedance Z.

Right: Fig. 7. Substitution of a suitable generator for the impedance Z in Fig. 6.





Left: Fig. 8. Equivalent input circuit of a four-terminal network terminated in an impedance Z.



Right: Fig. 9. Equivalent output circuit of a four-terminal network.

hence presents to the generator V the impedance Z_{O1} by definition, so that,

$V/I = Z_{O1} = Z_{s1}Z_T^2/(Z_T^2 - Z_{s1}Z_{s2})$,

Therefore,

$Z_T^2 = Z_{s2}/(1/Z_{s1} - 1/Z_{O1})$ ..... (vi)

Now, instead of adjusting V' to make I' zero, we will adjust the voltage of the generator connected to terminals 1 & 2 to make the current I zero. To do this we have to make $V = (Z_{s1}/Z_T)V'$, from (iv).

As a result, V'/I' becomes

$$\frac{V}{(Z_{s1}/Z_T)V'/Z_T - (V'/Z_{s2})}, \text{ from (v)}$$

$$= Z_{s2}Z_T^2/(Z_{s1}Z_{s2} - Z_T^2)$$

By the same reasoning as before, the impedance presented to the generator V' is Z_{O2}, so that, noticing the direction of I' in Fig. 5,

$-V'/I' = Z_{O2} = Z_{s2}Z_T^2/(Z_T^2 - Z_{s1}Z_{s2})$

Therefore,

$Z_T^2 = Z_{s1}/(1/Z_{s2} - 1/Z_{O2})$

Comparing this with (vi), we see that

$Z_{s1}/Z_{O1} = Z_{s2}/Z_{O2}$ ..... (vii)

Although we defined *four* impedances Z_{s1}, Z_{s2}, Z_{O1}, and Z_{O2}, we see that they are not independent, but are related in a simple way as shown in equation (vii).

We are now in a position to calculate the behaviour of the four-terminal network when terminated in a general impedance Z, as in Fig. 6.

In this case the voltage V' is produced by the current I' flowing through Z, and is therefore related to I' by the equation V' = ZI'. We can substitute this value of V' into equations (iv) and (v) without further ado, but for the benefit of readers who have not fully grasped the idea of generator substitution I repeat that, *as far as the network is concerned*, the impedance Z may be replaced by a generator of zero impedance and voltage V' = ZI', as shown in Fig. 7, without in any way affecting the currents I and I'.

(**a**) Input Impedance Z_{in}.

This is the ratio V/I which in this case equals

$$\frac{V}{(V/Z_{s1}) - (ZI'/Z_T)} \text{ from (iv)}$$

Z_T is given by (vi), and I' is given by (v) as follows

$I' = V/Z_T - ZI'/Z_{s2}$

$= V/[Z_T(1 + Z/Z_{s2})]$ ..... (viii)

Therefore,

$$Z_{in} = \frac{V}{(V/Z_{s1}) - ZV/[Z_T^2(1 + Z/Z_{s2})]}$$

$$= Z_{O1}Z_{s1}(Z + Z_{s2})/(Z_{O1}Z_{s2} + ZZ_{s1})$$

The input circuit is therefore as in Fig. 8.

Using equation (vii), we could express this impedance in terms of Z and *any three* of the four impedances Z_{O1}, Z_{s1}, Z_{O2} and Z_{s2}.

Notice in passing that $Z_{in} = Z_{s1}$ for $Z = 0$ and $Z_{in} = Z_{O1}$ for $Z =$ infinity, as we would expect.

(**b**) Output Circuit.

Substituting for Z_T from (vi) into equation (viii), I' becomes

$$\frac{V}{(1 + Z/Z_{s2})\sqrt{Z_{s2}/(1/Z_{s1} - 1/Z_{O1})}}$$

$$= V\sqrt{\frac{Z_{s2}(Z_{O1} - Z_{s1})}{Z_{O1}Z_{s1}}} \Big/ (Z + Z_{s2})$$

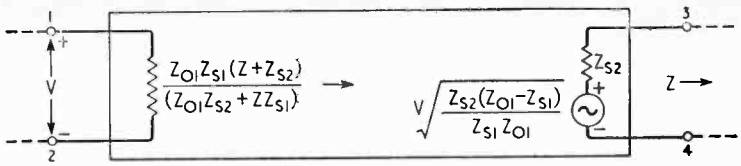
This suggests the output circuit shown in Fig. 9, which is of course none other than that indicated by the well-known " Helmholtz-Thevenin " theorem. Z_{s2}, as we saw, is the impedance measured across terminals 3 and 4 when the source of voltage V is short-circuited.

Once again, the output e.m.f. could have been expressed in terms of V and *any three* of the four characteristic impedances of the network.

(**c**) Combined Equivalent Circuit.

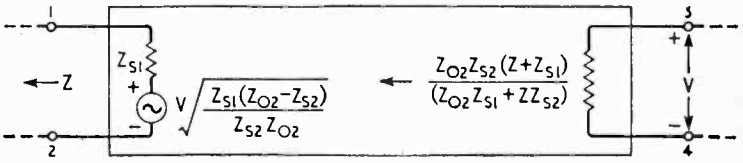
Combining the results (a) and (b) into one circuit, we can express the whole of the left-to-right behaviour of the network as in Fig. 10.

The dotted lines suggest other circuitry. The circuitry connected to terminals 1 and 2 *results in*



Left : Fig. 10. Left-to-right equivalent circuit of a four-terminal network obtained by combining the input and output circuits of Figs. 8 and 9.

Right : Fig. 11. Right-to-left equivalent circuit of a four-terminal network obtained by interchanging suffixes 1 and 2 in the left-to-right circuit of Fig. 10.



a voltage V across these terminals—it is not, of course, necessary to suppose an actual generator of zero impedance and voltage V connected directly to these terminals.

To derive the right-to-left behaviour, we do not need to go through all these calculations again. We only need change all suffixes 2 into 1 and all suffixes 1 into 2. Fig. 11 shows the result.

Application to the T-network.

Fig. 12 shows the circuit of the general T-network. Its open- and short-circuit impedances are:

$$Z_{O1} = Z_1 + Z_3,\ Z_{O2} = Z_2 + Z_3$$
$$Z_{S1} = Z_1 + Z_2Z_3/(Z_2 + Z_3),\ Z_{S2} = Z_2 + Z_1Z_3/(Z_1 + Z_3)$$

If a voltage V is applied to terminals 1 and 2, and an impedance Z is connected to terminals 3 and 4, the voltage appearing across Z is

$$VZZ_3/(ZZ_1 + ZZ_3 + Z_1Z_2 + Z_1Z_3 + Z_2Z_3)$$

And the input impedance across terminals 1 and 2 comes to

$$(ZZ_1 + ZZ_3 + Z_1Z_2 + Z_1Z_3 + Z_2Z_3) \div (Z + Z_2 + Z_3)$$

The reader may check for himself that the equivalent circuit of Fig. 10 gives exactly the same results.

If we solve for Z_1, Z_2 and Z_3, we get

$$Z_1 = \sqrt{Z_{O1}}(\sqrt{Z_{O1}} - \sqrt{Z_{O2} - Z_{S2}})$$
$$Z_2 = \sqrt{Z_{O2}}(\sqrt{Z_{O2}} - \sqrt{Z_{O1} - Z_{S1}})$$
$$Z_3 = \sqrt{Z_{O1}(Z_{O2} - Z_{S2})} = \sqrt{Z_{O2}(Z_{O1} - Z_{S1})}$$

It follows therefore that a given network having open- and short-circuit impedances Z_{O1}, Z_{O2}, Z_{S1} and Z_{S2} will behave, as far as coupling between input and output is concerned, exactly like a T-network

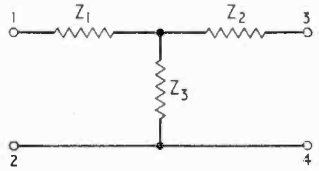


Fig. 12. General T-network.

whose series arms have impedances $\sqrt{Z_{O1}}(\sqrt{Z_{O1}} - \sqrt{Z_{O2} - Z_{S2}})$ and $\sqrt{Z_{O2}}(\sqrt{Z_{O2}} - \sqrt{Z_{O1} - Z_{S1}})$, and whose shunt arm has impedance $\sqrt{Z_{O1}(Z_{O2} - Z_{S2})}$.

The above treatment is quite general for sinusoidal voltages and currents. In so far as Z and the four characteristic impedances Z_{O1}, Z_{O2}, Z_{S1} and Z_{S2} can be expressed as Laplace coefficients Z(p), $Z_{O1}(p)$, $Z_{O2}(p)$, $Z_{S1}(p)$ and $Z_{S2}(p)$, the results obtained express the transient behaviour of the network just as well as its steady-state behaviour.

Another point to be emphasized is that the treatment supposes nothing about the four-terminal network beyond its linearity, and the results therefore hold for any form of coupling from input to output, e.g., the coupling existing between two aerials.

Imperial College

SELECTED in 1953 as the spearhead of the national attack on the problem of providing more university-trained scientists and engineers, the Imperial College of Science and Technology, London, is in the process of doubling its size to provide for 3,000 students. The college, which has been a school of the University of London since 1908, is itself a federation of three institutions—Royal College of Science, Royal School of Mines and City & Guilds College. Since 1953 the number of students has increased by 1,000 and there are now some 2,600. There have also been established over 40 new posts as professor or reader. Sir Patrick Linstead, C.B.E., F.R.S., is Rector.

The work of Imperial College is divided between the three constituent colleges; the R.C.S. covering pure sciences (chemistry, physics, mathematics, botany, zoology, geology and meteorology), the R.S.M. mining, mineral dressing, metallurgy, mining geology, oil technology and applied geophysics, and the C. & G. the main branches of engineering (aeronautical, chemical, civil, electrical and mechanical).

The normal undergraduate honours degree course is of three years leading to the B.Sc. or B.Sc.(Eng.) of London University and the Associateship of the particular college (A.R.C.S., A.R.S.M. or A.C.G.I.). Advanced study or research leads to the Diploma of Membership of Imperial College (D.I.C.) and/or a higher degree.

The Dean of the Royal College of Science is Professor H. Jones, F.R.S. The head of the physics department is Professor P. M. S. Blackett, F.R.S., with Dr. M. Blackman and Dr. C. C. Butler professors of physics, Dr. J. D. McGee, O.B.E., professor of instrument technology, Dr. A. Salam, F.R.S., professor of theoretical physics and Dr. W. D. Wright professor of technical optics. Dr. R. W. B. Stephens is reader in acoustics and Drs. J. A. Clegg, H. Elliot, O. Klemperer and C. E. Wynn-Williams readers in physics.

The Dean of the City & Guilds College is Professor O. A. Saunders, F.R.S. The teaching staff of over 40 includes Dr. E. C. Cherry (professor of telecommunications), Dr. D. Gabor (professor of applied electron optics), A. Tustin (professor of electrical engineering), Dr. A. R. Boothroyd (reader in electronics) and Drs. B. Adkins, J. Lamb and D. G. O. Morris (readers in electrical engineering).

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Beam Indexing Tubes

2.—CIRCUIT DETAILS OF THE COLOUR TELEVISION DISPLAY UNIT

By IAN MACWHIRTER,* A.M.I.E.E.

(*Concluded from page 7 of the January 1961 issue*)

HAVING considered the matching of a beam index tube to an N.T.S.C. type colour signal, the next step is to examine the problem of beam position indexing and the synchronizing of the chrominance signal with the phosphor strips. A simple method of determining the position of the beam on the screen, would be to have a photomultiplier cell, optically filtered to receive light from one primary colour, say blue, and to use the repetitive series of blue light pulses to generate rectangular gating pulses for switching on the appropriate colour video signal.[11] However, this arrangement suffers from the disadvantage of requiring extremely fast rise-time amplifiers and expensive artificial delay lines. In practice the method is best suited to laboratory development work where the possible errors of signal translators and the loss of saturation occasioned by comparatively wide angle sampling of the chrominance signal by the display screen may be completely obviated. Moreover, small departures from linearity in the line time base will not cause objectionable colour errors, provided that such departures are small, compared with one colour triplet of width, say, 60×10^{-3} in.

A complete circuit diagram for a gated display is shown in Fig. 9(a) and (b).

The indexing pulses generated in the photo pick-up are amplified in a wideband amplifier and limiter. No afterglow correction is provided since the indexing strips are made of P16 phosphor whose afterglow is down some 20 dB in 100 mμsec, whereas the pitch of the indexing pulses is approximately 240 mμsec. The pulses are fed from the wideband amplifier to an earthed grid stage (V1) which raises the pulse level to about 5 V. This is sufficient to be differentiated and to trigger the transistor (T1) in the avalanche mode.[12] The triangular output of some 20 V p-p and rise time of 4 mμsec is applied to the grid of V2 in whose anode circuit is a short-circuited delay line. The line can be a lumped-constant one, but the cut-off frequency should be not less than 50 Mc/s and preferably higher. The line has a delay of 20 mμsec which provides a rectangular pulse at the anode of V2 of width 40 mμsec (this width was chosen as being suitable for one application of the circuit). This pulse is injected via a polarity inverter (V3); (a) into the lower valve (V7) of a series pair which constitute part of the gate; (b) into a further delay line which is centre-tapped and whose delay is equivalent to twice the phosphor pitch. Again, the cut-off frequency of the delay line should be at least 50 Mc/s.

In one application the pulse at the input to this line feeds the " red " gate, the centre tap feeds the " green " gate and the end of the line feeds the " blue " gate; the delay between adjacent colours is 80 mμsec, so that the total line delay is 160 mμsec.

Referring now to the gate proper, it consists of V5, V6 and V7 which are therefore triplicated. Video signals of the appropriate colour are fed into the grid of V5, from a preceding stage (V4) where the direct component is re-inserted.

The video signal appears at the anode of V7 and is periodically " lifted up " by the gating pulse so that the black portion (if any) of the " lifted " video signal is greater in amplitude than peak white level of the " unlifted " video signal. The remaining valve of the gate (V8) is biased well beyond cut-off so that only the " lifted up " video signal appears at the anode. This point is connected directly to the anodes of the other two gates (V9 green), (V10 blue). The peak signal here of some 20-25 volts is polarity inverted by (V11). The rectifier restorer in the grid circuit works sufficiently well to prevent V11 from passing grid current when the signal amplitude is large. The signal from V11 is then fed to the output stage V12 in whose grid is a d.c. clamp of conventional design.

It is possible to obtain a signal of just 100 V p-p at the anode of V12. The video pulse rise time at this point is 10 mμsec, the pulse base width is 40 mμsec, and the repetition rate is about 4.25 Mc/s in one particular application. The overall linearity is good, and the differential non-linearity between channels is negligible. (See Appendix 3).

Ultra-violet Indexing Strips

A better method for beam position indexing in a domestic receiver still employs light pulse pick-up, preferably from a low visibility ultra violet phosphor which may be conveniently mixed with the visible blue primary phosphor. From this pulse is derived a sinusoidal signal which is used to heterodyne the incoming equi-angle chrominance signal up to the colour switching frequency of the screen, which can then sample directly the chrominance information, as outlined earlier in this article.

If the manufacturing technology of the screen structure allowed indexing pulses to be generated whose rise times are very short i.e. less than 5 mμsec, and a wideband amplifier followed the photo pick-up, it should be possible to limit the amplitude of the indexing signals at the level corresponding to the 1% minimum beam current. From these limited rectangular pulses there may be derived the sinusoidal indexing signal. Provided that the maximum negative excursion of the approximately sinusoidal chrominance signal does not allow the beam current to drop below 1% of its maximum value (i.e. pulse

* Associated Electrical Industries Ltd.

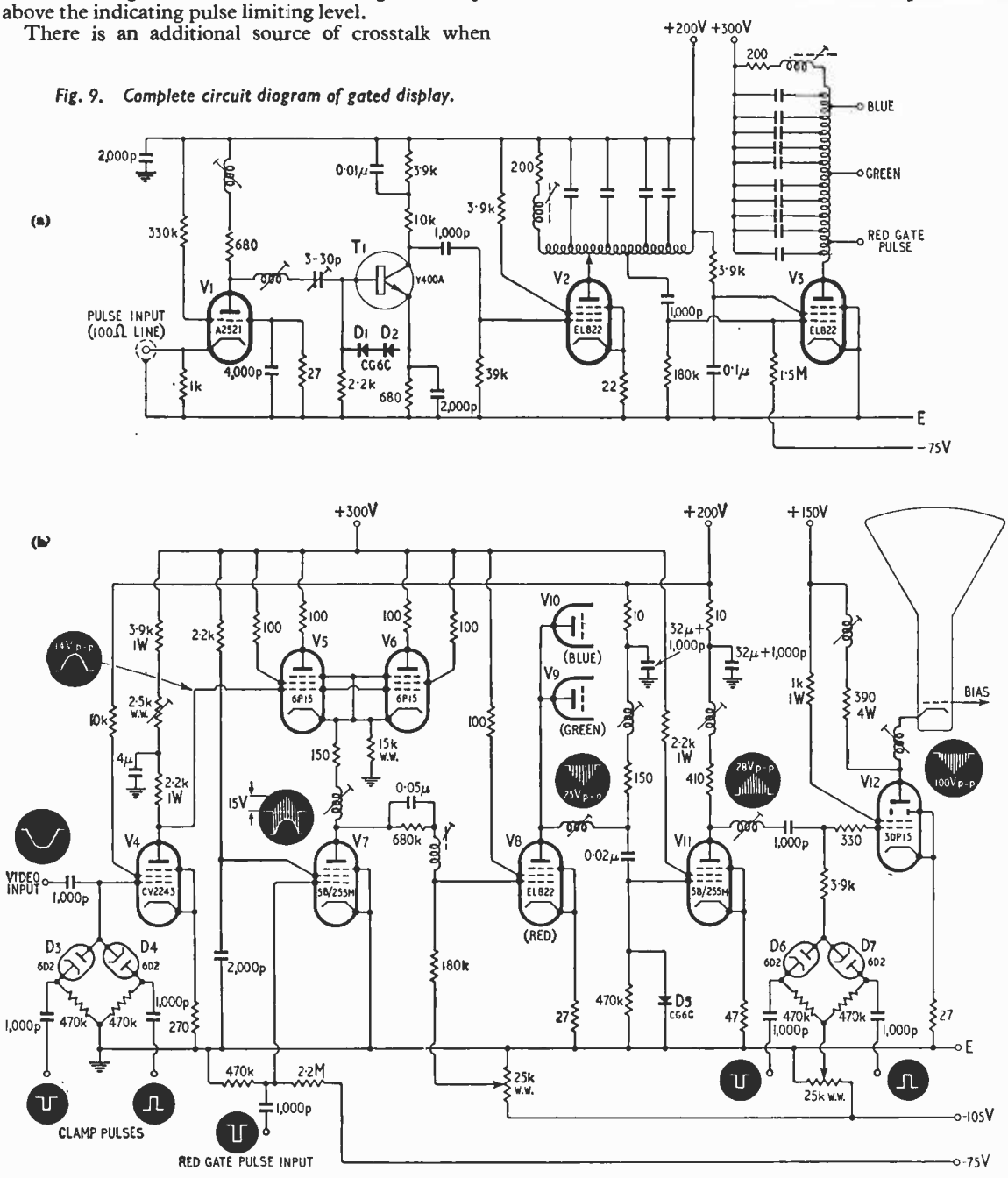
limiting level), no crosstalk will be caused by any change in phase of the chrominance signal.

In practice, it has been found difficult to make a screen structure of indexing phosphor strips of sufficient sharpness to allow this simple method to be used completely free from phase crosstalk. For example, for one experimental display tube, an indexing pulse rise time of 40 mμsec was measured. Whilst the use of *rectangular* chrominance pulses, as employed in the gated display, does not provide objectionable crosstalk, it has been found that the use of an approximately sinusoidal chrominance signal aggravates crosstalk. This happens even if the maximum negative excursion of the signal is kept above the indicating pulse limiting level.

There is an additional source of crosstalk when approximately sinusoidal chrominance information is applied directly to the screen structure, irrespective of indicating strip shape i.e. whether ideally rectangular or trapezoidal as found in practice. Consideration of Fig. 10 will explain this point.

It is seen that the ultra-violet indexing strip is placed behind the blue phosphor strip. The chrominance signal *c*, sitting on top of some luminance pedestal, will be approximately sinusoidal in shape. Let the colour shown be a saturated blue, then the indicating pulses will be generated as shown at *p*; from these pulses an indicating sinusoid *s* may be formed. Now let the phase of the chrominance sub-carrier be shifted in order to reproduce a

Fig. 9. Complete circuit diagram of gated display.



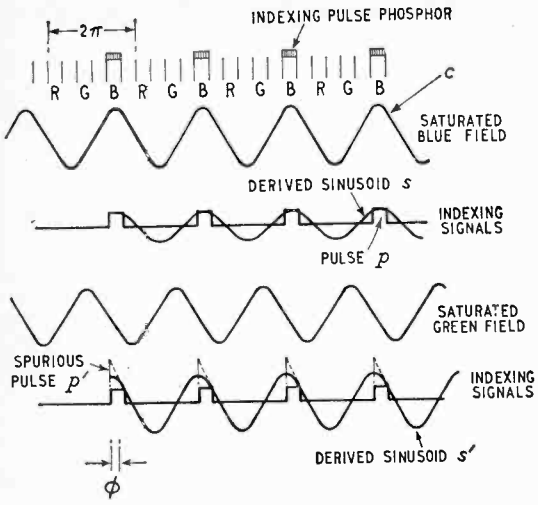


Fig. 10. Illustrating the development of crosstalk when using sinusoidal chrominance information. For diagrammatic clarity a point spot size has been assumed.

saturated green field. Assuming the green drive voltage to be the same as for the blue, we can see that part of the green sinusoid will generate a spurious indicating pulse p' as well as the regular indicating pulse p which is generated by a pre-set minimum beam current. Thus the sinusoidal indicating signal s' formed by both p and p' will be displaced in time as shown by ϕ (See Appendix 1).

Further colour errors may be introduced by unwanted changes in indexing frequency. If the transverse scanning of the phosphor strips should be non-linear, or if the pitch of these strips should vary as a result of manufacturing inaccuracies, then the frequency of the sinusoidal indicating signal will vary. It is essential that the phase of this signal be preserved if colour errors are to be avoided. In general, the phase response of a normal amplifier over a limited pass band is such that the phase angle ϕ varies more or less linearly with frequency, i.e., the envelope delay D is constant since $D = d\phi/d\omega = K$. In amplifying the sinusoidal signal the requirement is that $D = d\phi/d\omega = 0$ and this is satisfied by combining the indicating sinusoid amplifier with a suitable phase corrector (see Fig. 16)

Slow variations in line time-base linearity (e.g., a normal "exponential" sweep) and scan amplitude will be accommodated by this method, colour synchronization remaining good. It is possible, however, that apparent changes in linearity of a transient nature will result in areas of local colour errors. Such transients may be caused by flaws in the evenness of the display tube face plate.

In order that the colour synchronizing circuits shall not become inoperative in areas of picture black it is necessary to run the display tube with a minimum beam current of about 1% of the peak white value.

The chrominance signals illustrated in Fig. 10 have, in fact, been squared by the transfer characteristic of the display tube gun, but similar spurious signals are generated.

For the reasons given, it appears prudent to adopt a screen layout which might minimize the crosstalk and of many possible solutions to the problem of layout, two are here described.

Case I.—(Using regular R, G, B, sequence phosphor strips).

Fig. 11 shows a phosphor strip structure in which there is an indexing strip in every gap between the R, G, B, strips. When scanned, the frequency of the indexing signal will be three times the colour repetition frequency and it can be shown that although the indicating signal may be modulated in amplitude by the luminance and chrominance signals it is not phase modulated (see Appendix 2). This indexing signal, after amplitude limitation and after a frequency division by three, may be u ed directly to control the colour circuitry of the receiver, provided that the frequency divider starts off in the correct phase at

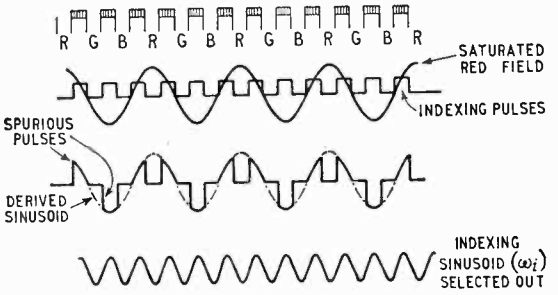


Fig. 11. Use of intermediate ultra-violet indexing strips.

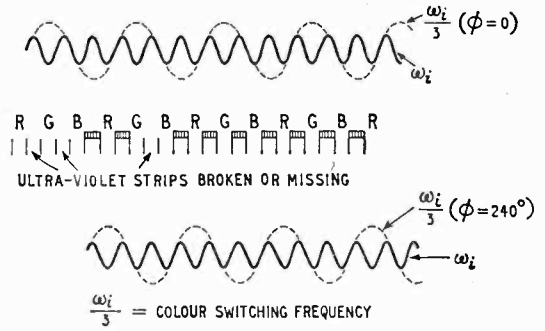


Fig. 12. Effect of broken or missing indexing strips.

the beginning of each line. Referring to Fig. 12 it can be seen that if the first ultra-violet strips at the beginning of the line sweep are unbroken, i.e., missing, this would be true; however, a broken ultra-violet strip would cause a phase error in the frequency division. In order to avoid this triple phase ambiguity of 0°, 120°, 240°, it is necessary to have at the beginning of each line a further set of strips which, on scanning, generate a frequency whose possible phases with reference to the indexing frequency uniquely determine the phase of frequency division. A suitable frequency for the second set of scanned strips would be at triplet repetition frequency, only two possible phases for frequency division would then be possible 0°, and 360°. It should be clear that these "run-in" strips should only exist at the beginning of the line sweep when no chrominance signals are applied to the tube, in this way there will be no cross modulation between the "run-in" signal and the video signal.

Fig. 13(a) shows a suitable layout for a practical

(*Continued on page 95*)

screen structure, and Fig. 13(b) shows a way in which a control signal may be derived. However, it should be pointed out that it may not be desirable to generate both signals by the same means, i.e., photoelectrically, and it is possible to pick off the "run-in" signals from secondary-electron emitting strips and a suitable collector within the display tube bulb.

The photocell P_1 will generate two signals, one at a frequency f_r i.e. "run-in" frequency, and one at $3f_r$. Component f_r will be present only at the beginning of scan where there is no video modulation. The filter F separates the two components and will have band-pass characteristics to allow for variations in scanning speed, etc. Component $3f_r$ is presented to a normally "closed" gate, this gate will be "opened" by a signal f_r. When the gate opens, the frequency divider provides an output of $\frac{3f}{3} = f_r =$ colour switching frequency f_c. The component $f_r = f_c$ is then applied (a) back to the gate via a suitable equalizing delay, so that the divider will continue to work when the run-in signal has stopped, (b) to the chrominance control circuits of the receiver.

Since the component $3f_r$ is not cross-modulated by the video signal the phase of the output control signal f_c will also be unaltered.

Case II.—(Using an alternating sequence strip structure.[13])

Fig. 14 shows a different screen structure which will directly generate an indexing signal of correct frequency and free from cross-modulation effects.

It will be seen that red phosphor borders each side of the combined blue and ultra-violet indexing strip. Let the colour shown be a saturated blue, then the indexing pulses will be generated as shown at p; from these pulses an indexing sinusoid may be formed.

Now let the phase of the sub-carrier be shifted to reproduce a saturated green field. Assuming the green drive voltage to be the same as for the blue, we

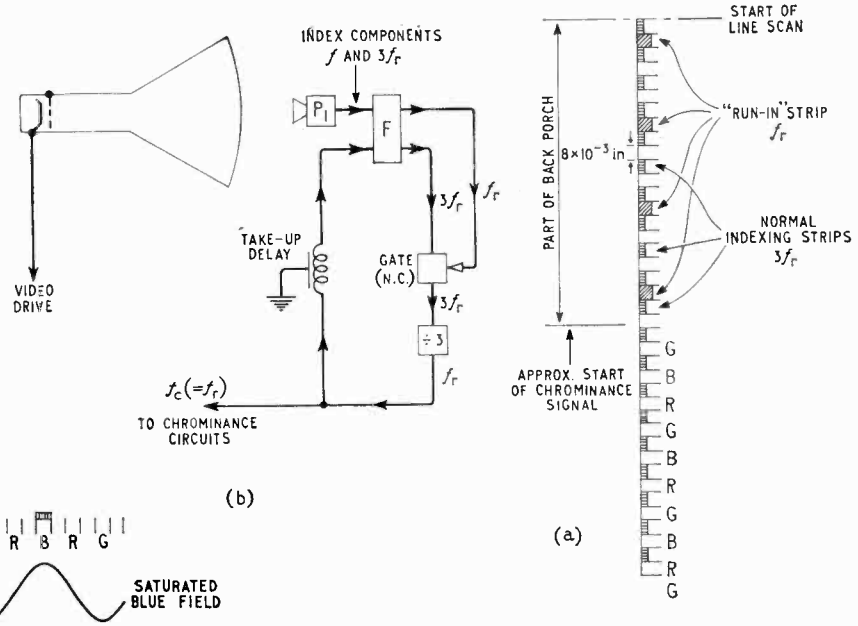


Fig. 13(a). Section of practical screen structure and (b) derivation of control signal.

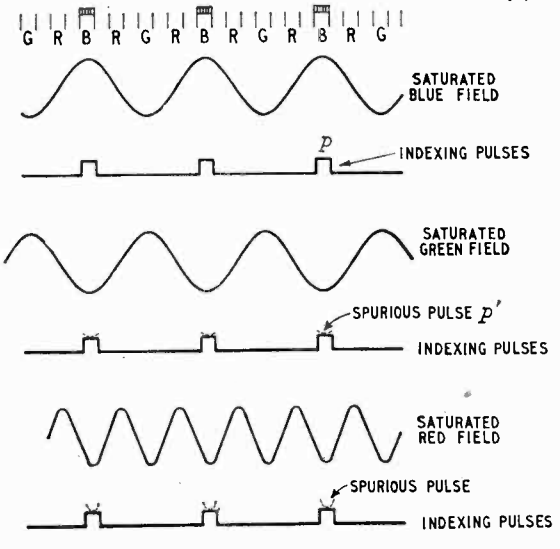


Fig. 14. Alternative screen structure with red-bordered combined blue and ultra-violet strips.

can see that the contribution of the green signal to a spurious indexing signal p' is not only small but symmetrical about the true indexing pulse. When the phase of the sub-carrier is shifted again to show a saturated red field, the spurious indexing pulse is larger in amplitude than before, but is again symmetrically placed about the true indexing pulse. These small, symmetrically placed, spurious signals will not phase-modulate the indexing signal.

A block diagram for a receiver using this screen structure is shown in Fig. 15. Because there are two red phosphor strips per unit group of white forming strips, it is necessary to gate the red signal at twice the indexing signal frequency.

A screen with this structure has the additional advantage of producing more red light than from a simple colour triplet. Therefore, less inert material need be mixed with the green and blue phosphors and the maximum brightness for a given beam current, will increase. However, it would not be easy to use

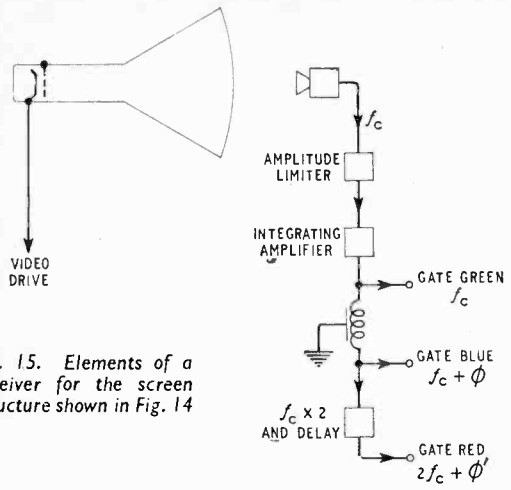


Fig. 15. Elements of a receiver for the screen structure shown in Fig. 14

a tube with this screen structure in a non-gating receiver and it is doubtful whether the extra complexities in the video circuitry would cost less than the extra circuitry used for handling the " run-in " signals.

A complete colour receiver using a beam position indexing cathode ray tube and the N.T.S.C. proportioned signals is shown in block form in Fig. 16.

It has been shown that the formulation of the N.T.S.C. signal is not suited for direct application to the beam indexing tube. The question now arises whether it would be advantageous to modify the transmitted signal to the form suggested earlier in this report. Before making any recommendations on this it must be borne in mind that the formulation of a compatible band-shared colour television signal should never be designed for the requirements of any particular type of display tube to the exclusion of all others. With the exception of contrast-law correction problems the N.T.S.C. formulated signal uniquely satisfies these general requirements:

(i) *Compatibility.* Compatibility on black and white display tubes is potentially good since the luminance composition of the colour signal is similar to the photoptic visibility curve of the eye, i.e., the luminance of colours shown by a black and white display would be the same as if seen direct by the eye and the subjective effect of this is to observe pleasing tones of grey in the picture.

A change to an equi-weighted luminance signal will adversely affect this compatibility. Moreover, the colour receiver would no longer obey the constant luminance principle unless some deficiencies in colour reproduction are tolerable.

(ii) *Constant Luminance Principle.* The composition of the luminance signal is inevitably involved with the relative contributions of the reproducing phosphors to white, if constant luminance operation is considered necessary with a simultaneous display.

The effectiveness of these two concepts is restricted by the present form of contrast-law correction and it is outside the scope of this article to comment further on this. However, it should be recognized that as permanent colour television standards are still unformed in the United Kingdom the possibility of re-scaling the luminance signal to match any new developments in phosphors ought not to be excluded. It is possible to modify the angular positions of the N.T.S.C. chrominance vectors to make them more suitable for use with a beam indexing display, but one attraction with the present formulation is that the two colour differ-

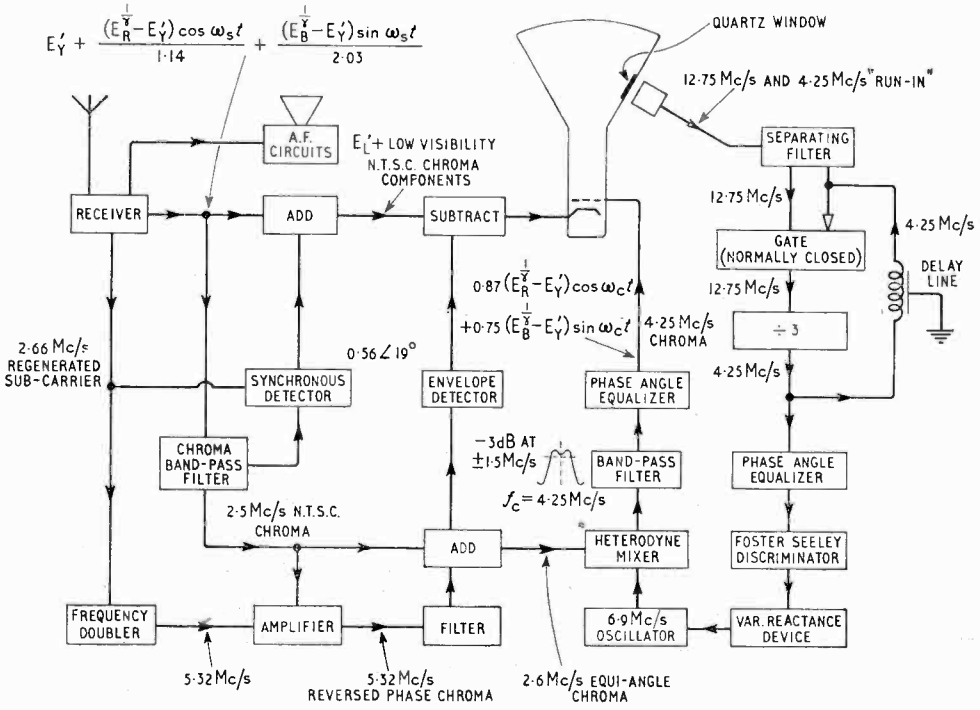


Fig. 16. Block diagram of complete beam index tube colour receiver working from an N.T.S.C. colour signal.

ence components are in exact quadrature. This fact alone provides such operational advantages that the benefit from the change would have to be proved significant.

Conclusions

The " beam indicating " or " beam index " display tube of the kind described can provide superior pictures, both in colour and black and white, to the shadow mask cathode ray tube. Whilst the former tube is relatively cheap to make, it must appear disappointing that, at the present state of the art, the costing estimate of a receiver with such a tube and all the refinements necessary to produce correct colour reproduction, is not significantly less than the ordinary three-gun shadow mask receiver. Whilst certain economies may be effected in the exactness in operation of the signal translating apparatus already described, it appears necessary to employ line time bases with non-linearities of the order of 1% if objectionable colour errors are to be avoided.

It can be said that if this figure for line time base non-linearity is considered impracticable for cheap, mass produced receivers, and the subsequential colour errors are accepted, the remaining advantage in using the beam indexing display is the superiority in the reproduction of black and white pictures. Therefore, until simple circuitry can be devised which permits the use of line time base non-linearities of some 7% and yet secures satisfactory colour reproduction, the single-gun beam indexing display cannot be considered as a potential successor to the well-established, three-gun shadow mask display.

Acknowledgements

The above review of some of the problems of beam indexing tubes formed part of a programme on colour television displays carried out at the Applications Laboratories of the Radio & Electronic Components Division of Associated Electrical Industries Ltd. and the author wishes to thank the company for permission to publish these results. In particular, the author thanks the Divisional Engineering Manager, Mr. C. L. Hirshman for helpful criticisms of the review's contents and Mr. D. W. Furby for his design of the pulse generator using an avalanche transistor.

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[13] U.S.A. patent No. 2,752,420, Philco Corporation and W. G. Ehrich.

APPENDIX I

The generation of the spurious indexing signal is not only dependent on cross-modulation caused by the non-linearity of the display tube gun but on the simple scanning of the indexing phosphor structure. An attempt to illustrate this graphically has already been made in the text relevant to Fig. 10; a simple equation is derived below which identifies the relative magnitudes of the cross-modulation parameters.

If the display tube has a linear transfer characteristic (i.e. contrast = unity) then the light output L from the whole screen can be expressed by

$$L = k\left[E_y' + E'_c \cos(\omega_c t + \phi)\right]$$

where E_y' is the luminance signal.

E_c' is a measure of saturation

ϕ is a measure of hue

The generated indexing signal S is of the form

$L(a_o + a_1 \cos \omega t + a_2 \cos 2\,\omega t + \ldots\ldots a_n \cos n\,\omega t)$

Thus $S = Lk\left[E_y' + E'_c \cos(\omega_c t + \phi)\right]\left[a_o + a_1 \cos \omega_c t + \text{etc.}\right]$

$= Lk\left[E_y'\, a_o + a_o\, E_c' \cos(\omega_c t + \phi) + a_1\, E_y' \cos \omega_c t + a_1\, E_c' \cos \omega_c t \cos(\omega_c t + \phi) + a_2\, E_c' \cos \omega_c t \cos(2\,\omega_c t + \phi) + \ldots\ldots a_n\, E_c' \cos \omega_c t \cos(n\,\omega_c t + \phi)\right]$

Extracting components at the fundamental frequency (ω_c) S becomes $Lk\left[a_o\, E_c' \cos(\omega_c t + \phi) + \frac{a_2\, E_c'}{2} \cos(\omega_c t + \phi) + a_1\, E_c' \cos \omega_c t\right]$

which shows that the amplitude and phase of S will be affected by the phase ϕ of the chrominance signal.

APPENDIX II

It has been stated in the text that with the use of an indexing strip between each colour phosphor an indexing sinusoid may be generated which is not affected by the phase of the chrominance signal. The key point in understanding this is that the generated indexing pulses are of equal mark/space ratio and therefore the even harmonic components are zero.

As in Appendix 1,

$L = k\left[Ey' + E_c' \cos(\omega_c t + \phi)\right]$

The generated indexing signal S is of the form

$L\left[a_o + a_1 \cos 3\,\omega t + a3 \cos 5\,\omega t + \ldots\ldots \ldots\ldots\ldots a_n \cos(n + 2)\,\omega t\right]$

where n is not an even integer.

Thus $S = Lk\left[Ey' + E_c' \cos(\omega_c t + \phi)\right]\left[a_o + a_1 \cos 3\,\omega_c t + a_3 \cos 5\,\omega_c t + \text{etc.}\ldots\ldots\right]$

$= Lk\left[a_o\, Ey' + a_o\, E_c' \cos(\omega_c t + \phi) + a_1\, Ey' \cos 3\,\omega_c t + a_1\, E_c' \cos 3\,\omega_c t \cos(\omega_c t + \phi) + a_3\, Ey' \cos 5\,\omega_c t + a_3\, E_c' \cos 5\,\omega_c t \cos(\omega_c t + \phi) + \text{etc.}\right]$

extracting the components at a frequency ($3\,\omega_c$), S becomes $Lk\,(a_1\, Ey' \cos 3\,\omega_c t)$ which shows that the generated indexing sinusoid will be unaffected by the phase (ϕ) of the chrominance signal.

It should be pointed out, though, that any manufacturing inaccuracies of the strip structure, or any sudden change in scanning linearity can cause even-harmonic components to appear; this will be accompanied by a colour error in the reproduced picture.

APPENDIX III

The actual figures for the linearity of the complete gate circuit are not stated because the overall linearity (i.e. picture contrast or " gamma ") including the display tube, depends on:—

(a) The shape of the gating pulses entering the gate. Fig. A illustrates the formation of a simple gated step wedge by the gate circuit as shown in Fig. 9

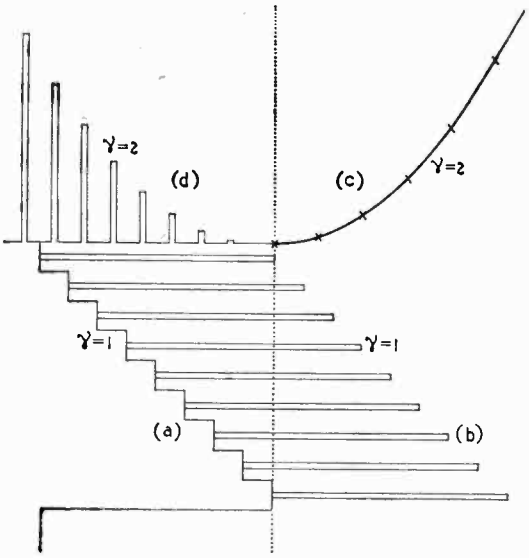


Fig. A

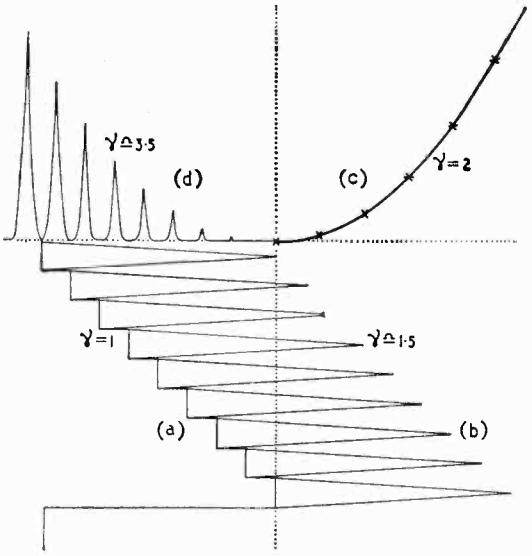


Fig. B

when ideal rectangular gating pulses are available. It will be seen from (b) in Fig. A that the overall contrast of the reproduced picture is that of the display tube (for which adequate correction is usually made in the formulation of the video signals at the transmitter).

Fig. B illustrates the reproduction of the same step wedge when only bandwidth-limited gating pulses are available. In practice trapezoidal pulses are used, although triangular pulses are shown in the figure. Now the phosphor excitation is proportional to the area under the pulses as shown in (d), it can be seen that there will be a considerable reduction in low level excitation. (Notice the reduction in base width.) For the triangular pulses a calculation showed that the picture contrast may be increased by 1·5. This clearly establishes the need for maintaining a good pulse shape, at least until the gate proper. Such residual contrast in excess of unity can be corrected by means of judiciously introduced non-linearity in the main amplifier.

(b) Subsequent integration of the pulses in amplifier following the gate. In practice, the effect of integration has not been proved detrimental to picture quality, because the bandwidth of the main amplifier is quite adequate to handle the trapezoidal gate pulses.

(c) Spot modulation defocusing. No measurements on this possible source of contrast change are available.

BOOKS RECEIVED

Phototubes, Edited by Alexander Schure. A mainly non-mathematical survey of the field of photoelectricity. The history of the photoelectric effect is discussed and the theory behind the operation of modern devices is explained. A chapter is included on the design of phototube-operated amplifiers designed to perform a variety of functions. Pp. 88; Figs. 40. John F. Rider Publisher, Inc., 116, West 14th Street, New York 11, N.Y.

Electronics and Nucleonics Dictionary, by Nelson M. Cooke and John Markus. This second edition contains over 12,000 definitions of terms. Attention has been paid to modern practice in hyphenation and usage. The range has been extended to cover the related field of nuclear energy technology and new developments in electronics. Where American usage is at variance with British, this is noted. Pp. 543; illustrated. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 93s.

Fundamentals of Semiconductors, by M. G. Scroggie. The level of treatment is at an intermediate stage between the simplified layman's guide and the advanced textbook. The whole field is covered, from basic electron theory to short descriptions of electroluminescence, Hall effect, and masers. Pp. 160; Figs. 129. Gernsback Library, Inc., 154, West 14th Street, New York 11, N.Y. Price $2.95.

A Simple Approach to Electronic Computers, by E. H. W. Hersee. Concerned with principles rather than practice, the book explains to the layman the operation of simple digital and analogue computers. Non-mathematical in treatment, it deals with most of the basic computing-circuit elements and methods in general terms. Pp. 104; Figs. 27. Blackie and Son, Ltd., 16-18, William IV Street, Charing Cross, London, W.C.2. Price 12s 6d.

How to Install and Service Auto Radios, by Jack Darr.. A practical book on car radios. Well known to readers of *Wireless World* for his humorous articles on radio servicing, Mr. Darr writes in a readable style, giving helpful advice to servicemen in all phases of their dealings with car radio installations, including transistorized and hybrid types. Pp. 154; Figs. 101. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 26s.

Radar and Collision—A Handbook for Mariners, by L. Oudet. A discussion of the principles and practice of the avoidance of collision between radar-equipped ships. Seeks to impress the concept of intelligent use of radar facilities, rather than reliance on its capabilities as a "magic box." Examples of actual collisions are used to illustrate the arguments. Pp. 89; Figs. 36. Hallis and Carter, 25, Ashley Place, London, S.W.1. Price 15s.

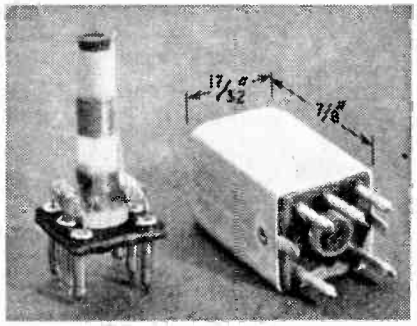
MANUFACTURERS' PRODUCTS

NEW ELECTRONIC EQUIPMENT AND ACCESSORIES

Transistor I.F. Transformers

SHOWN in the illustration is a new miniature 10.7-Mc/s i.f. transformer introduced by Denco for use in transistor v.h.f./f.m. receivers. The transformer (IFT15) consists of two coupled circuits with tapped primary and secondary windings each tuned by polystyrene-foil fixed capacitors. Adjustment is by means of the customary dust-iron core. The unloaded "Q" of each winding is said to be approximately 70 at 10.7Mc/s and the working bandwidth 250kc/s (−6dB points).

There is a companion ratio-detector transformer



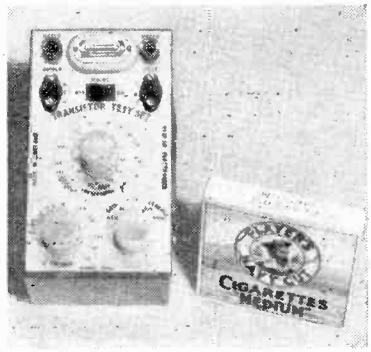
Denco 10.7-Mc/s i.f. transformer for transistor v.h.f./f.m. receivers.

(RDT2) having a bifilar secondary winding and an effective bandwith of 220kc/s.

I.F. and discriminator transformers are provisionally priced at 10s 6d each and the makers are Denco (Clacton), Ltd., 357-359, Old Road, Clacton-on-Sea, Essex.

Transistor Test Set

IN the compact mains-operated Beulah Electronics Model D900, variable input currents (up to 1mA) and collector voltages (up to 25V) are provided for measuring transistor direct-current gains and leakage currents

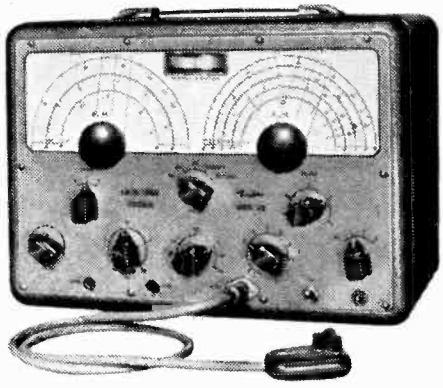


Beulah Electronics Model D900 transistor test set.

with the aid of an external meter. This instrument can also measure the a.c. gain of a transistor *in situ*. To do this the transistor is connected in an oscillatory circuit in the test set and the feedback decreased until oscillations as indicated by a flashing neon just cease. The degree of feedback then gives a measure of the current gain. The oscillations have a high harmonic content which also allows them to be used as an a.f. and r.f. signal tracer source. The model D900 costs £10 and is available from Beulah Electronics of 138 Lewisham Way, New Cross, London, S.E.14.

A.M./F.M. Signal Generator

THE Taylor Model 61A contains both an a.m. and a f.m. (or sweep) generator. C.w., a.m., f.m. or swept signals or, alternatively, a combination of a swept and a c.w. or a.m. signals can be obtained. The a.m. (or c.w.) generator covers from 4 to 120Mc/s on fundamentals: the f.m. (or sweep) generator covers from 4 to 12Mc/s as well as from 70 to 120Mc/s (also on fundamentals). The f.m. deviation is at 400c/s and can be continuously varied up to ±100kc/s; the sweep deviation is at 50c/s and can be continuously varied



Taylor Model 61A a.m./f.m. signal generator.

up to ±1Mc/s. The r.f. output is 100mV, and a 0 to 120dB attenuator is provided. Up to three crystals can be mounted internally for calibration purposes. This generator costs £55 and is manufactured by Taylor Electrical Instruments Ltd., of Montrose Avenue, Slough.

D.C. Milli-microvoltmeter

THE Keithley Model 149 has 13 overlapping ranges with full-scale deflections extending from as low as 0.1μV up to 100 mV (d.c.). The stability after an hour's warming up is within 0.01μV per hour or 0.03μV per 8 hours: the noise with the input short circuited is less than 0.003μV peak-to-peak. The response speed is within one second except on the 0.1μV f.s.d. range where it is within two seconds. The input resistance is 10^5MΩ/V on the ranges up to 100μV f.s.d. and 10MΩ on all ranges above this. On many of the scales (but not the 0.1 or 0.3μV f.s.d. ranges) zero suppression up

Keithley Model 149 d.c. milli-microvoltmeter.

to 100 times full scale is possible. A 10V, 5mA output for feeding a recorder is also provided. This instrument utilizes a 100 c/s mechanical chopper followed by a resonant amplifier and synchronous detector. It costs £352 and is distributed in the U.K. by Livingstone Laboratories, Ltd., of Retcar Street, London, N.19.

New Elapsed-time Indicators

EACH indicator in the new Industrial Instruments "Selachron" range contains a small replaceable electrochemical cell. As current is passed through the cell the anode is consumed so that its remaining length indicates the elapsed time. Each indicator is 2$\frac{1}{4}$in long, has a diameter of 1in and weighs less than 2oz. Different models cover maximum elapsed times from 100 to 10,000 hours and a.c. or d.c. inputs from 6 to 300V. Different input voltages and a.c. are catered for by the use of suitable dropping resistors and semiconductor half-wave rectifiers respectively. The current consumption of these

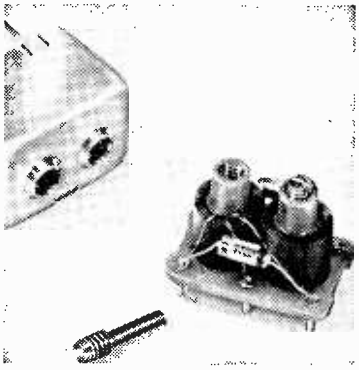
Electro-chemical elapsed-time indicator by Industrial Instruments.

units ranges from a maximum of 4.7mA for a 100-hour indicator down to 0.065mA for a 10,000-hour indicator. These indicators cost £2 5s each and the address of their manufacturer is Industrial Instruments Ltd., of 9 Paved Court, Richmond, Surrey.

Miniature I.F. Transformers

THE Wireless Telephone Company (one of the Plessey group) has introduced a new range of miniature i.f. transformers for portable transistor receivers with intermediate frequencies within the range 450-480kc/s. Chief feature of the new transformers is the parallel mounting of the coils which gives stable coupling and compact assembly. The ferrite-cup cores are potted in an epoxy resin which ensures good mechanical rigidity and resistance to vibration. Can size has been reduced to $1\frac{1}{16} \times \frac{3}{8} \times 1\frac{1}{8}$in high.

Double-tuned transformers are used in the first two stages and a single-tuned unit in the third with diode and i.f. by-pass capacitor included in the can. Alignment is carried out by adjustable dust cores mounted



Wireless Telephone Co.'s new miniature i.f. transformers for transistor receivers.

in a novel way. In place of the usual threaded core a plain core is bonded to a polystyrene screw working in a threaded hole in the coil former. This provides a robust screw for adjustment by an ordinary metal-bladed screwdriver, and it also allows the cores to be wax sealed after final trimming.

Of special interest to production engineers is the use of a colour coded indent to identify each transformer type. The indent enables an operator to orient the transformer correctly when assembling a receiver chassis.

Further details can be obtained from the Wireless Telephone Co. Ltd., Hallamgate Works, Crookes Road, Sheffield 10.

Multi-band Short-wave Aerial

THE SWL7 wire-trap aerial, as it is styled, is intended to provide efficient reception on the seven short-wave broadcast bands of 11, 13, 16, 19, 25, 31 and 49 metres. Briefly the principle involved is that if a tuned circuit, or its electrical equivalent, is inserted at each of two points along a random length of wire they behave as insulators at the frequency to which they are tuned and the section of wire between them behaves as an efficient half-wave dipole at that frequency. Like an orthodox dipole its efficiency is well maintained over a limited range of frequencies either side of the resonant frequency.

By inserting a number of traps along the aerial on either side of the centre point and with pairs adjusted to "look like" insulators at one of the above short-wave broadcast bands, a single-wire can be made to function as a number of separate half-wave dipoles with a single low-impedance feeder connected to the electrical centre of the system. And the feeder will be satisfactorily matched to the aerial on all bands. This is the basic design of the SWL7. Practically it covers seven short-wave bands. It costs £7 complete and including 100ft of 75Ω twin-wire feeder.

Aerials functioning on any desired combination of bands can also be supplied and further details are obtainable from Mosley Electronics Ltd., 15 Reepham Road, Norwich, Norfolk.

FEBRUARY MEETINGS

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

LONDON

1st. Brit.I.R.E.—"A fast electronically scanned [radar] receiving system" by Dr. D. E. N. Davies at 5.30 at the London School of Hygiene, Keppel Street, W.C.1.

2nd. I.E.E.—"Silicon power rectifiers" by A. J. Blundell, A. E. Garside, R. G. Hibberd and I. Williams at 5.30 at Savoy Place, W.C.2.

7th. Brit.I.R.E.—"Tunnel diodes", joint meeting with Institute of Physics and Physical Society, at 2.15 at 47 Belgrave Square, S.W.1. (Members only.)

7th. I.E.E.—"Magnetic properties of thin films for computing devices" by E. M. Bradley at 5.30 at Savoy Place, W.C.2.

8th. Brit.I.R.E.—"Perseus, a medium-scale data processing system" by G. Emery at 5.30 at the London School of Hygiene, Keppel Street, W.C.1.

8th. Women's Engineering Society.—"Space flight" by a member of the British Interplanetary Society at 7.0 at 45 Great Peter Street, S.W.1.

8th. British Kinematograph Society.—"Past, present and future trends in sound recording techniques" by F. W. Rennie at 7.30 in the Mezzanine Cinema, Shell-Mex House, Strand, W.C.2.

9th. Radar & Electronics Association.—"Digital computers" by A. St. Johnston at 7.30 at the Royal Society of Arts, John Adam Street, W.C.2.

10th. Television Society.—"Transistorized distribution amplifiers" by B. Marsden at 7.0 at the Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, W.C.2.

13th. I.E.E.—Discussion on "The road to corporate membership: what is the responsible experience required?" opened by A. H. Mumford and D. S. Rolfe at 6.0 at Savoy Place, W.C.2.

14th. Brit.I.R.E.—"Some psychoacoustic and engineering aspects of hearing aid design" by J. Jessop at 5.30 at the London School of Hygiene, Keppel Street, W.C.1.

14th. I.E.E.—Discussion on "Technical teacher training" opened by Dr. F. T. Chapman at 6.0 at Savoy Place, W.C.2.

16th. I.E.E.—Faraday Lecture "Transistors and all that" by L. J. Davies at 6.0 at Central Hall, S.W.1.

17th. B.S.R.A.—"Organ pipes and reeds" by H. Willis at 7.15 at the Royal Society of Arts, John Adam Street, W.C.2.

22nd. Brit.I.R.E.—Discussion on transistorized medical and biological electronic equipment at 5.30 at the London School of Hygiene, Keppel Street, W.C.1.

22nd. British Kinematograph Society.—"Carbon in motion picture engineering and electronics" by A. C. Conford at 7.30 at the Central Office of Information, Hercules Road, Westminster Bridge Road, S.E.1.

23rd. Television Society.—"Programme problems and possibilities associated with Monitor by Huw Wheldon at 7.0 at the Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, W.C.2.

28th. Society of Instrument Technology.—"Three terminal bridge measurements and automation" by Dr. V. S. Griffiths at 7.0 at 26 Portland Place, W.1.

BIRMINGHAM

22nd. Television Society.—"Television on Royal occasions" by T. H. Bridgewater at 7.0 at the College of Advanced Technology, Gosta Green.

BRISTOL

14th. Television Society.—"Television advertising—the first five years" by D. Ingram at 7.30 in the Colston Room, Hawthorns Hotel, Woodland Road, Clifton.

15th. Brit.I.R.E.—"High speed digital applications of transistors" by M. L. N. Forrest at 7.0 at the College of Science and Technology.

CARDIFF

8th. Brit.I.R.E.—"The principles of analogue to digital computer conversion" by J. L. W. Churchill at 6.30 at the Welsh College of Advanced Technology.

CHELTENHAM

24th. Brit.I.R.E.—"Design aspects and characteristics of long-distance waveguide communication systems" by Dr. A. E. Karbowiak at 7.0 at the North Gloucestershire Technical College.

CHESTER

23rd. Society of Instrument Technology.—"The atomic clock" by J. V. L. Parry at 7.0 in the Lecture Theatre, Administration Building, The Associated Ethyl Co., Oil Sites Road, Ellesmere Port, Wirral.

EDINBURGH

8th. Brit.I.R.E.—"Measuring stability and spurious modulation spectra of high-quality oscillators" by A. L. Whitwell at 7.0 at the Department of Natural Philosophy, The University, Drummond Street.

FAWLEY

3rd. Society of Instrument Technology.—"Instrumentation in radio astronomy" by Dr. H. P. Palmer at 5.30 at the Administration Building, Esso Refinery.

GLASGOW

9th. Brit.I.R.E.—"Measuring stability and spurious modulation spectra of high-quality oscillators" by A. L. Whitwell at 7.0 at the Institution of Engineers and Shipbuilders, 39 Elmbank Crescent.

LIVERPOOL

15th. Brit.I.R.E.—"Inertial navigational systems" by Wing Cdr. E. W. Anderson at 7.0 at the Adelphi Hotel.

MANCHESTER

2nd. Brit.I.R.E.—"The manufacture of television tubes" by P. Funnell at 7.0 at Reynolds Hall, College of Technology.

SOUTHAMPTON

22nd. Brit.I.R.E.—"The application of computers to commercial problems" by N. D. Hill at 7.0 at the Lanchester Building, the University.

WOLVERHAMPTON

8th. Brit.I.R.E.—"Computers and mathematics" by R. Wooldridge at 6.15 at the College of Technology, Wulfruna Street.

RANDOM RADIATIONS

By "DIALLIST"

Colour Television

MYSELF, I'm glad that the Postmaster-General hasn't approved the starting of a colour television service by the B.B.C. There's no doubt that the B.B.C. could make a good job of it with satisfactory and completely compatible transmissions; but I don't feel that the time is yet ripe, or that it will be until much cheaper receivers have been developed. And they must be such that their adjustments stay put and don't call for constant, or at any rate frequent, fiddling with delicate controls; otherwise they'd be of little use to the man-in-the-street, and he'd quickly be put off buying by tales of tribulations of his friends who had taken the plunge and gone in for colour receivers. The very fact that a service was in being would in all probability give him the idea that prices of colour sets would quickly come down to his sort of figure and would have a distinctly harmful effect on the sale of black-and-white receivers. Much better—don't you think?—that people shouldn't be led to believe that colour television is just around the corner.

It'll Come

Colour television will undoubtedly come, but I don't think that when it does it will be done by any of the systems so far developed. Something much less complicated and fiddly is needed and I think there's no question that it will come along in time. Till then let's be content with the monochrome system and put money and brains into improving that. The TV receiver, when you come to think of it, is now vastly better than it was only a few years ago. The number of outside-the-cabinet knobs has been steadily reduced by increasing the number of inside pre-set controls and by introducing refinements such as automatic brightness control. And there are other similar improvements. Anyhow, we mustn't put on colour TV until we're certain that it won't be a flop.

U.S. Television DX

AN American reader tells me that there is a strong body of enthusiasts for long-distance v.h.f./f.m. and television reception in his country and in Canada. They have formed The American Ionospheric Propagation Association which now has members all over the world. Should any DX-minded reader of *Wireless World* wish for particulars, the address of the association is: c/o 68 Amber Street, Buffalo 20, N.Y., U.S.A. I've often seen accounts in American magazines of long-distance reception of television programmes and I know that London has been received in or near New York under freak conditions. My correspondent doesn't appear to have picked up any of our TV stations, but he says he is going "to keep his eyes peeled for London this winter." Here's wishing him success. I don't suppose that a standard American receiver would answer unless it were specially adapted. For one thing, their images are negative, the sync and the intervals being not blacker than black, but whiter than white. I wonder if the real enthusiasts get British sets.

Some Telescope!

THE Americans, I see, are to build a gigantic radio telescope in the Allegheny Mountains of West Virginia. Our own at Jodrell Bank, with its reflector bowl 250 feet in diameter, is a pretty sizeable affair; but the new American 'scope will quite dwarf it, for it is to have a bowl no less than 600 feet in diameter. Carried by 256 railway wagon wheels, this can be revolved on a circular rail track. It is stated that its range will be 38,000 million light years—and a light year is quite some distance, being in round figures six million million miles. Our Jodrell Bank telescope has made some remarkable discoveries about outer space and the bodies existing in it. Still more astonishing results are to be expected from the device in the Allegheny Mountains when it gets to work. It should also be of great value for tracking space vehicles launched by man and for obtaining data transmitted from them to earth. The cost is estimated at £29M!

Television in Eire

A TELEVISION service is due to start in the Dublin area before the end of this year. From this beginning TV will be extended gradually over the whole of Southern Ireland. Since there are already the best part of 100,000 405-line sets in use in the country for the reception of B.B.C. and I.T.A. transmissions in Northern Ireland, a 405-line standard is to be adopted, to begin with at any rate. What standard will finally be used hasn't yet been decided, but presumably it will be governed by the decision taken in this country. It won't be an easy business to provide a service giving national coverage, for there are many mountainous districts and they always mean headaches for planning engineers. The solution may well be similar to what we have developed in Wales, Scotland and other hilly districts, a few high-powered stations and the gradual building up of a network of low-powered relays. I don't suppose that the system will ever be so com-

CONFERENCES AND EXHIBITIONS

We regret the omission of the dates of the British National Radio and Television Show from the list of conferences and exhibitions in our January issue. Since going to press with that issue we have also obtained details of other forthcoming events. The following should therefore be added to the list given in our last issue:—

Mar. 5-14	**Leipzig Spring Fair** (Leipziger Messeamf, Post Box 329, Leipzig C1)	Leipzig
Mar. 20-25	**Radio & Electronic Engineering Convention** (Institution of Radio Engineers (Australia), 157 Gloucester Street, Sydney, N.S.W.)	Sydney
Aug. 23-Sept. 2	**National Radio and Television Show** (Radio Industry Exhibitions Ltd., 59 Russell Square, London, W.C.1)	Earls Court, London
Sept. 1-8	**Firato—International Radio Show** (Firato Secretariat, Emmalaan 20, Amsterdam)	Amsterdam
Sept. 14-25	**French Electronics, Radio & Television Show** (Fédération Nationale des Industries Electroniques, 23 rue de Lubeck, Paris XVI)	Paris

plete as our own, for that would cost a great deal of money and Southern Ireland's population is scattered.

Not Dead Yet

FOR some time there have been those who say that the valve is on the way out; but it's still a very long way from being a back number, for there are so many things that it can do and that transistors can't—not yet, at any rate. It's difficult, for instance, to imagine the output stage of a high-powered transmitter being worked by any sort of semiconductor devices. That may come, but it's still a long way off. Meantime, interesting developments continue to be made in the world of valves. For example, the compactrons, tiny multiple valves, each containing several sets of electrodes within its small envelope. I confess that I've never been very keen on multiple valves myself, largely because if the single heater goes west you may lose the equivalent of a pair or a trio of valves at one blow. But that may be an old-fashioned idea, for people today don't seem to fight shy of them.

Components on Show

THE 1961 Radio and Electronic Components Show will be held in Olympia and it will be at least three times as big as those of yesteryear which were somehow fitted into one big room at Grosvenor House, with latterly a small overflow into a nearby building. To me the Components Show has always been one of the highlights of the year. It'll go on being a highlight, but it's now to be held every other year. This year's will be of special interest because it is to include components for computers, for the controlling mechanisms of machine tools, for man-made satellites, for guided missiles and for apparatus used in nucleonic engineering.

UNBIASED

By "FREE GRID"

Diary Worry

WE have had our *Wireless World* Diaries in use for a few weeks now, and many of us have had occasion to use the information on one or more of the eighty data-packed pages which precede the actual diary.

I received my Diary as a gift from the Editor and I am, therefore, a little worried about a recent decision of the High Court in which it was laid down that for income-tax purposes such a gift should be rated at its second-hand value. To unthinking people such a value in the case of a diary—even a *Wireless World* one—would be a small fraction of the few shillings at which it was priced when new.

But some diaries, unlike a suit of clothes which was actually the test-case gift dealt with by the court, have a habit of increasing in value enormously when second hand. This is obvious when one considers what the original diaries of Pepys, Evelyn or even Nell Gwynne would fetch on the open market today. As was recently pointed out, parts of Pepys diary were so severely critical of certain personalities of his day that they have never been published, and this greatly enhances their potential value.

Naturally my own year-by-year diary contains many references to famous names in the world of wireless, and in some cases critical remarks which could bring me a tempting offer from certain sensational newspapers, as any income-tax inspector would quickly realize. I hope, therefore, that next year the Editor will make it a suit of clothes (vital statistics 40-in × 38-in × 29-in) and I will buy my own diary.

As for the *Wireless World* Diary, I have nothing but praise for the data pages and it is only the actual diary section for which I have any criticism. I can't grumble at being told such an obvious thing as that Christmas Day falls on December 25th, as *Wireless World* has many readers in non-Christian countries who would not necessarily know this.

All the same, I do feel that rather than be told that Lammas falls on August 1st, I should have been informed of when the National Radio Show opens its doors. But maybe the show date was not known when the diary went to press.*

* It was not; but it was when the calendar of conferences and exhibitions in the January issue went to press. We regret the omission. The dates are Aug. 23 to Sept. 2.—ED.

C.I.D. Censured

WHEN a person as important as the chief of the C.I.D. writes his memoirs I always feel that he ought to take the utmost care to be meticulously accurate, especially when dealing with a technical subject like wireless. The late Sir Basil Thomson who was chief of the C.I.D. in the first world war rather let Scotland Yard down in that respect; at least that is my opinion.

In his book entitled "Queer People," which I recently picked up, he discusses the great German spy scare of 1914 when it only needed the flimsiest reason for reports to reach the C.I.D. that somebody was sending wireless messages across the North Sea to the enemy.

Such a wireless spy scare was in evidence before the war started and I recalled a striking instance of it when writing on this subject in the issue of *Wireless World* for June 4th, 1937, although a natural modesty made me omit to mention being a witness of it.

It happened that an unfortunate girl was paying a visit to her brother in a certain naval dockyard where there was a powerful radio transmitter. By chance, she was standing within a few feet of the aerial mast when the operator started transmitting. The field strength was so great that the metal ribs of her "stays"—a commonplace appliance in 1914—were forced into electrical oscillation, they apparently resonating to a harmonic of the wave being radiated. The result was that sparks were observed to be leaping from her person to some earthed iron railings against which she was leaning, and she was promptly arrested.

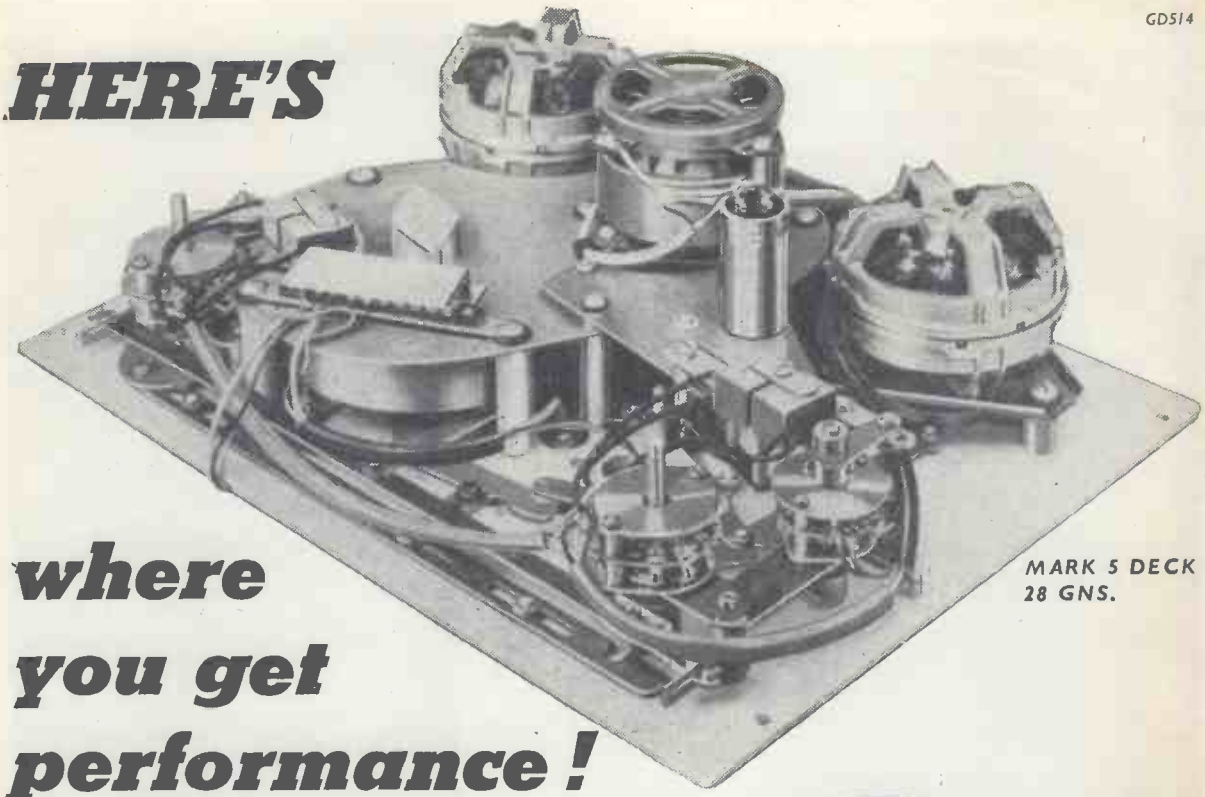
This incident led to patriotic young men following girls in the interests of national security, especially the younger girls whose trailing tresses could so easily have concealed a primitive dipole. In my illustration it can be clearly seen that an alert young man's attention has been attracted by the suspicion-rousing coiffure of a young girl in the grounds of the old White City on which the B.B.C.'s new TV headquarters now stands. This patriotic following of girls led so frequently to the altar—or should be say halter—that the whole idea was later suspected to have been initiated by the wiles of women.

Sir Basil seems to dismiss the feasibility of spies using a radio transmitter in those days because, to quote his own words, "a Marconi transmitter needed a 4 h.p. engine to generate the wave." In actual fact with a standard Marconi 10-in spark coil and a couple of 12-volt car batteries with an aerial suspended down a chimney, I should be very surprised indeed if a spy could not have sent a message from the East Kent coast to the nearest point of the Belgian coastline occupied by the Germans, a distance of 40 to 50 miles; even if the enemy were using the—by modern standards—relatively insensitive magnetic detector.

Such a transmitter as I have described, using a 12-cell 80 AH capacity storage battery, was the basic emergency transmitting equipment of a British ship in those days. The maximum current taken by the coil just before the make-and-break did its stuff was between 7 and 8 amps, which is, of course, not at all beyond the capabilities of a car battery of large capacity. Ships' emergency transmitters were expected to—and did—have a much greater range than 40-odd miles.

GD514

HERE'S



MARK 5 DECK
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where you get performance!

A tape recorder is only as good as its deck. This is where precision in manufacture and assembly is vital for professional standards of recording and reproduction. In the Brenell Mark 5 deck there's a rare combination of advanced technology and an almost-forgotten kind of craftsmanship.

The Mark 5 deck has a remarkable, new main motor of a type widely regarded as the most efficient to be used in tape recording. The HYSTERESIS SYNCHRONOUS MOTOR, with a balanced outer rotor and a heavy, statically and dynamically balanced flywheel. It brings 'wow and flutter' down to below .1% at 7½ ips!

This and the other components providing the specification shown below are assembled with fanatical care. Brenell Mark 5 (and all other equipment) production is an individual task which is repeatedly checked and tested. Nothing less than mechanical and electrical perfection will do.

At 28 gns., you'd be missing a great deal to pay less and there's no need to pay more.

Abridged specification
3 INDEPENDENT MOTORS
4 RECORDING SPEEDS
FAST REWIND in either direction. 1,200ft. reel rewound in 45 seconds.

WOW AND FLUTTER				FREQUENCY RANGE:			
Below	.05%	at	25 ips	15 ips:	50/16,000 c/s	±	3db
Below	.1%	at	7½ ips	7½ ips:	60/12,000 c/s	±	3db
Below	.15%	at	3¾ ips	3¾ ips:	60/7,000 c/s	±	3db
Below	.25%	at	1⅞ ips	1⅞ ips:	60/4,000 c/s	±	3db

SELECTIVE FREQUENCY CORRECTION at 15, 7½ and 3¾ ips.
ACCEPTS 8½in. REELS, PAUSE CONTROL, DIGITAL REV. COUNTER.
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MK. 5

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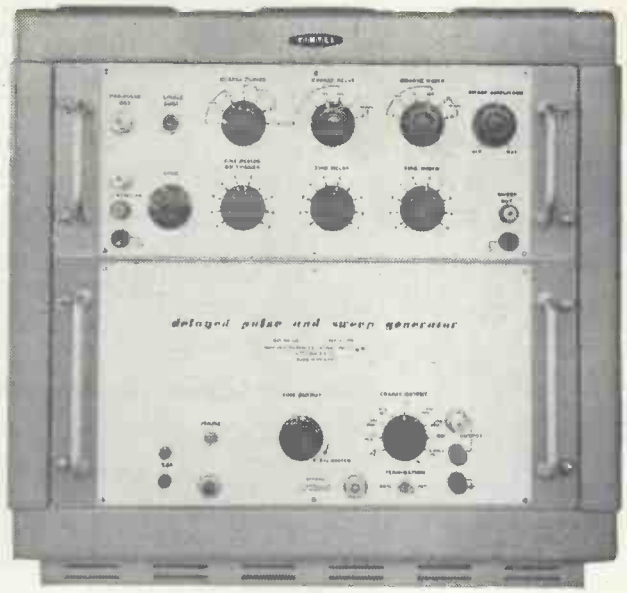
DELAYED PULSE AND SWEEP GENERATOR

A versatile pulse generator designed to meet the need for a comprehensive instrument covering a wide range of pulse work. Four main facilities are provided: a pre-pulse, a main pulse delayed on the pre-pulse, a negative going sawtooth and a fast rising pulse formed from a pure line.



BRIEF SPECIFICATION

Period

Continuously variable from 0·9μsec to 1·05sec i.e. 0·95c/s to 1·1Mc/s. Accuracy ±5%.

Pre-pulse

40mμsec. 8V peak in 75Ω, positive going.

Main pulse

Width: Variable from 0·09μsec to 105msec ±5%.

Amplitude: Control gives 4:1 attenuation of each of four maximum outputs as follows:

5V max in	75Ω	rise time 10mμsec
10V max in	150Ω	rise time <20mμsec
25V max in	600Ω	rise time <40mμsec
50V max in	1000Ω	rise time 50mμsec

Polarity: Positive or negative going.

Accuracy: ±2%.

Delay

Conclusion of pre-pulse to advent of main pulse, delay variable from 0·09μsec to 105msec. Accuracy ±5%.

Sweep

D.C. coupled negative going sawtooth same width and delay as main pulse. 15V peak max.

Cable pulse

Obtained from short circuited pure line. One positive and one negative going pulse coincident with main pulse. 25mμsec wide 3V max in 75Ω, rise time <8mμsec.

Sync, trigger or single shot facilities provided. Full data available on request.

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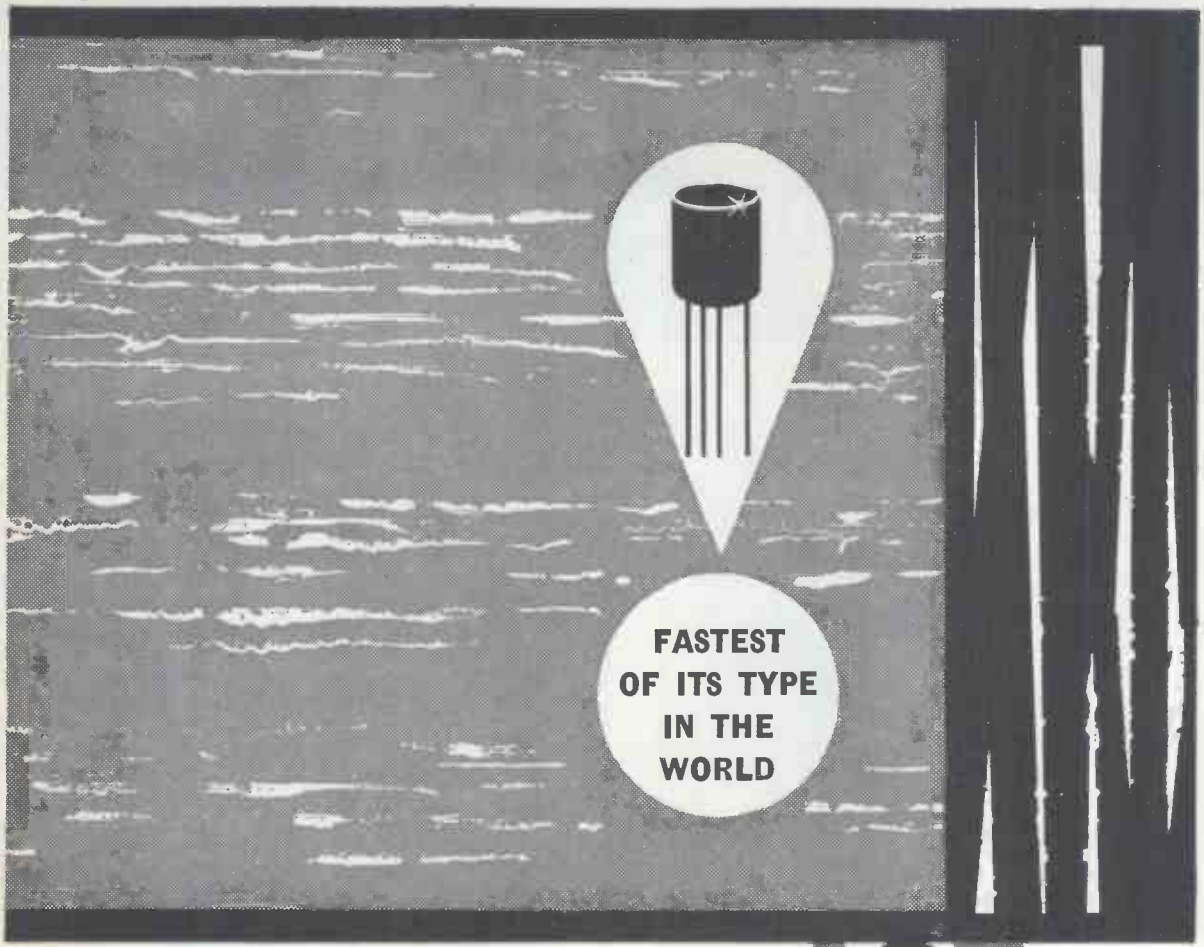


NEW MULLARD AVALANCHE TRANSISTOR

Today you can specify a truly *dependable* avalanche junction transistor, for use in very high speed circuits. It is the Mullard ASZ23—a new *purpose-made* transistor that is manufactured by the Mullard alloy diffusion technique to give complete reliability of the avalanche mode. Mullard experience in the development of alloy diffused transistors has made possible the production of this high avalanche performance p - n - p junction transistor at a realistic price.

Here is a transistor to give the designer tremendous scope. The ASZ23 opens up a new field of nanosecond pulse techniques. A typical application is in the sampling oscilloscope circuit shown alongside.

Supplies of the ASZ23 are immediately available.

ASZ23 ALLOY DIFFUSION p-n-p JUNCTION TRANSISTOR

Absolute Maximum Ratings

Collector current ic (pk) max	100mA
Reverse emitter-base voltage V_{eb} max	—2.0V

Temperature Ratings

Storage temperature limits	—55 to +75°C
Maximum junction temperature	75°C
Junction temperature rise above ambient	0.6°C/mW
Junction temperature rise above case	0.5°C/mW

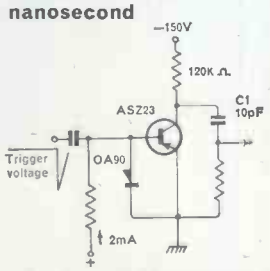
Typical Characteristics

at T junction =25°C	
V_{eb} turnover at I_{co} = 1mA, Ie=0	—24V
Rise time of output pulse in circuit shown	1ns

If you would like more detailed information, please write to the address below:

ASZ 23

60mA pulse with rise time of 1 nanosecond



A typical method of obtaining a predetermined sampling by means of the ASZ23

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semiconductors for Industry

another ALLOY DIFFUSION transistor

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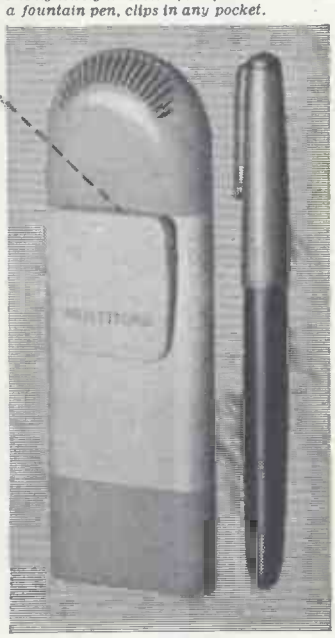
MIS 30a

Pocket Paging PAYS!

The lightweight receiver, compared here with a fountain pen, clips in any pocket.



In an increasing number of progressive firms and institutions, the Multitone Pocket Paging System is saving countless wasted man-hours. It can do the same for your organisation—and your customers.

On telephone working alone, Pocket Paging reduces 'call-backs' and the need for extra lines and operators sufficiently to offset the cost—a few shillings per week per man 'on call'.

Not a telephone of any kind, Multitone 'Personal Call' is a unique paging system which enables any of your key staff to be contacted immediately wherever they happen to be, selectively and without disturbing anyone else—no loudspeakers, bells, flashing lights or any other distraction.

This all-British equipment, which is installed in hundreds of hospitals and an even larger number of industrial firms in 30 countries, is simple to install and foolproof to operate.

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Points to note when choosing a L.F. Phase Meter

AIRMEC L.F. PHASE METER, TYPE 206

OPERATION. **Is operation simple and rapid?**
In many applications it is necessary to take a series of phase measurements at short intervals and the necessity to re-adjust a number of critical controls for each new reading is intolerable. Setting up the Airmec L.F. Phase Meter Type 206 consists merely of balancing the attenuators, whereupon a reading of phase angle is obtained at once.

INDICATION. **Is the indication direct and unambiguous?**
Tedious calculations and other possible sources of error are obviously undesirable in measurements of phase angle. Phase is indicated on the Airmec L.F. Phase Meter Type 206 on a large, clear panel meter having four scales. A continuous reading of phase angle is presented over a range of either 360° or 180°. The frequency range is 20 c/s-100 kc/s.

INPUT LEVEL. **Is the input level range wide enough?**
In present day circuitry, wide differences in signal level are likely to be encountered. The Airmec L.F. Phase Meter Type 206 will accept input signals between 1 millivolt and 1 volt, the maximum level difference between the two measured points being 60 dB.

LEVEL COMPARISON. **Can a direct comparison of signal level difference be obtained?**
Even though phase measurement is the primary object, it is advantageous to be able to read instantaneously the value of any level difference between the points of measurement. Signal level differences are indicated on the Airmec L.F. Phase Meter Type 206 by reference to the settings of two attenuators, one in each channel.

INPUT IMPEDANCE. **Is the input impedance high enough?**
The addition of a measuring device to the circuit under test should obviously not change the operating conditions. The input impedance of the Airmec L.F. Phase Meter Type 206 is 12 Megohms at 1 kc/s.

PRICE AND DELIVERY. **Are both the price and delivery reasonable?**
The price of the Airmec L.F. Phase Meter Type 206 will be found a pleasant surprise and delivery is immediate.

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- ★ BACKGROUND NOISE AND SPEECH LEVEL
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SPECIAL FEATURES INCLUDE

- ★ Built-in meter for monitoring sound pressures from +20dB to +150dB and "loudness" at three "weightings"
- ★ Jack for connection of headphone for aural monitoring
- ★ Choice of eight filters covering the range 20 c/s to 12,000 c/s.
- ★ Built in retractable microphone
- ★ Provision for connection of external microphone, or for connection of transducer or accelerometer for vibration measurements

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NATURAL COOLED

TETRODES

FOR COMMUNICATIONS & INDUSTRY

The English Electric Valve Co. Ltd. offer a range of natural cooled tetrodes for the lower power communication and industrial application. The majority of the types in this range, comprising both single and double tetrodes, are capable of operation, at full ratings, well into the V.H.F. band — up to 250 Mc/s in the case of the C178A/5894. Even higher frequencies may be attained with suitable de-ratings. All are equivalents or near equivalents to American and CV types.

For full details of these valves please write to the address below.

'ENGLISH ELECTRIC'

	E.E.V. Type	American Type	British Services Type	Operating Frequency Mc/s	Max. Anode Dissipation (W)
FOR NEW EQUIPMENTS	4D32	4D32	CV3543	60	50
	C178A/5894	5894	CV2797	250	20+20
	C1108	4-125A*	CV2130	120	125
	C1112	4-250A*	CV2131	75	250
	C1134	6252 *	CV2799	150	10+10
MAINTENANCE	813	813	CV26	30	100
	829B	829B	CV2666	200	20+20
	832A	832A	CV788	200	7.5+7.5

** Near equivalent*

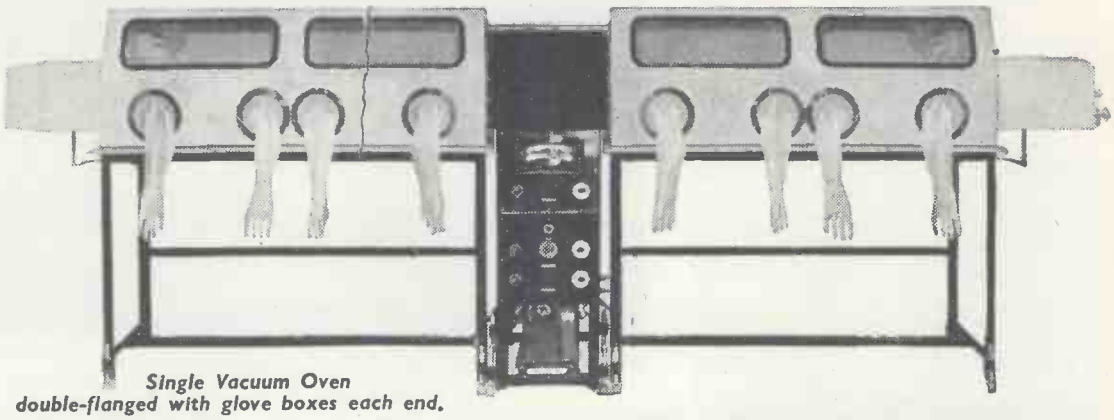
AGENTS THROUGHOUT THE WORLD

ENGLISH ELECTRIC VALVE COMPANY LIMITED

Chelmsford, England | *Telephone: Chelmsford 3491*

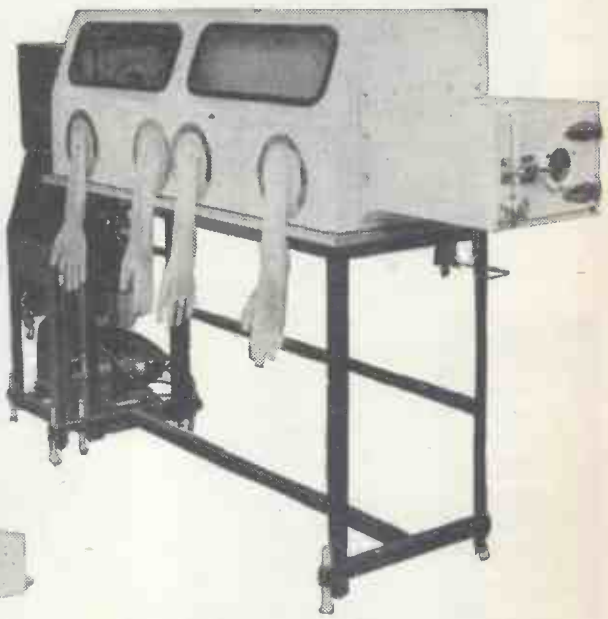
AP 169

DOUBLE ENDED STAINLESS STEEL VACUUM OVENS



Single Vacuum Oven double-flanged with glove boxes each end.

- ★ Made throughout in polished stainless steel.
- ★ Single action door openings.
- ★ Rectangular with shelf spacings to suit.
- ★ Double ended controls.
- ★ Electrical interlocking of air inlet and isolation valves.
- ★ Outer cover hermetically sealed.
- ★ Temperature range 0°-300°C or equivalent F.
- ★ Temperature Control: Normal ±7½°C. Special ±1C.
- ★ Internal Spacing 7in. x 8in. x 18in. (can be altered to special requirements).
- ★ Vacuum Range: To 10-4.
- ★ Respective Vacuum Gauges incorporated.
- ★ Automatic air inlet valve on Backing Pump.
- ★ Visual indicators and fuses on all switches.
- ★ Flanged for fitting into Dry Box.



View showing automatic interlocking of unloading compartment on glove box.

Vacuum Oven with glove box.

We design and manufacture Ovens to Customers' special requirements. Should you have any problems in this field our Technical Department is always willing to help you solve them.

Vacuum Ovens with temperatures of up to 600°C are also manufactured by us on similar lines but with Sectional Heating and Water-Cooled Ends.

VACWELL ENG. CO. LTD.

VACWELL ENGINEERING CO. LTD.

WILLOW LANE, MITCHAM, SURREY

Phone : MITcham 8211 (3 lines)

oscilloscope

with all facilities

Important characteristics:

4% calibrated vertical deflection (maximum sensitivity: 50 mV/cm, bandwidth: 0—5 Mc/s)

Optimum trigger stability with manual and automatic level control at repetition frequencies between 10 c/s and 1 Mc/s

Dimensions: 16 x 25 x 34 cm (6.5" x 10" x 13.5")

These three main characteristics make this oscilloscope the standard instrument for service and monitoring applications in industry. It gives just those features you are looking for and which up till now were not available in instruments of this price-class.

Some other data

Vertical amplifier
Bandwidth: 0—5 Mc/s (—3 dB), risetime 70 mμsec
Sensitivity: 50 mV/cm—20 V/cm in 9 calibrated steps (accuracy ± 4%)
Continuous control: 1: 2.5

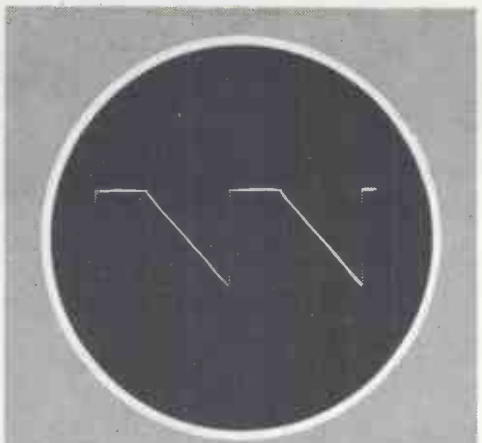
Time base
Sweepspeeds: 0.5 μsec/cm—30 msec/cm in 7 steps and continuously adjustable

Trigger-possibilities
Internal or from an external source both with pulse repetition frequencies from 10 c/s to 1 Mc/s, as well as from the mains frequency. Stability control and manual or automatic level control.

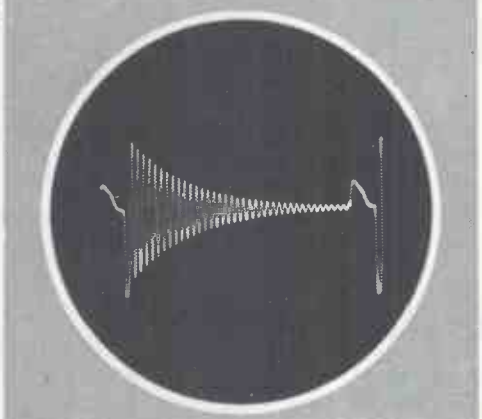
Horizontal input
Bandwidth: 5 c/s—2 Mc/s
Sensitivity: 3—50 $V_{p\text{-}p}$/cm (continuously adjustable)

C.R.T.
7 cm flat-faced with 1.4 kV accelerating voltage

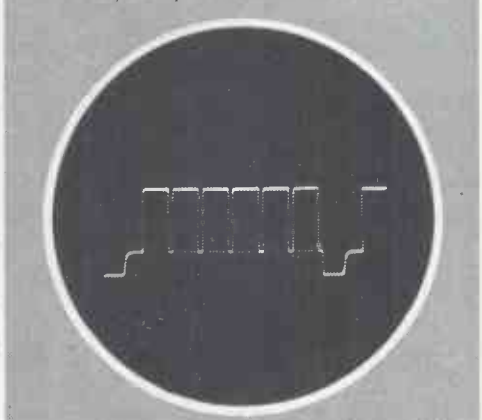
Probe
Attenuator probe (10:1) available



timebase voltage of GM 5600 (triggered position)



1 Mc/s damped sine-wave on GM 5600



one line of a TV pattern with vertical bars

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PHILIPS

WIDEBAND

circuit designs simplified with new rf pentodes

E55L

E810F

The introduction of the E810F and E55L wideband pentodes makes possible cascaded amplifiers with bandwidths hitherto only achievable by distributed amplifier techniques. They will be of particular interest to designers of wideband amplifiers for oscilloscopes, microwave radio links and telephone repeaters.

In the E810F the frame grid technique has been used for both the control grid and screen grid. This results in a particularly good ratio of anode to screen grid current. Moreover, special attention has been paid to the provision of an adequate grid base—making the valve ideally suitable for large signal applications.

The E55L has twice the anode dissipation of the E810F whilst still achieving a figure of merit of nearly 200Mc/s—a performance far in advance of conventional power pentodes. Like the E810F this large valve has the grid base required for large signal applications.

ABRIDGED DATA

Characteristics	E810F	E55L
V_a	120V	125V
V_{g_2}	150V	125V
V_{g_3}	0V	0V
V_{g_1}	−1.9V	−2.0V
I_a	35mA	50mA
I_{g_2}	5mA	10mA
g_m	50mA/V	45mA/V
$\mu_{g_1-g_2}$	58	38
r_a	70kΩ	20kΩ
r_{g_1}	500Ω (f=100 Mc/s)	1000Ω (f=50 Mc/s)
Gain bandwidth product	238 Mc/s	194 Mc/s
Capacitances (unshielded)		
c_{a-g_1}	40mpF	110mpF
c_{in}	16pF	18pF
c_{in} (working)	25pF (I_k=40mA)	28pF (I_k=60mA)
c_{out}	3.5pF	4pF
Valve Base	**B9A**	**B9D**

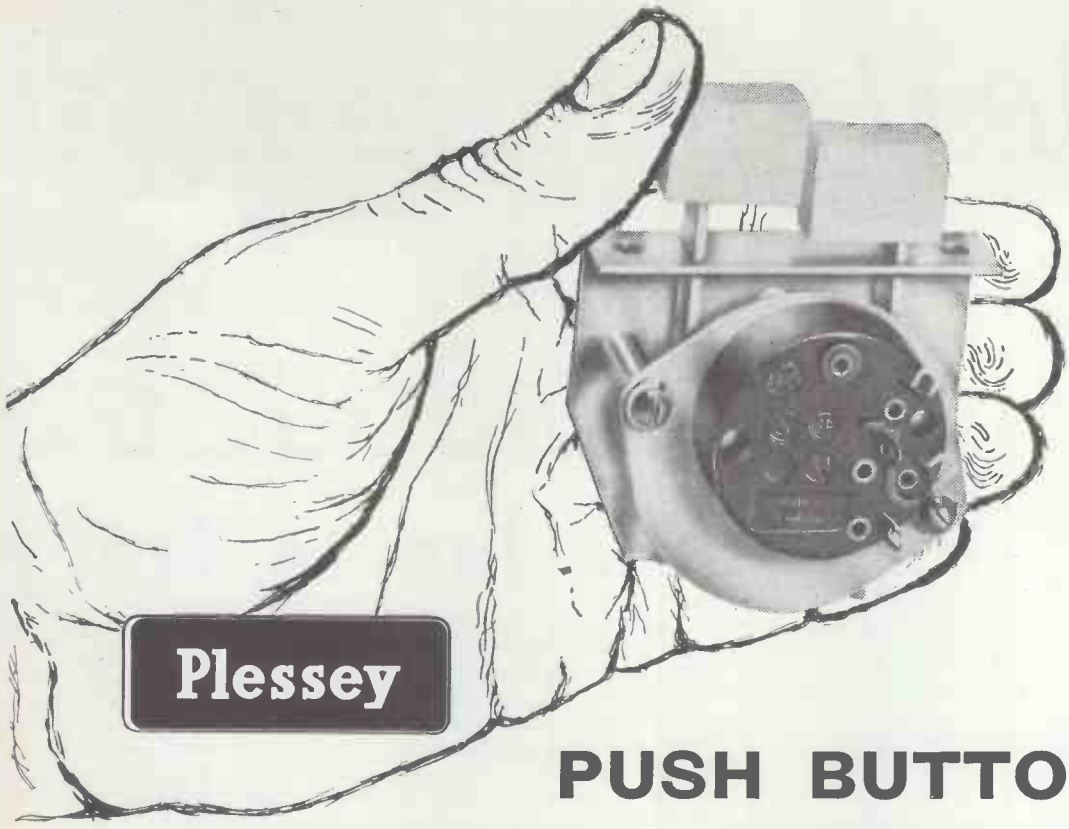
✳ *For more detailed information please write to the address below or telephone LANgham 6633.*

Mullard
GOVERNMENT AND INDUSTRIAL VALVE DIVISION

Mullard Limited,
Government and Industrial Valve Division

MULLARD HOUSE, TORRINGTON PLACE, LONDON, W.C.1

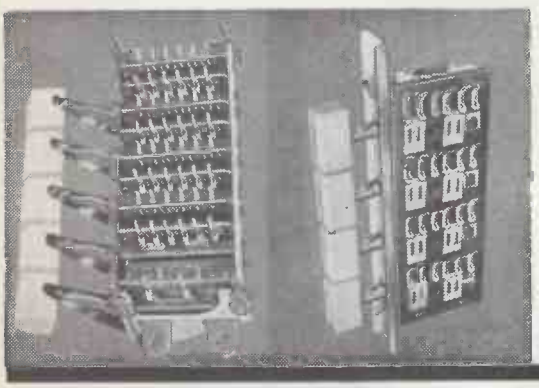
MVTA 4128



PUSH BUTTON & PIANO KEY SWITCHES

A whole range of PB and PK switches is provided by Plessey to meet the contemporary requirement in TV, radio and audio equipment design. And whether you plan to employ the one or the other, you will find a suitable Plessey switch with the shape of key or button you prefer — in the colour of your choice.

By the use of Plessey switches you can give your equipment the advantage of self-cleaning, positive contact switching with low contact resistance. All Plessey switches are free from electrical noise, due to their unique 'Wedgelock' riveted construction—which represents a great advance over conventional eyeleted methods. Standard or printed circuit contacts.



MINIATURE PIANO KEY SWITCHES

Among the many universally employed ranges of Plessey switches is featured a miniature piano key series, available with either standard or printed circuit contacts.

* *May we suggest that you talk to a Plessey Technical Representative about your switch requirements.*

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Plessey

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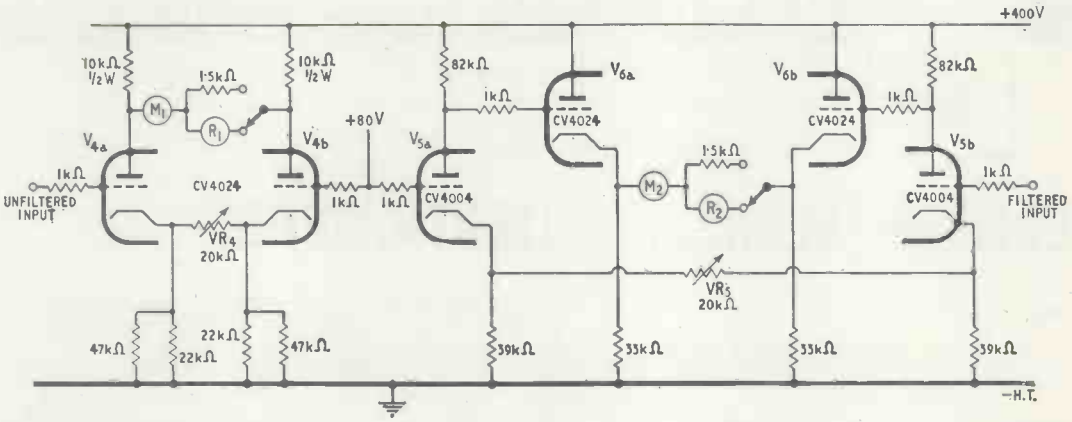

Water-level Surge Recorder

The current January issue of ELECTRONIC TECHNOLOGY includes an article which describes an instrument developed for measuring the amplitude and frequency of standing oscillations in an experimental water wave channel. The author gives details of the unusual problems arising and provides information on the transducer and various sections of the instrument, including a low-pass filter, driver amplifier and recorder. Drift and noise figures for the instrument and calibration and operation procedures are also given.

ARTICLES IN THE FEBRUARY ISSUE INCLUDE:

SPEED CONTROL OF D.C. MOTORS
In this article, the authors describe electronic methods of controlling the speed of small d.c. motors, such as those used in tape recorders. It is shown that by using transistor circuits it is possible to design speed-control systems for d.c. motors which are economic in cost, physical size and current consumption, giving speed performances which are superior and more reliable than those obtained from electro-mechanically-governed motors. Details and circuit diagrams are given for two systems.

EXPERIMENTAL TRAVELLING-WAVE TUBES
Small-size t.w.ts are described in this article with 150-W and 300-W c.w. output and gains greater than 20 dB over the band 7.5 to 11.5 kMc/s. The author describes various experimental tubes, gives details of their construction and performances and shows that by using high-pressure water cooling of helices, the advantage of high coupling impedance over a very broad band is retained and the thermal dissipation proves to be sufficient up to power limits set by other factors.

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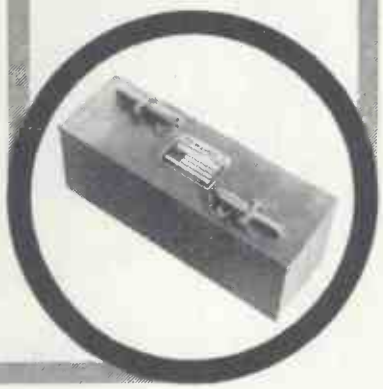

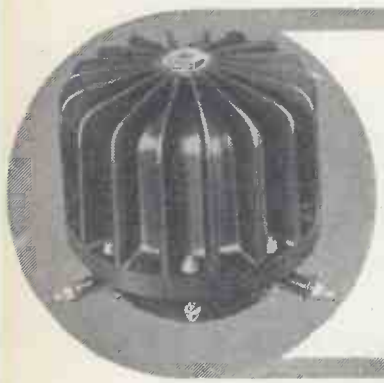

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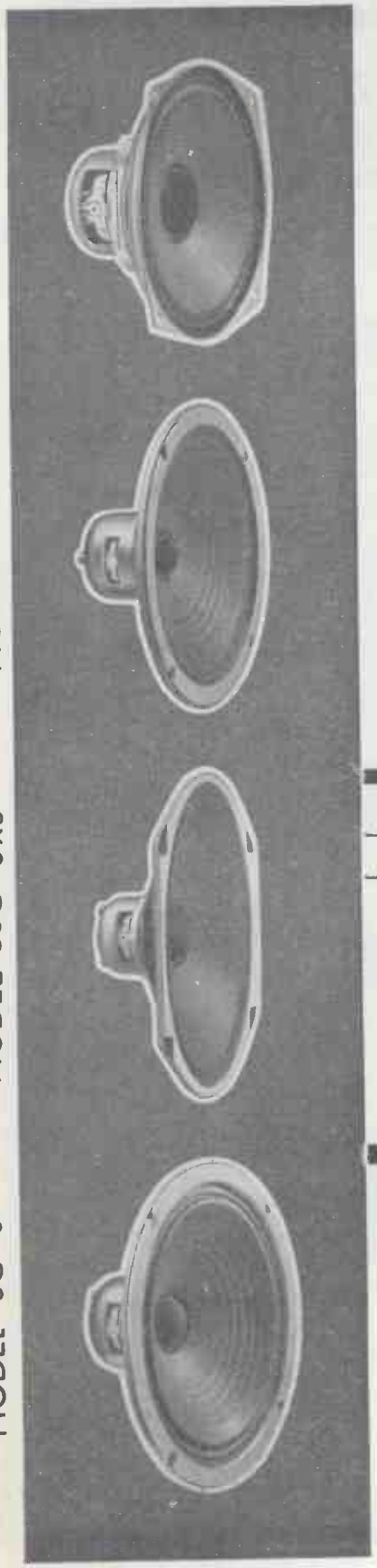

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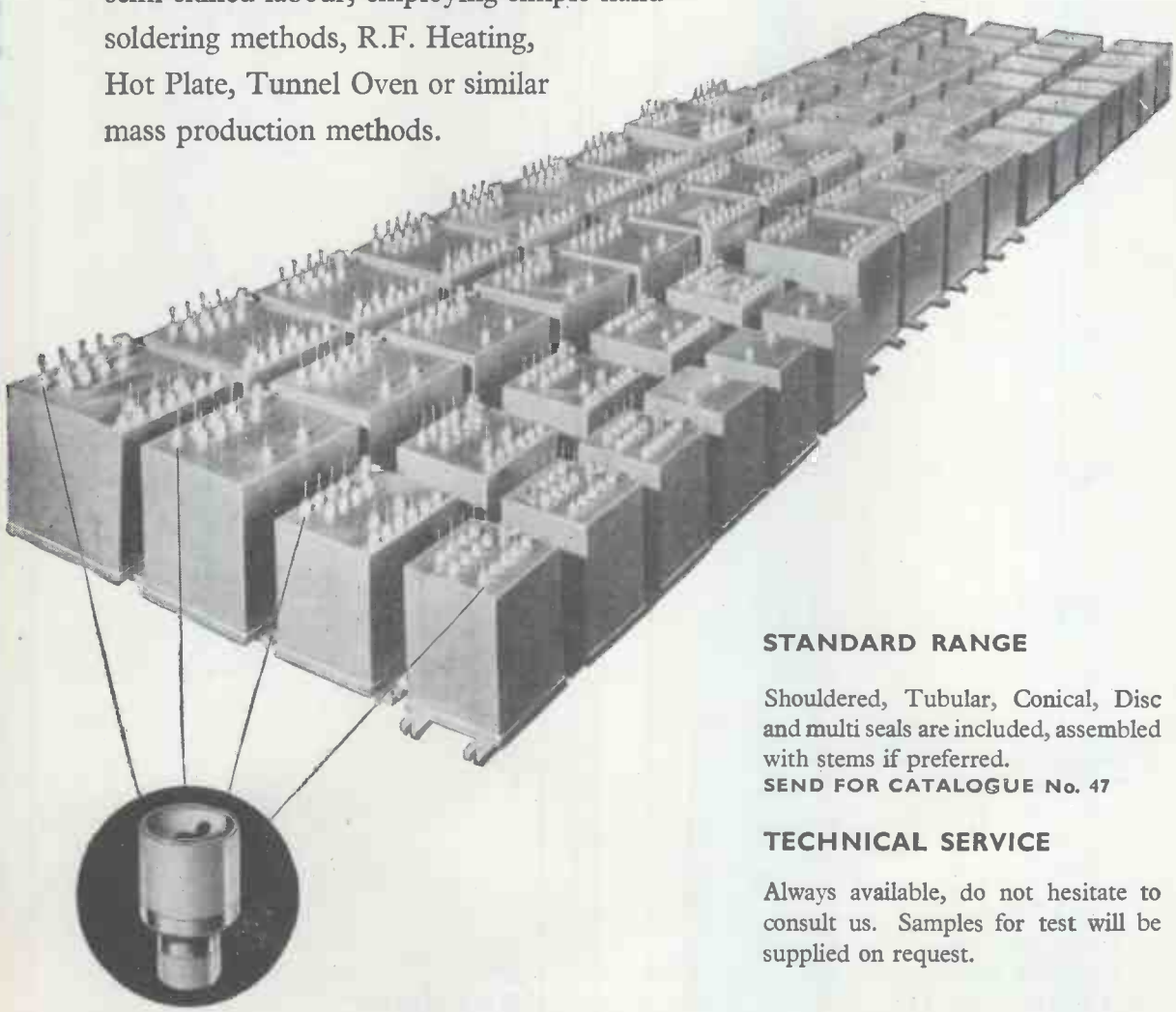

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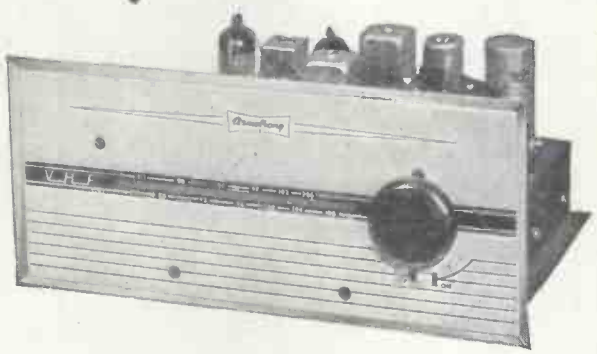

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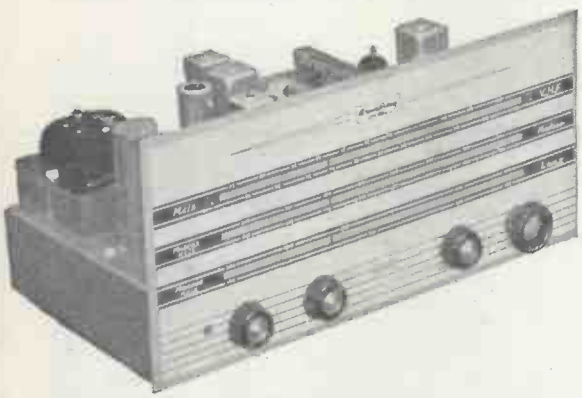

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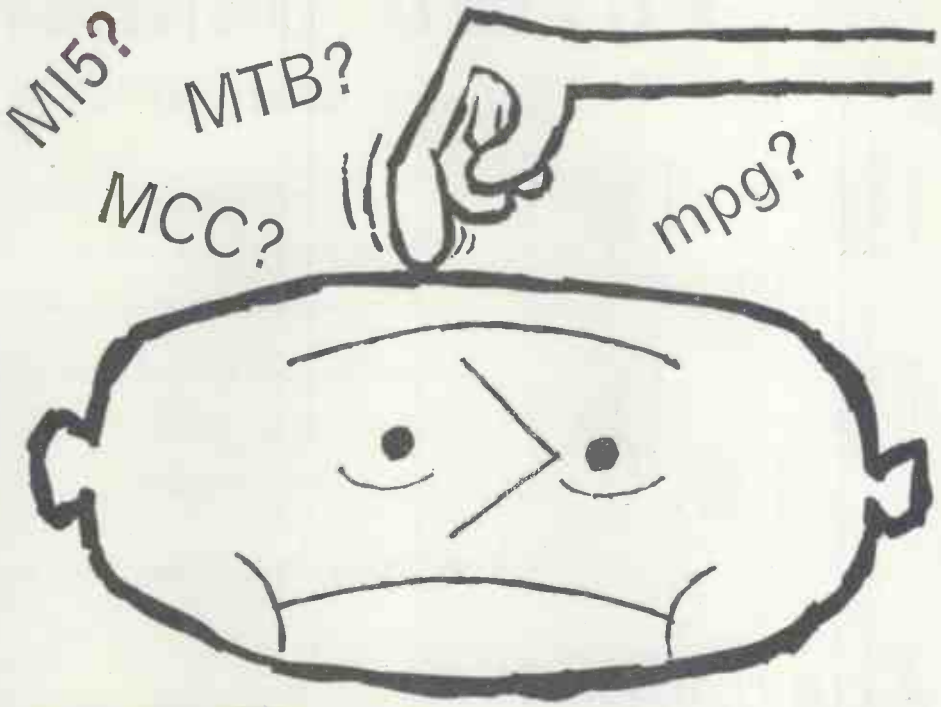

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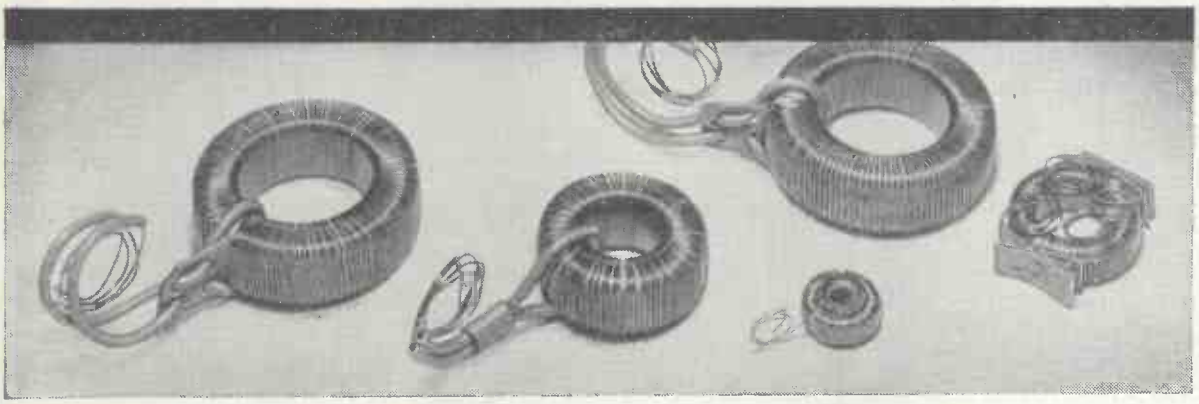

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B1	1.3	0.7	0.52	3.5	from 250 μH (½ amp) to 750 μH (0.1 amp)
C2	2.3	1.2	0.8	14.5	„ 100 „ (1½ „) to 1000 „ (½ amp)
C3	2.95	1.4	1.3	50	„ 100 „ (2½ „) to 1000 „ (½ amp)
C4	4.1	2.4	1.3	85	„ 100 „ (4 „) to 2000 „ (1½ amp)
C5	4.8	2.7	1.4	130	„ 100 „ (5 „) to 2000 „ (2 amp)

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CODE	Inductance at Cont. rated current (μH)	Current Rating		Volt Drop at Cont. Rated Current (V)	Self Resonating Frequency (Mc/s)	D.C. Resis. (Ω)
		Cont. (A)	Peak (A)			
C1A8 300	300 ± 10%	0.5	0.7	0.25	5.0	0.5
C2B8 500	500 „ „	1.0	1.2	0.30	3.2	0·3
C3BC1000	1000 „ „	1.5	2.2	0.45	1.2	0.3
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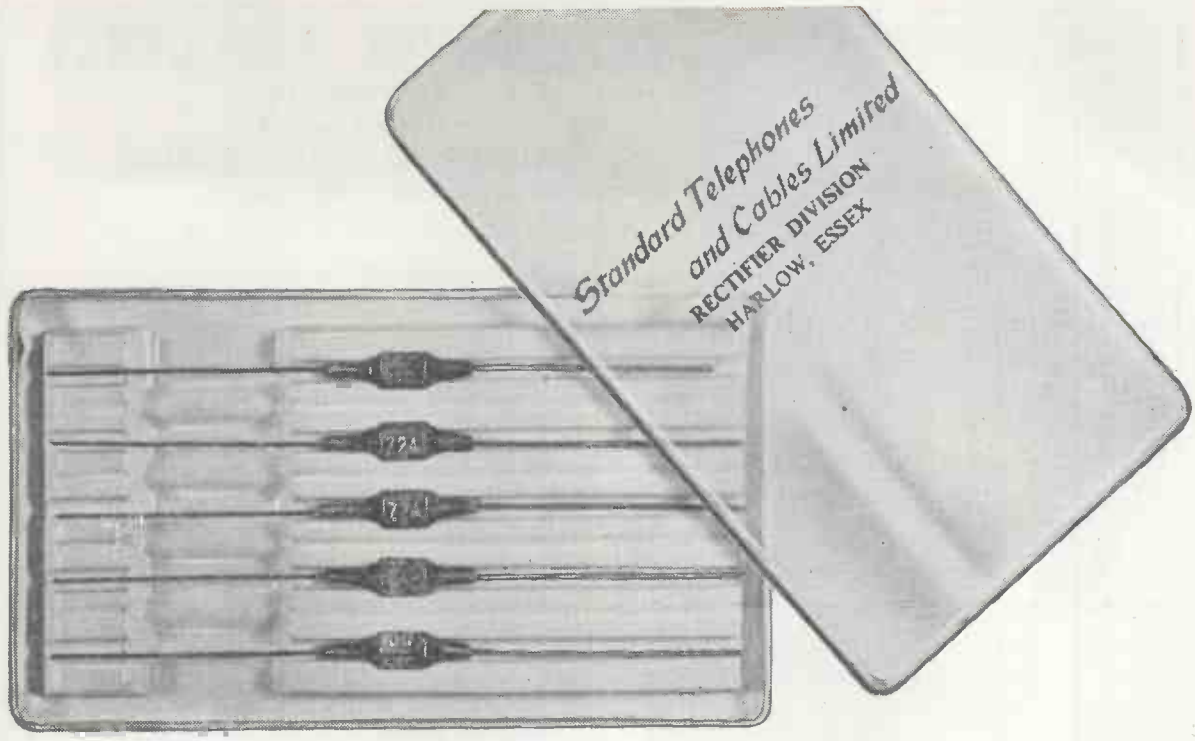

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	Z2A36F	3.6
	Z2A39F	3.9
± 10% Voltage Tolerance (Red and Yellow Sleeves)	Z2A43F	4.3
	Z2A47F	4.7
	Z2A51F	5.1
	Z2A56F	5.6
	Z2A62F	6.2
	Z2A68F	6.8
	Z2A75F	7.5
	Z2A82F	8.2
	Z2A91F	9.1
±20% Voltage Tolerance (Red and Blue Sleeves)	Z2A100F	10
	Z2A110F	11
	Z2A120F	12
	Z2A130F	13
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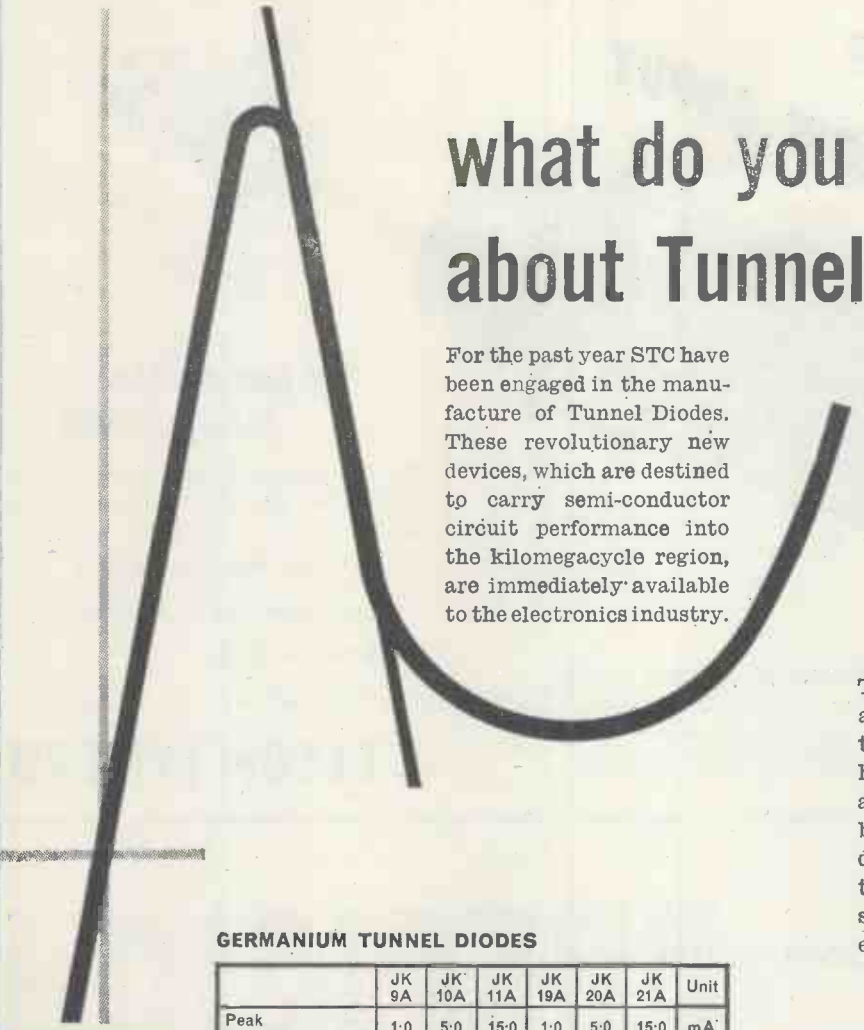

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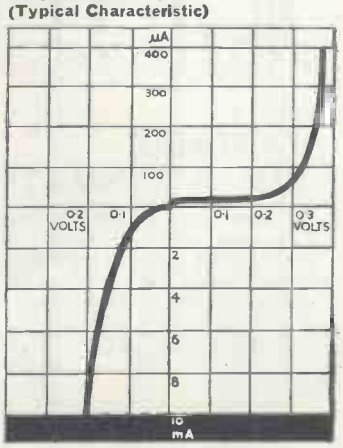
	JK 9A	JK 10A	JK 11A	JK 19A	JK 20A	JK 21A	Unit
Peak Current nom	1·0	5·0	15·0	1·0	5·0	15·0	mA
Current Ratio typ	4	4	4	6	6	6	
Junction Capacitance typ	25	50	125	10	40	80	pF
Resistive cut-off Frequency typ	540	810	810	1200	880	1100	Mc/s

BACKWARD DIODE

Typical Characteristics		Unit
Current in high resistance direction. (V_R=200mV)	·10	μA
Current in low resistance direction. (V_F=200mV)	10	mA
Slope resistance. (V_F=400mV)	1·1	Ω
Shunt capacitance. (V_R=200mV)	90	pF

BACKWARD DIODE
(Typical Characteristic)



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61/6MK

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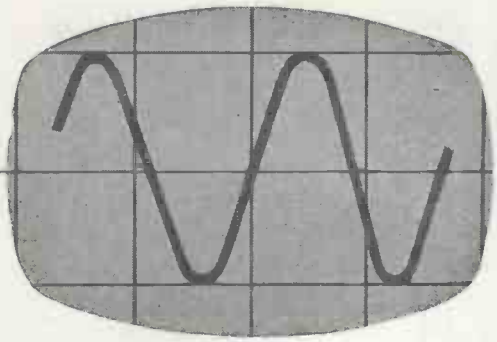

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Type	I/P V Range	O/PV r.m.s.	Watts	p.f.	Net Price in U.K.
CVH60A	190–260 50 ~	240	60	1.00	£10 10
CVH125A	190–260 50 ~	240	125	1.00	£17 0
CVH420A	190–260 50 ~	240	420	1.00	£37 0
CVH750A	190–260 50 ~	240	750	1.00	£68 0
CVH1500A	190–260 50 ~	240	1,500	1.00	£99 0
CVH3000A	190–260 50 ~	240	3,000	1.00	£185 0
CVH6000A	190–260 50 ~	240	6,000	1.00	£355 0

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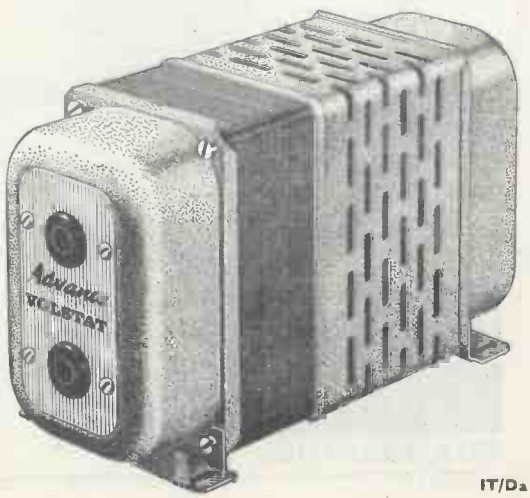

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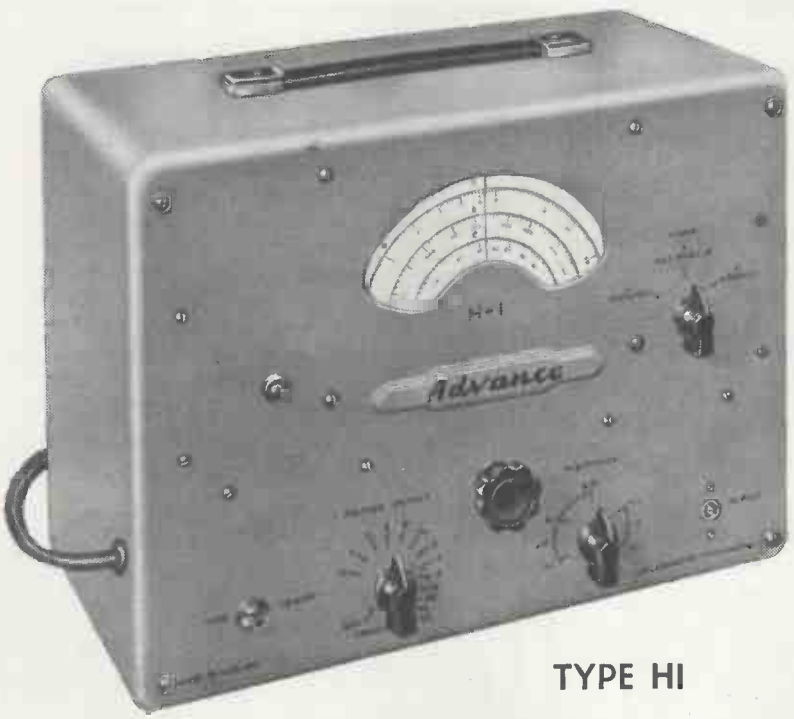

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TYPE H I

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  Sine Wave, 200 μV, to 20 V., r.m.s.
  Square Wave, 800 μV. to 80 V., peak-to-peak.
- Distortion less than 1% at 1,000 c/s.

List Price in U.K. **£30**

Full technical details in leaflet W41.

TYPE J I

- Frequency Range 15 c/s. to 50,000 c/s.
- Output (Sine Wave only)
  Into 600 ohms, 0.1 mW. to 1 W. continuously variable.
  Into 5 ohms, maximum 0.5 W.
- Output Impedance
  600 ohms, unbalanced.
  5 ohms, unbalanced (one side earthed).
- Distortion, less than 2% at full output.

List Price in U.K. **£36**

Full technical details in leaflet W33.

TYPE J2

Identical with the Type J1 but with output voltage meter.

List Price in U.K. **£42**

Full technical details in leaflet W33.

Advance COMPONENTS LIMITED

INSTRUMENTS DIVISION

ROEBUCK ROAD • HAINAULT • ILFORD • ESSEX TELEPHONE : HAINAULT 4444

TGD 731

Each Model incorporates the highly successful HF/TR3 Amplifier (described opposite), thus ensuring truly "Hi-Fi" record and playback facilities.

All prices quoted provide for the COMPLETE RECORDER including CRYSTAL MICROPHONE and 1-200ft. Spool of Tape.

There are no "better value for money" Tape Recorders on the market—if you can't call and hear them send S.A.E. for fully descriptive leaflets.

Stern's "fidelity" TAPE RECORDERS

BEFORE YOU BUY—YOU SHOULD HEAR THESE RECORDERS—THEY ARE COMPARABLE TO THE MUCH HIGHER PRICED MODELS

MODEL CR3/S. Incorporates the new Collaro "STUDIO" TWIN TRACK 3-speed Deck **£39.10.0**
H.P. Terms: Deposit £7/18/- and 12 months of £2/17/11.

MODEL CR3/T. Incorporates the very popular 3-speed COLLARO Mk. IV "TRANSCRIPTOR" Deck, which has both upper and lower tape tracks **£47.10.0**
H.P. Terms: Deposit £9/10/- and 12 months of £3/9/8.

MODEL TR3/Mk. VI. Incorporates the New TRUVOX Mk. VI TWIN TRACK 2-speed Tape Deck **£49.10.0**
H.P. Terms: Deposit £9/18/- and 12 months of £3/12/7.

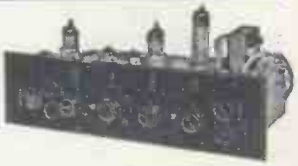
TAPE AMPLIFIERS and PREAMPLIFIERS presented from MULLARD DESIGNS

MULLARD TYPE "C" TAPE-PREAMPLIFIER ERASE UNIT

The "Hi-Fi" link to add full tape recording facilities to High Fidelity home installations. Incorporates FERROXCUBE POT CORE PUSH-PULL OSCILLATOR and 3-speed treble equalisation by FERROXCUBE POT CORE INDUCTOR. FOR WEARITE—COLLARO—TRUVOX—BRENELL or MOTEK TAPE DECKS. Includes separate Power Supply Unit.

KIT OF PARTS..... **£14.0.0** or ASSEMBLED..... **£17.0.0**
H.P. £3/8/- Deposit and 12 months at £1/4/11.
(Excluding Power Unit £11/15/- and £14/10/- respectively.)

MODEL HF/TR3 TAPE AMPLIFIER



(Mullard Type "A" design)
A very high quality Amplifier incorporating 3-speed treble equalisation, using the latest FERROXCUBE POT CORE INDUCTOR. FOR COLLARO-TRUVOX-BRENELL WEARITE or MOTEK Tape Decks, has GILSEN Output Transformer. Includes separate Power Supply Unit.

KIT OF PARTS..... **£12.15.0** or ASSEMBLED..... **£16.10.0**
H.P. £3/6/- Deposit and 12 months at £1/4/2

FOR THE HOME CONSTRUCTOR SPECIAL "COMBINED ORDER" PRICES

(a) The COLLARO "STUDIO" TAPE DECK and our Mullard Type "C" PRE-AMPLIFIER and Power Unit assembled and tested **£29.10.0**
H.P. Terms: Deposit £5/18/- and 12 months at £2/3/3.

(b) As above but Type "C" PRE-AMPLIFIER supplied as complete Kit of Parts..... **£26.10.0**

(c) The COLLARO Mk. IV TAPE DECK and the MULLARD Type "C" PRE-AMPLIFIER and Power Unit assembled and tested..... **£35.0.0**
H.P. Deposit £7 and 12 months £2/11/4.

(d) As above but the Type "C" supplied as complete Kit of Parts **£32.0.0**

(e) The TRUVOX Mk. VI TAPE DECK and the assembled Type "C" PRE-AMPLIFIER and Power Unit..... **£40.0.0**
H.P. Deposit £8 and 12 months £2/18/8.

(f) As above but the Type "C" supplied as complete Kit of Parts **£36.10.0**

(g) The BRENELL Mk. V Deck and the assembled Type "C" PRE-AMPLIFIER and Power Unit..... **£46.0.0**
H.P. Deposit £9/4/- and 12 months at £3/7/6.

(h) As above, but the Type "C" supplied as complete Kit of Parts..... **£43.0.0**

(i) The WEARITE 4A DECK with Type "C" assembled and tested **£56.0.0**
H.P. Deposit £11/4/- and 12 monthly £4/2/1.
(Carriage and Insurance on above quotes 10/- extra.)

EACH OF ABOVE CAN BE SUPPLIED IN PORTABLE CASE FOR £5/10/- extra, THUS FORMING A COMPLETE PORTABLE PRE-AMPLIFIER SEND FOR DETAILS.

(a) COMPLETE KIT to build the HF/TR3 Amplifier, together with the COLLARO "STUDIO" DECK **£25.10.0**

(b) As above but HF/TR3 ASSEMBLED and TESTED H.P. TERMS: Deposit £5/16/-, 12 months of £2/2/6. **£29.0.0**

(c) COMPLETE KIT to build the HF/TR3 together with the Mk. IV COLLARO "TRANSCRIPTOR" DECK (£1 extra if we are required to wire up Deck switches.) **£30.15.0**

(d) As above but HF/TR3 ASSEMBLED and TESTED... H.P. Terms: Deposit £7, 12 months at £2/10/5. (£1 extra if we are to wire up Deck Switch Banks.) **£34.10.0**

(e) COMPLETE KIT to build the HF/TR3 together with the NEW TRUVOX Mk. VI TAPE DECK..... **£36.0.0**

(f) As above but HF/TR3 ASSEMBLED and TESTED... H.P. Terms: Deposit £7/18/-, 12 months of £2/17/11. **£39.10.0**

(g) COMPLETE KIT to build the HF/TR3 AMPLIFIER with the BRENELL Mk. V TAPE DECK..... **£41.10.0**

(h) As above but HF/TR3 ASSEMBLED and TESTED... H.P. Terms: Deposit £9, 12 months of £3/6/-. **£45.0.0**

(i) THE ASSEMBLED and TESTED HF/TR3 AMPLIFIER with the WEARITE MODEL 4A DECK, incorporates Wearite Head Lift Transformer, etc..... **£55.0.0**
H.P. TERMS: Deposit £11, 12 months of £4/0/8.
(Carriage and insurance on each above is 10/- extra.)

Attractive PORTABLE CASE is available to accommodate the TRUVOX or COLLARO TAPE DECKS and we offer it together with ROLA/CELESTION 10 x 6in. LOUDSPEAKER—ACOS CRYSTAL MICROPHONE —and 1,200ft. SPOOL E.M.I. TAPE—ALL FOR..... **£9.10.0**
(Carriage and Insurance 5/- extra.)

A LARGE PURCHASE OF BRAND NEW and FULLY GUARANTEED TRUVOX and GARRARD TAPE EQUIPMENT ENABLES THESE OUTSTANDING PRICE REDUCTIONS

THE "MODEL HF/G2R" PORTABLE TAPE RECORDER (Original Price £33.0.0)

FOR ONLY **22 GNS.** H.P. Dep. £4/14/-. 12 months £1/13/9. (Carriage and Ins. 10/- extra).

INCORPORATES THE LATEST GARRARD "MAGAZINE" TAPE DECK and MATCHING AMPLIFIER. Based on the successful MULLARD TYPE "A" DESIGN and specifically developed to operate the GARRARD DECK. PRICE INCLUDES THE GARRARD TAPE MAGAZINE and 4in. SPOOL OF DOUBLE PLAY TAPE. A Twin Track Recorder operating at 3¾in/sec. providing up to 1 hour 10 mins. playing time. The outstanding features being excellent performance and simplicity of operation. Incorporates EXT. SPEAKER SOCKET, also operates as independent amplifier for direct reproduction from P.U., mike or Radio tuner. Weighs only 22lb.

WE ALSO OFFER DECK and AMPLIFIER, CONNECTED, TESTED, FOR IMMEDIATE OPERATION, 19 gns. H.P. Dep. £4 and 12 months £1/9/4. Carriage and Ins. 10/- ex. INCLUDES SPEAKER, Tape Magazine and 4in. Spool of Double Play Tape. Comprises a complete tape recorder chassis ready for easy fitting into cabinet.

THE "MODEL TR3/Mk. IV" PORTABLE TAPE RECORDER (Original Price £49.10.0)

FOR ONLY **£36.10.0** PRICE INCLUDES A 7in SPOOL OF EMI TAPE.
H.P. Dep. £7/6/- and 12 months £2/13/6.
(Carriage and Insurance 10/- extra).

INCORPORATES THE TRUVOX Mk. IV TAPE DECK ROLA/CELESTION 9 x 5in. LOUDSPEAKER and the Truvox Type "K" AMPLIFIER specifically developed by Truvox Ltd. to correctly operate their Mk. IV Tape Deck. This combination affords first-class tape recording facilities.

A Twin Track Two Speed model operating at 3¾ and 7½in./sec. Incorporates SAFETY BUTTON (prevents accidental erasure).

TONE and VOLUME CONTROLS, also operates as independent AMPLIFIER for direct reproduction from P.U., mike or Radio tuner.

WE ALSO OFFER THE DECK and AMPLIFIER AS FOLLOWS: Mk. IV TAPE DECK, £16/10/-. H.P. Deposit £3/6/-. 12 months £1/4/3. TYPE "K" AMPLIFIER, £15. H.P. Deposit £3. 12 months £1/2/9. COMBINED ORDER FOR BOTH DECK AND AMPLIFIER, £30. H.P. Deposit £6. 12 months £2/4/-.

STERN RADIO LTD. DEPT. W. 109 FLEET ST., LONDON, E.C.4
Telephone: FLEET STREET 5812/3/4

FULLY DESCRIPTIVE LEAFLETS ON ALL OF ABOVE ARE AVAILABLE—BUT PLEASE ENCLOSE S.A.E.

STERN'S MULLARD DESIGNS

COMPLETE KIT OF PARTS

Designed by MULLARD—presented by STERNS strictly to specification

MULLARD "5-10" MAIN AMPLIFIER

For use with the MULLARD 2-stage pre-amplifier with which an undistorted power output of up to 10 watts is obtained. We supply SPECIFIED COMPONENTS AND NEW MULLARD VALVES including PARMEKO MAINS TRANSFORMER and choice of the latest Ultra-linear PARMEKO or the PARTRIDGE Output Transformer.

Price: COMPLETE KIT (Parmeko O/put Trans.)..... **£10.0.0**

Alternatively we supply ASSEMBLED AND TESTED.... **£11.10.0**

ABOVE INCORPORATING PARTRIDGE OUTPUT TRANSFORMER £1/6/- extra.

MULLARD'S 2-VALVE PRE-AMPLIFIER TONE CONTROL UNIT

Employing two EF86 valves and designed to operate with the Mullard MAIN AMPLIFIER but also perfectly suitable for other makes.

Supplied strictly to MULLARD SPECIFICATION and incorporating:

- Equalisation for the latest R.I.A.A. characteristics.
- Input for Crystal Pick-ups and variable reluctance magnetic types.
- Input (a) Direct from High Imp. Tape Head. (b) From a Tape Amplifier or Pre-Amplifier.
- Sensitive Microphone Channel. ● Wide range BASS and TREBLE Controls.

Price: COMPLETE KIT OF PARTS **£6.6.0** ASSEMBLED AND TESTED **£8.0.0**

COMPLETE MULLARD 5-10 AMPLIFIER

The popular and very successful complete "5-10" incorporating Control Unit providing up to 10 watts high quality reproduction.

Specified components and new MULLARD VALVES are supplied including PARMEKO MAINS TRANSFORMERS and choice of the latest PARMEKO or PARTRIDGE ULTRA Linear Output Transformers.

Price: COMPLETE KIT. Parmeko Transformer..... **£11.10.0**

Alternatively we supply ASSEMBLED AND TESTED. **£13.10.0**

Hire Purchase (Assembled Amp. only). Deposit £2/14/-, 12 months at 19/10.

ABOVE incorporating PARTRIDGE OUTPUT TRANSFORMER £1/6/- extra.

PRICE REDUCTIONS

(a) The COMPLETE KIT OF PARTS to build both the "5-10" Main Amplifier and the 2-Stage Pre-Amplifier Control Unit..... **£15.15.0**

(b) The "5-10" and the 2-Stage Pre-Amplifier both Assembled and Tested..... **£18.18.0**
H.P. TERMS: Deposit £3/16/- and 12 months of £1/7/8.

(c) The COMPLETE KIT OF PARTS to build the Dual Channel "3-3" Amplifier and the Dual Channel Pre-Amplifier Control Unit..... **£21.10.0**

(d) The Dual Channel "3-3" Amplifier and the Dual Channel Pre-Amplifier Control Unit both Assembled and Tested..... **£25.0.0**
H.P. TERMS: Deposit £5 and 12 months of £1/16/8.

(e) The COMPLETE KIT OF PARTS to build one "5-10" Main Amplifier (Parmeko Transformer) and the Dual Channel Pre-Amplifier Control Unit **£21.10.0**

(f) One "5-10" Amplifier (Parmeko Transformer) and the Dual Channel Pre-Amplifier both Assembled and Tested..... **£25.0.0**
H.P. TERMS: Deposit £5 and 12 months of £1/16/8.

(g) COMPLETE KIT OF PARTS to build Two "5-10" Main Amplifiers (incorporating Parmeko Output Transformers) and the Dual Channel Pre-Amplifier Control Unit..... **£31.0.0**

(h) Two "5-10" Amplifiers (Parmeko Output Transformers) and the Dual Channel Pre-Amplifier Control Unit both Assembled and Tested..... **£36.0.0**
H.P. TERMS: Deposit £7/4/- and 12 months of £2/12/-. Carriage and insurance 7/6 extra.

Prices quoted are subject to £1/6/- extra for Partridge Trans.

MULLARD FOUR CHANNEL MIXING UNIT

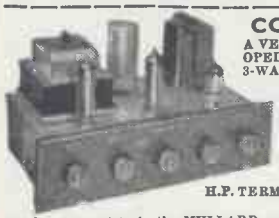
Self powered with Cathode follower output. Incorporates Two inputs for CRYSTAL MICROPHONES, one for CRYSTAL PICKUPS and a Fourth for Radio or Tape.

KIT OF PARTS **£8.8.0** ASSEMBLED AND TESTED **£10.0.0**

Terms: Deposit £2 and 12 months at 15/-.

Model I.L. one microphone input matched for moving coil or ribbon mike £1/17/- extra.

COMPLETE MULLARD 3-3



A VERY HIGH QUALITY AMPLIFIER DEVELOPED FROM THE VERY POPULAR 3-VALVE 3-WATT AMPLIFIER DESIGNED IN THE MULLARD LABORATORIES.

Price for COMPLETE KIT OF PARTS **£7.10.0**
(Plus 6/6 carriage and insurance).

Alternatively supplied ASSEMBLED AND FULLY TESTED (Plus 6/6 carriage and insurance).... **£8.19.6**

H.P. TERMS: Deposit £2 and 8 monthly payments of £1.

Our kit is complete to the MULLARD specification including supply of specified components, valves and PARMEKO OUTPUT TRANSFORMER. We also include switched inputs for 78 and L.P. records plus a Radio position. Extra power to drive a Radio Tuning Unit is also available.

STEREO "3-3" MAIN AMPLIFIER

Comprises two MULLARD 3-3 Main Amplifiers on one chassis. Operates with MULLARD STEREO PRE-AMPLIFIER. Output power 6 watts. Inputs for Crystal Pick-up and Radio Tuner.

KIT OF PARTS..... **£10.0.0** or ASSEMBLED..... **£11.15.0**

COMPLETE STEREO AMPLIFIER

Meets the many requests for a low priced but good quality Stereophonic Amplifier. Output power is 4 watts. Inputs for Crystal Pick-ups and Radio Tuner.

KIT OF PARTS..... **£8.10.0** or ASSEMBLED..... **£10.10.0**

Mk. II "Fidelity" FM TUNING UNIT

An attractively presented Unit incorporating MULLARD PERMEABILITY TUNING HEART and corresponding Mullard valve line-up. Very suitable to operate with our Mullard Amplifiers.

FOR THE CONSTRUCTOR.... **£10.10.0** or ASSEMBLED.... **£14.5.0**

STEREO DUAL CHANNEL PRE-AMPLIFER

This model incorporates two 2-valve Pre-Amplifiers (described above) combined into a Single Unit enabling it to be used for both STEREOPHONIC and MONAURAL operation. It is designed primarily to operate with our range of MULLARD MAIN AMPLIFIERS but will also operate equally well with any make of Amplifiers requiring an input of 250 m/v.

Price: COMPLETE KIT OF PARTS **£12.10.0** Alternatively ASSEMBLED and TESTED **£15.0.0**

H.P. Terms on assembled unit: £3 Deposit and 12 months of £1/2/-.

SPECIAL CASH ONLY OFFER ! !

This very attractive PORTABLE AMPLIFIER CASE together with a good quality GRAM AMPLIFIER and a matched P.M. SPEAKER. ALL FOR ONLY **£8.7.6** (plus 7/6 carr. and ins.). The Amplifier consists of a 2-stage design incorporating the 3 modern BVA valves and has separate BASS and TREBLE CONTROLS. The Portable Case will also accommodate almost any make of Autochanger and is attractively finished in Grey Colour Rexine—WE ALSO SUPPLY SEPARATELY:—

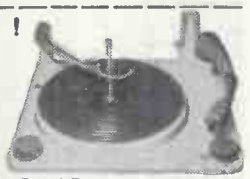
(a) The 2-stage (plus Rectifier) AMPLIFIER £4 2 6

(b) The PORTABLE CARRYING CASE £3 17 6

(c) 6½in. P.M. SPEAKER.... 18 9

(Carriage and Insurance 4/- extra)

! ! RECORD PLAYERS ! !



The LATEST MODELS are in Stock. Many at REDUCED PRICES ! ! !

Send S.A.E. for ILLUSTRATED LEAFLET

B.S.R. MONARCH UA8 4-spd. Mixer Autochanger with Crystal Pick-up **£6.19.6**

The COLLARO "CONQUEST" 4-spd. Autochanger, Studio "O" Pick up **£7.10.0**

The NEW COLLARO Model RP594, 4 speed Single Record Player, Studio Cartridge **£9.18.9**

The COLLARO 4-speed Single Record Player, incorporating the Studio "O" Pick-up **£6. 9.6**

THE NEW B.S.R. Model UA12 is in stock. A 4-"SPEED" MIXER AUTOCHANGER **£8. 7.6**

UA12 is also available incorporating the B.S.R. STEREO Pick-up, plays L.P. and 78 records. **£10.10.0**

GARRARD RC210 4-speed Autochanger fitted with latest Crystal Pick-up **£10.10.0**

The latest GARRARD TRANSCRIPTION MOTOR "301" **£22.7.3**

The new GARRARD Model 4HF High Quality Single Record Player fitted with the latest T.P.A.12 Pick-up arm and G.C.S.Crystal Cartridge **£18.7.6**

GARRARD Model TA/MK. II Single Record Player fitted with high output Crystal Pick-up, detachable head..... **£8.10.0**

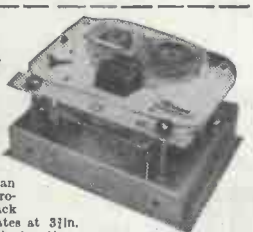
HIRE PURCHASE TERMS available on all units £8/19/6 and over Carriage and insurance on each above 5/- extra.

"Hi-Fi" LOUDSPEAKERS

WE HAVE IN STOCK A COMPLETE RANGE BY GOODMANS—WHARFEDALE—W.B.

ILLUSTRATED AND PRICED LEAFLETS ON REQUEST

THE "ADD-A-DECK"



INCORPORATING GARRARD "MAGAZINE" TAPE DECK and the MATCHED MODEL HF/G2P PREAMPLIFIER. Supplied on ONE CHASSIS (as illustrated) READY FOR USE.

PRICE: Including GARRARD MAGAZINE and 4in. SPOOL DOUBLE PLAY TAPE (Carr. & Ins. 10/- extra). **18 gns.**

H.P. Deposit £3/16/- and 12 months of £1/7/8.

Provides complete tape recording facilities and designed to operate through the pick-up sockets of the standard type of RADIO RECEIVER, or an AMPLIFIER, from which really first class reproduction is obtained. It consists of a Twin Track Deck connected to the Pre-amplifier and operates at 3¾in./sec. speed, providing up to 1 hour 10 mins. playing time. Only needs connecting to the mains supply and pick-up sockets. Very simple to operate and easily installed in a cabinet, only four fixing screws being required.

! ! HOME CONSTRUCTORS ! !

A RANGE OF "EASY TO ASSEMBLE" PREFABRICATED CABINETS

Designed by the W.B. "STENTORIAN" COMPANY for "Hi-Fi" Loudspeaker systems or to accommodate high quality equipment. The acoustically designed Bass Reflex Cabinets containing the very successful "Stentorian" speakers give really first-class reproduction and are well recommended. Models are also available to accommodate high-quality Amplifiers, Pre-amplifier, Tuning Units, Record Players, etc. All models are very easily assembled, in fact only a screwdriver is required.

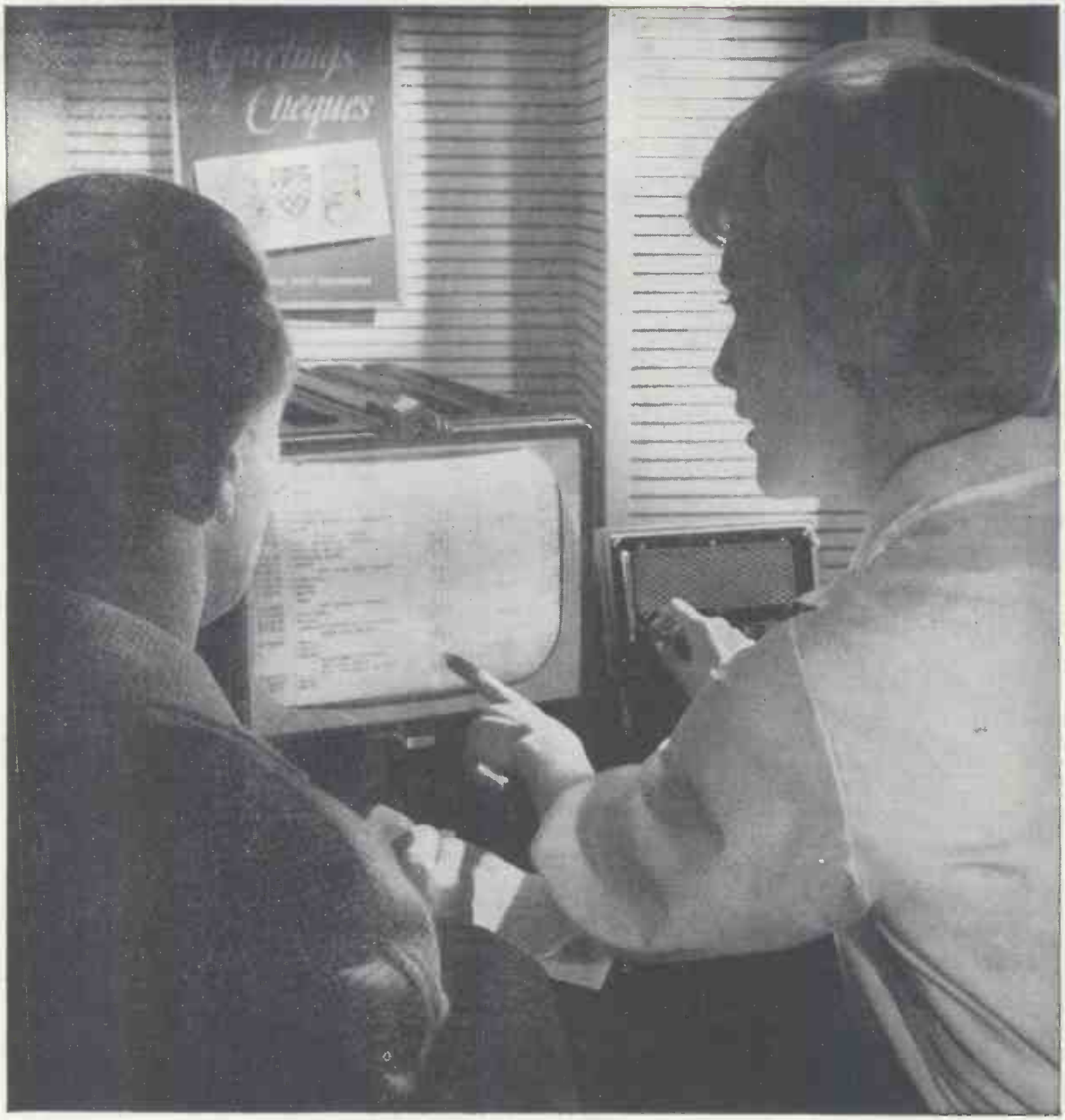
Fully illustrated leaflets are available, including complete specifications of the various STENTORIAN LOUDSPEAKERS. Please enclose S.A.E.

H.P. TERMS ARE AVAILABLE ON ALL EQUIPMENT OVER £9. FULLY DESCRIPTIVE LEAFLETS ARE AVAILABLE FOR ALL EQUIPMENT, BUT PLEASE SEND S.A.E.

STERN RADIO LTD.

DEPT. W. 109 FLEET ST., LONDON, E.C.4

Telephone: FLEET STREET 5812/3/4



Westminster Bank uses Pye Television

The Pye Industrial TV Division, a member of the Pye Instrument Group, has supplied all the television equipment to the Westminster Bank for the first inter-branch TV network. The new system which makes centralised book-keeping possible has been brought about by the closest co-operation with the GPO who have supplied Post Office lines to carry the signals. The illustration shows a customer checking his banking account.

The Pye Instrument Group consists of: Pye Atomics Division, Pye Industrial Television Division, Faraday Electronic Instruments Ltd., Labgear Ltd., W. G. Pye & Co. Ltd., Pye Telecommunications Ltd., Unicam Instruments Ltd., W. Bryan Savage Ltd., W. Watson & Sons Ltd.

"BELLING-LEE" NOTES

No. 25 of a Series

Voltage Rating

The voltage rating of an electrical component is one of several parameters defining its conditions of use. It is usually determined by the electrical strength of the materials and parts of which the item is constructed, the limiting factor being the value of the lowest rated ingredient. However, other considerations sometimes govern the rating, such as the safety of the users, or the nature of the application for which the component is intended.

Thus we find in the case of a certain class of fuseholder that two alternative lids are available to permit their use on 250 volt or 440 volt supplies, although from the point of view of electrical breakdown there is nothing to choose between them. The only difference lies in their physical size, the one for use at the higher voltage being much larger than the other in order to provide adequate protection to the fingers of the user so that they cannot possibly come into too close proximity to live metal parts. However, as unnecessary size can be inconvenient, the smaller lid is provided for use in circumstances where the danger is less. On the other hand, it is common practice to rate terminals entirely on considerations of electrical breakdown, leaving it to the equipment designer to take whatever precautions he thinks necessary in the interests of safety. The same sort of thing applies to plugs and sockets, and it must not be assumed from the voltage rating alone that a particular connector is suitable for mains use unless B.S.S.415 is referred to; this defines the general requirements of safety for mains connectors in terms of shielding, creepage distances, etc.

Some components, which are themselves only part of a unit, may be rated in terms of the lowest rated member of the overall device; thus a fuseholder may be rated in relation to the fuse-links which are immediately available for use in it, rather than by electrical considerations of the fuseholder alone. It may be argued that this is logical, but who knows whether fuse-links of higher voltage rating may one day become available? It has happened already in the case of the size "O" (1¼in. × ¼in.) with the introduction of the heavy duty type for 440 volt circuits, whereas the standard light duty variety is restricted to 250 volts.* The real rating of the fuseholder may be determined largely by its sheer physical dimensions, and it may be suitable for the higher voltage without in any way being over-designed.

Other components may be rated according to their applications, and this applies in the case of the familiar 3-pole, flat pin connectors rated at 80 volts; from purely electrical considerations obviously they will withstand considerably higher pressures. However, they were designed essentially for use in audio signal circuits where voltages are not likely to exceed this figure, and it is a feature of the design that they cannot be interchanged with standard mains connectors, making it impossible to insert the plugs into mains outlets by mistake with the obvious danger which would ensue to the user and the appliance.

Ratings may be given in terms of D.C., A.C., or peak voltages, and if the condition is not specified, it is advisable to enquire which applies. The stresses imposed on an insulator by an alternating supply are quite different from those under steady conditions, and we are not thinking simply of the peak value of the alternating supply so much as the repetitive reversal of loading, and the dielectric current. In other words, even with an unpolarised component it is not necessarily safe to divide a D.C. rating by $\sqrt{2}$ and assume that the result is the permissible A.C. loading.

It must also be remembered that the voltage rating of a component is related to specific environmental conditions, for humidity, temperature and pressure all exert a considerable influence, and so also can the frequency of the supply, and, of course, high frequency radiation starting with frequencies in the visible spectrum (photo-electrical effects). It can be seen, therefore, that voltage ratings must be interpreted very carefully, with full knowledge of the context, and all the practical conditions of application.

*The voltage rating of a fuse-link is governed by the rupturing conditions which it can withstand, that is to say the intensity of the arc which it can handle on blowing (see "Notes on Fusing," section 4).

FREE. The series of notes on "Fusing" is now complete and, in response to many requests, will shortly be reprinted for issue as a booklet. Please write if you would like a copy, if you have not already done so.

Aspects of design

31

19 AND 23 INCH TELEVISION CR TUBES

This is No. 31 of a series of articles dealing with advanced problems in circuit design published by The Ediswan Mazda Applications Laboratory. No. 32 will appear next month. We will be pleased to answer queries arising from this or other articles. Reprints of the first twenty-four articles, in booklet form, are available on request.

British television receivers have used 17 and 21 inch C.R. tubes with 110° deflection for some considerable time. They were originally introduced for the purpose of decreasing cabinet depth, thereby enabling better overall styling to be achieved. Their introduction, however, created a number of problems, particularly in respect of the design of the bulb. The more an evacuated bulb departs from a spherical form the more difficult it becomes to make it strong enough to withstand the external pressure of the atmosphere. To provide a bulb of the necessary strength which could be manufactured by the usual CRT bulb production techniques and also to simplify scanning problems, the faceplates of the 110° tubes were given a smaller radius of curvature than those of corresponding tubes of 90° deflection angle. In addition, the back of the bulb was given considerable curvature and the sides and corners of the faceplate were also rounded. This gave a picture which departed considerably from a true rectangular shape.

The new Ediswan Mazda CME1901 and CME2301 (19 and 23 inch) tubes have been developed with the main object of improving the picture presentation. The face has been made more nearly rectangular and its radius of curvature has been increased making it flatter. Although the picture height and width have only increased slightly, compared with 17 and 21 inch tubes, the straighter sides and lesser curvature at the corners of the face have resulted in a greater picture diagonal and added picture information previously lost in the corners. See Fig. 1.

Techniques and materials for producing scanning coils for 110° tubes are readily available, so new tubes should be designed to use coils which do not depart, radically, from existing coils. The CME2301 is designed to give a diagonal deflection angle of 110° with the external contours of the glass in the scanning coil region identical with previous types.

In the CME1901, which is the tube most likely to be used in transportable receivers, where space is at a premium, the diagonal deflection angle has been increased to 114°. This results in a bulb length, from the reference line to the front of the face, which is only slightly greater than that of previous 17 inch tubes. Due to the fact that the face of the new CME1901 is more nearly rectangular than that of previous 17 inch tubes, the increase of diagonal scanning angle from 110° to 114° is not accompanied by a corresponding increase in the horizontal and vertical scanning angles; in fact, it will be found that the scanning power requirements for the new tube are practically identical with its 17 inch predecessor. Slightly less scanning power is required in the CME2301 than in its 21 inch predecessor.

To avoid substantial changes from the scanning coil winding shapes previously used with 110° tubes, the external mechanical contours of the glass in the scanning coil region on the CME1901 have been made identical with its predecessor. See Fig. 2. The increased deflection angle of 114° has been accommodated by removing glass from the inside of the neck at the point of closest approach of the electron beam.

Thus, the inside of the neck-to-bulb flare has a fluted form with longitudinal grooves corresponding to the corners of the picture. The 114° deflection angle and the flatter face of the CME1901 tube, mean that with the scanning coils designed for the 17 inch predecessor the CME1901 will give some pincushion distortion. This also applies, in somewhat less degree, to the CME2301. It is possible, however, to design common scanning coil assemblies for both types of tube, the differences between the 114° and 110° deflection angles being taken up by changing the picture-shape correction magnets. Both new designs of tubes will employ magnetic cores of the original form and dimensions.

When using a tube with a faceplate radius of curvature much greater than the distance from screen to deflection centre, it is necessary to arrange for the rate of change of current in the scanning coils to be lower at the beginning and end of a deflection stroke than in the middle. This corrects the tendency for the linear velocity of the scanning spot to be greater at the sides of the picture than in the centre. This technique has been employed since the introduction of 90° tubes. The greater radii of curvature of the CME1901 and 2301 tubes call for slightly more linearity correction than the previous 17 and 21 inch types.

Both CME1901 and 2301 are fitted with unipotential electron guns designed to give good uniformity of focus over the whole of the tube face, despite the increased radius of curvature. Optimum performance is obtained with a first-anode voltage of approximately 450 V.

Under these conditions the normal production variations in voltage required by the third anode for best focus can be accommodated within the range of voltages normally available in a television receiver. These tubes are not critical to small changes in focus voltage and sufficient adjustment to take up production variations can usually be provided by four fixed tapping points between the chassis and the boosted HT line.

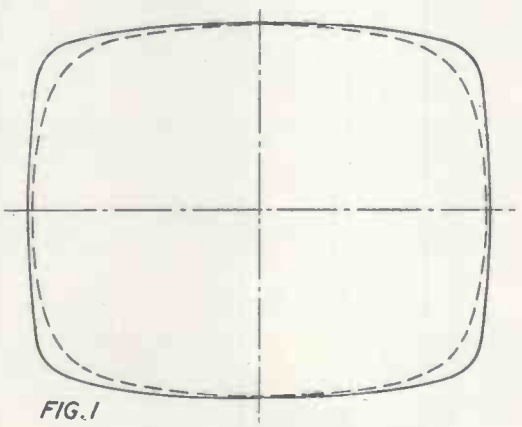


FIG. 1

Comparison of outlines of faceplates of CME2301 and CME2101 (dotted)

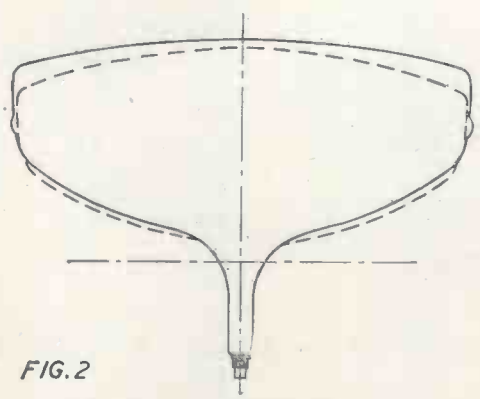


FIG. 2

Comparison of outlines of bulb shapes of CME2301 and CME2101 (dotted)

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Technical Service Department
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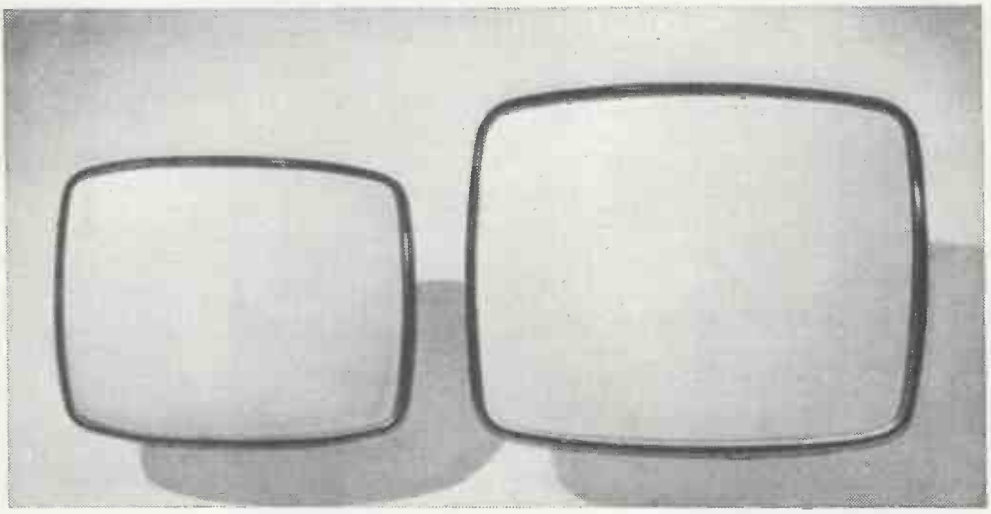
NEW 19" AND 23" TELEVISION CATHODE RAY TUBES



EDISWAN MAZDA TYPES CME1901 AND CME2301

The CME1901 and CME2301 are, respectively, 19in. and 23in. cathode ray tubes using magnetic deflection and electrostatic focus. The diagonal deflection angle of CME1901 is 114° and that of CME2301 is 110°. The shape of these tubes differs from the shape of conventional 110° tubes in that the face plates are more nearly rectangular. In addition the radii of curvature of the faces of the 19in. and 23in. tubes are greater than those of the 17in. and 21in. tubes. These changes result in a more pleasing presentation of the picture.

The external shape of the glass in the deflection region of these tubes is identical to that of conventional 110° tubes, enabling coils with conventional 110° internal mechanical contours to be used.

With equal values of final anode voltage, beam deflection in the CME1901 and CME2301 can be carried out with no more power consumption than in the CME1703 and CME2101.

GENERAL DETAILS

Rectangular face	Aluminised screen
Electrostatic focus	Silver activated phosphor
Magnetic deflection	Grey glass
Straight gun — non ion trap	External conductive coating
Heater for use in series chain	

Heater Current (amps)	I_h	0.3
Heater Voltage (volts)	V_h	12.6

TENTATIVE RATINGS AND DATA

Design Centre Ratings		CME1901	CME2301
Maximum Second and Fourth Anode Voltage (kV)	$V_{a_2,a_4(max)}$	17	17
Minimum Second and Fourth Anode Voltage (kV)	$V_{a_2,a_4(min)}$	14	15
Maximum Third Anode Voltage (volts)	$V_{a_3(max)}$	±700	±700
Maximum First Anode Voltage (volts)	$V_{a_1(max)}$	500	500
Maximum Heater to Cathode Voltage—Heater Negative d.c. (volts)	$V_{h-k(max)}$	180	180

Inter-electrode Capacitances (pF)		CME1901	CME2301
Cathode to All*	C_{k-all}	5	5
Grid to All*	C_{g-all}	8	8
Final Anode to External Conductive Coating (approx.)	C_{a_2,a_4-M}	1500	2000

*Inter-electrode capacitances including AEI "Clix" B8H holder VH68/81 (8 pin).

TYPICAL OPERATION

		CME1901	CME2301
Second and Fourth Anode Voltage (kV)	V_{a_2,a_4}	16	16–17
First Anode Voltage (volts)	V_{a_1}	450	450
Third Anode Voltage for Focus-Mean (volts)	$V_{a_3(av)}$	180	180
Grid Bias for cut-off of Raster (volts)		38 to 72	38 to 72
Average Peak to Peak Modulating Voltage for Modulation up to 350μA (volts)		34.5	34.5

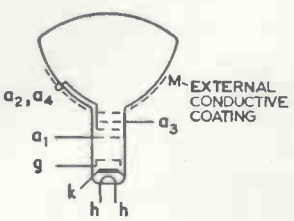
Note: All voltages given with respect to the cathode.

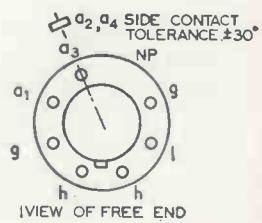
Maximum Dimensions (mm)	CME1901	CME2301
Overall Length	322	386
Face Diagonal	476†	598†
Face Width	420†	524†
Face Height	342†	422†
Neck Diameter	29.4	29.4

†The maximum dimension at the face seal may be 3.5 mm larger than this dimension but at any point around the seal the bulge will not protrude more than 2 mm.

Tube Weight (lb.)	CME1901	CME2301
Nett (approx.)	13.5	27

Side Contact: CT8 (Cavity) **Base:** B8H





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The playback amplifier may be used as a microphone or gramophone amplifier separately or whilst recording is being made.

The meter fitted for reading signal level will also read bias voltage to enable a level response to be obtained under all circumstances. A control is provided for bias adjustment to compensate low mains or ageing valves.

The power output is 4 watts heavily damped by negative feedback and an oval internal speaker is built in for monitoring purposes.

THE VORTEXION W.V.B. or W.V.A/S

are eminently suitable for making a high quality recording almost indistinguishable from the original since these models have facilities for monitoring the recording actually put on the tape with only a fraction of a second delay.

By this means, when for any reason the signal is distorted or not as required, the result of the recording on the tape can be heard almost instantly, and adjustments can be made until the results are as required.

Many types of music today have the treble boosted considerably, and may result in greater power being recorded at high frequencies than at middle frequencies, an overload of the tape at high frequencies gives a mushy quality with lots of hiss and background noise.

Adjustment to the bias level while listening to the result is useful in this connection especially where the brand of tape and the bias setting for it are not exactly known.

Again if clean treble recordings at $3\frac{3}{4}$in. are of prime importance it is now recognised that no other method is quite so effective in achieving this as reducing the bias slightly while listening to the results. The meter reading of the new bias setting for the particular tape used may be noted for future use.

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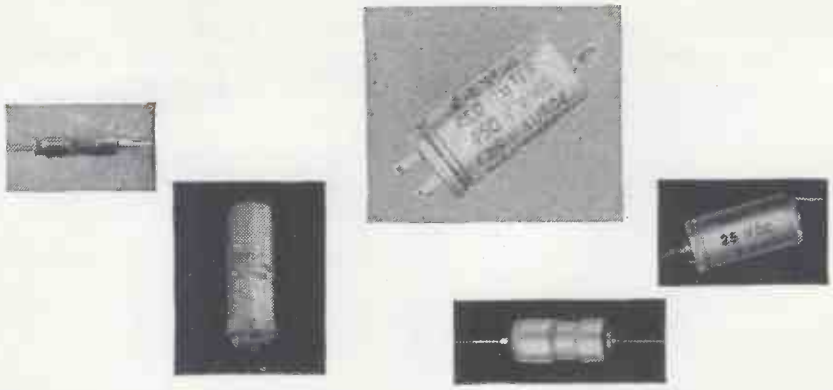
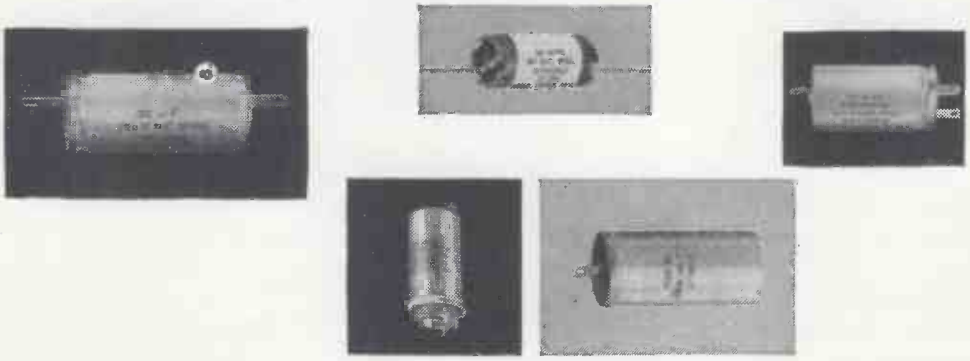


Capacitorability



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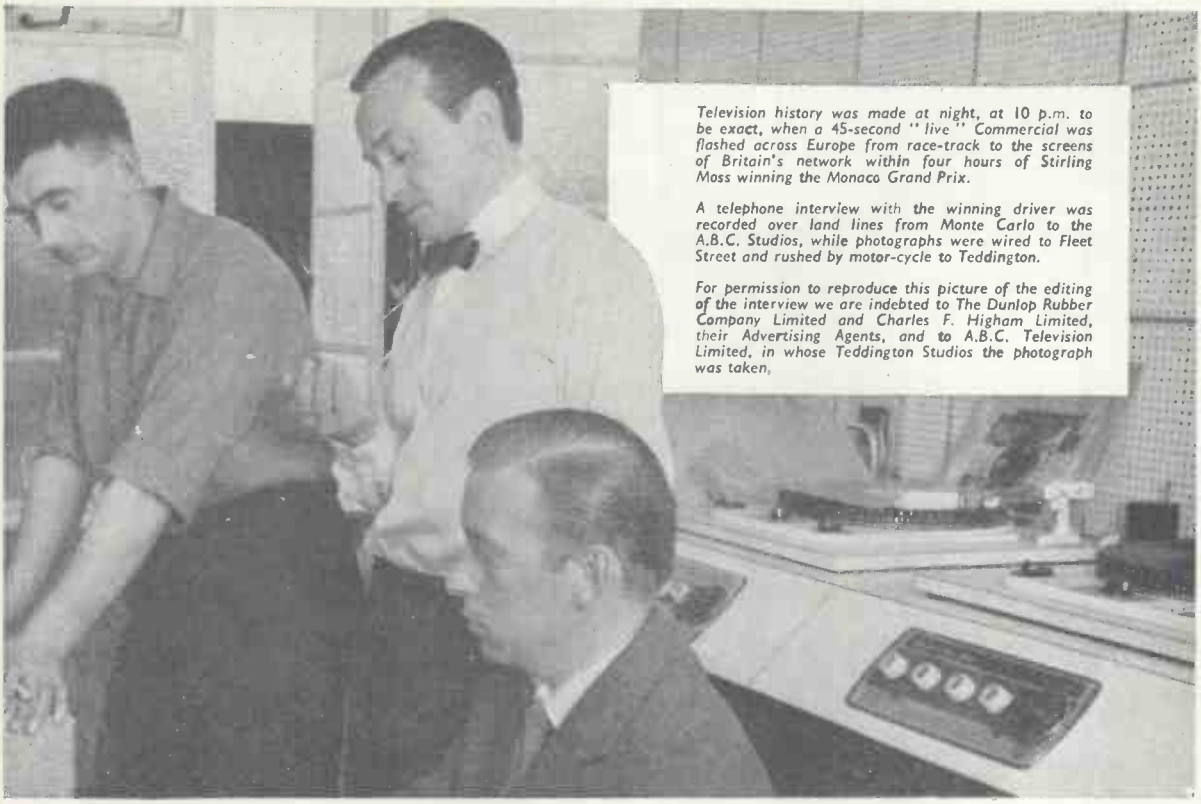

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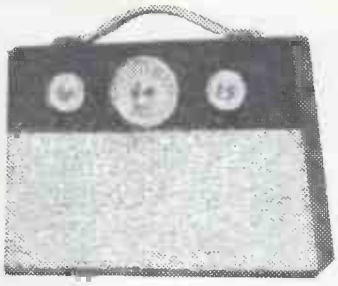

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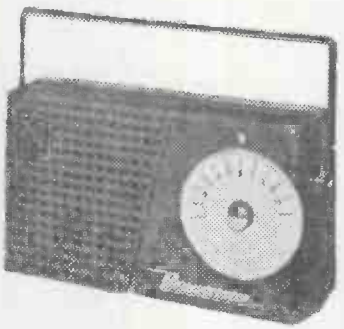

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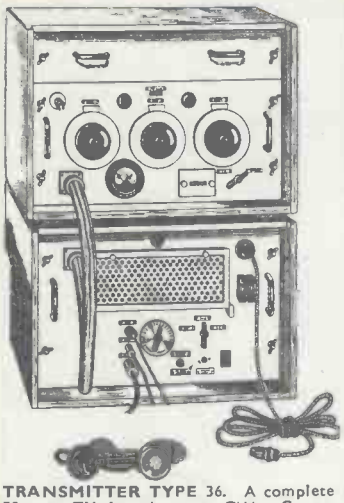

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G.E.C., sealed, wire ends, 670 2M2B H/D M1095..... **8/6**
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G.E.C., sealed, wire ends, 5,000Ω 2 c/o., plat., M1052 **17/6**
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Contains 100 ½ and 1 watt resistors, 50 Hi Stab resistors, wire wound resistors, carbon and W/W pots, 100 capacitors (mica, paper, Sprague, bias, variable, etc.), valveholders, tag strips, metal rectifiers, sleeving etc. All components are unused. **GUARANTEED VALUE.** 25/- plus 2/6 post.

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A crystal controlled heterodyne wavemeter covering 500 Kc/s. to 10 Mc/s. (Harmonics up to 30 Mc/s.) Requires 300 V. 15 mA. and 12 V. 0.3 a. D.C., but can be easily modified for 120 V. and 1.4 V. working. Size 7 x 7½ x 4in. Good condition, complete with valves, crystal, instruction manual and circuit. ONLY **59/6.** Post 3/6.

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PRECISION RESISTORS. 1 Megohm. 1% 1 watt wire wound, Ex-U.S.A. BRAND NEW. **10/6** per dozen.

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R.C.A. 0-500 microamps. 2½in. circular flush panel mounting. Dials are engraved 0-15, 0-600 volts. As used in the American version of the No. 19 set. BRAND NEW. Boxed. **15/-.**

American 0-100 microamps. 2½in. square flush panel mounting. BRAND NEW. Boxed. **42/6.**

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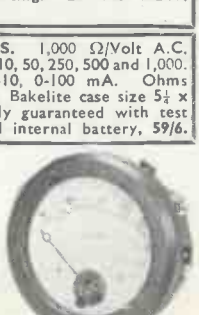
0-300 volts, 25-100 c/s. Moving iron, 6in. scale. Fl. mtg. Hermetically sealed, grade 1N. Made 1955. BRAND NEW. Boxed. **79/6.** Post 3/6.



RCA AR88D RECEIVERS

One of the most renowned American Communications Receivers ever manufactured. Widely used by all the Armed Services to maintain World-wide Communications and Monitoring Posts under all conditions. Employs 14 valves, and has 6 switched overlapping wave bands for complete coverage. Refinements include Mechanical Band Spread with Logging Scale, Automatic or Manual Volume Control. Automatic or Manual Noise Limiter, BFO with pitch control, RF and AF Gain Controls, Variable HF Tone Control, Variable Selectivity with Crystal Filter, Aerial Trimmer, Choice of Headphones or Speaker. Has internal mains power pack for nominal 115-230 volts A.C. In Black Crackled Case size 19½in. W. x 11in. H. x 19½in. D. Thoroughly reconditioned, immaculate in appearance, and in perfect working order. Covers 500 kc/s-32 Mc/s, price (add carriage 30/- and 50/- deposit on returnable transit case). **£45**
S.A.E. brings illustrated descriptive leaflet.

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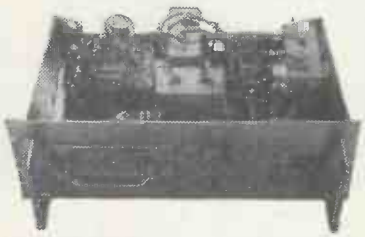
A.C. MAINS POWER PACK OUTPUT STAGE in black metal case to match receiver, enabling it to be operated immediately, by just plugging in, without any modification. Fitted with 8in. P.M. speaker **£6/10/-. DEDUCT 10/- IF PURCHASING RECEIVER AND POWER PACK TOGETHER.**
Send S.A.E. for illustrated leaflet, or 1/3 for 14-page booklet which gives technical information, circuits, etc., and is supplied free with each receiver. Add carriage 10/6 for Receiver, 5/- for Power Unit.

POWER UNITS TYPE 234



Primary 200/250 v. 50 cycles. Outputs of 250 v. 100 mA., and 6.3 v. 4 amps. Fitted double smoothing. For normal rack mounting (or bench use) having grey front panel size 19in. x 7in. ONLY 59/6 (carriage, etc., 7/6). Or fitted with 2½in. A.C. volts output meter, 79/6 (plus carr. as above).

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Frequency range 125-20,000 kc/s. in 2 bands. This is the United States Navy Model of the well-known BC.221 Frequency Meter, but has many additional features which increase its usefulness. Voltage stabilisation circuits and Crystal control ensure extreme accuracy and in addition it is fitted with an Internal Modulation switch to allow use as a Signal Generator. Size only 8½in. x 8in. x 8½in. Full information on request.

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Reads A.C. and D.C. Volts up to 1,000 in 5 ranges at 1,000 o.p.v., D.C. Current (3 ranges) to 500 mA. Resistance readings to 200 Kohms in 2 ranges. Basic movement 300μA sensitivity. Easily read open scale. Dimensions 5½in. x 3½in. x 2½in. Beautifully made, and fully guaranteed. Complete with leads, prods and internal battery. ONLY **59/6**

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Crystal controlled heterodyne frequency meter covering 100 kc/s to 20 Mc/s. in 8 switched bands and is virtually the British BC221. Power requirements 2 v. L.T. and 40-60 volts H.T. Complete with Calibration Book, Crystal, Operating Valves and full set of spares. BRAND NEW IN ORIGINAL TRANSIT CASES. ONLY £9/19/6 (carriage 15/-).

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F.S.D.	SIZE AND TYPE			PRICE
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50 microamps	D.C.	2½in. Flush	circular	59/6
50 microamps	D.C.	3½in. Flush	circular	80/-
100 microamps	D.C.	2½in. Flush	circular	39/6
1 milliamp	D.C.	2in. Flush	square	22/6
1 milliamp	D.C.	2½in. Flush	circular	30/-
1 milliamp	D.C.	2½in. Flush	circular	25/-
1 milliamp	D.C.	3½in. Flush	circular	50/-
200 milliamp	D.C.	2½in. Flush	circular	12/6
20 amps	D.C.	2in. Proj.	circular	7/6
40 amps	D.C.	2in. Proj.	circular	7/6
5 amps	D.C.	2in. Flush	square	12/6
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A First Grade Moving Iron Instrument with 6in. Mirror Scale, reading up to 150 volts A.C. at 400 and 1,500-2,400 cycles. In substantial Oak case with removable lid, overall size 8½in. x 8½in. x 5½in. Recently made for the Air Ministry, by Everett Edgcumbe, and in perfect order. Brand New & Unused. ONLY **£7/10/-**. Can also be supplied for 50 cycles, use either 0-150 or 0-300 volts.

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12 VOLTS AMERICAN DYNAMOTOR. Delivers 220 volts at 100 mills. Size 5½ x 3½in. diameter. Ideal for running Radio and Electric Shaver etc., from car battery. ONLY 32/6.

MARCONI SIGNAL GENERATOR TF 1440/7. Coverage 85 kc/s.-2.5 Mc/s. and 8 Mc/s.- 70 Mc/s. Complete, and in AS NEW CONDITION. ONLY £95.

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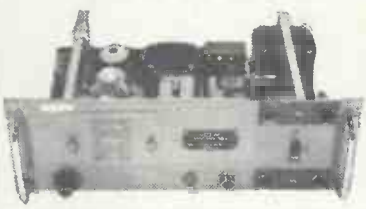

Utilises 4 valves, 1 each 5Z4G, 6V6G, 6J7G, 6J5G and high quality components such as "C" Core Transformers and Block Paper Smoothing Condensers. A.C. Mains Pack for nominal 110 x 230 volts. Provision for 600 ohms or High Impedance Input. Output to 600 ohm Line. For normal use only requires changing Output Transformer. Output approximately 4 watts. Designed for Standard Rack Mounting, having grey front panel size 19in. x 7in. All connections to rear panel, front having "On/Off" Switch Gain Control, Indicator Light. Fuses and Valves Inspection Panel. BRAND NEW IN MAKER'S PACKING. ONLY £4/9/6 (carriage 10/6).

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SEVEN TRANSISTOR SUPERHET

★ PRE-BUILT UNITS ★

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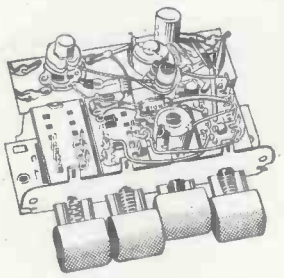

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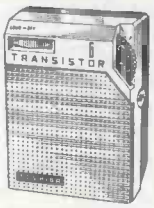
Size 3 x 2¼ x ⅞in.

THE WORLD'S SMALLEST RADIO

FITS INTO VEST POCKET OR PURSE



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STEREO RECORD PLAYER AMPLIFIER

New high-gain circuit with full tone, balance and volume controls. Can be used with all types of records as well as stereo.

★ 2 WATTS PEAK PER CHANNEL
★ ECC83; 2-ECL82 VALVES
★ MAINS 110/250V A.C.

Complete with speaker sockets, calibrated dials, etc. **£5.7.6**
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and
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2—OC45
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1—OC71
1—OC81D
2—OC81

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Coupled high gain circuit. Size 3 x 2 x ¾in., including mic. and battery.
All parts with earphone. 79/6. P.P. 1/-.

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Two transistor push-pull output stage. For use with Ranger-3 or similar. Includes Elac 3in. speaker.
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Crystal controlled oscillator. Uses fundamental crystals of FT243, 10X, R76, etc.
All parts (less crystal). 20/-. P.P. 1/-.
Crystals from 5/-. See separate list.
Ideal for frequency check or BFO.

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With two transistors and light sensitive cell. Operates from 12 to 18 volts. Includes relay. Size 3 x 2 x ¾in.
All parts. 29/6. P.P. 1/-.
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400 MILLIWATTS OUTPUT


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To build yourself Medium and Long waves—Push-Pull Superhet A.V.C. Perfect Car Radio reception. Size 10in. x 6¼in. x 4¼in. at base tapering to 4in. at top.
Very attractive two-tone grey Vynide covered cabinet with black and gold printed escutcheon plate, cream and gold knobs, handle and cabinet fittings. ★ Weight—complete with long-life 7½ volt battery—4½lb. ★ Mazda high-grade transistors throughout. ★ High-Flux 7in. x 4in. Elliptical Speaker. ★ Slow motion tuning. ★ Co-axial socket at rear for direct connection to Car Radio Aerial. ★ Improved reception by use of seven-section plated telescopic aerial disappearing into Cabinet when closed, 34in. above Cabinet when fully extended.
Construction simplified by Bakelite chassis board with the following components already mounted: I.F. Transformers (3). Oscillator Coil, Trimmer Bank, Output Transformer, Interstage Transformer, Aerial Brackets and Earth Bar. SPECIAL INCLUSIVE PRICE for all required components, full assembly instructions—nothing more to buy—is £10/19/6 plus 3/6 P. & P. Alignment service available. Full assembly instructions and individually priced parts list, all of which are available separately, 2/6, post free.

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(24) JASON J.T.V. 2 Tuner	£13 19 6	3/6	2/6
(25) RADIO JACK	19 6	1/6	6d.
(26) MULLARD TYPE "C" Tape pre-amp.	£12 9 6	3/6	2/6
(27) JASON WII Wobbulator	£14 19 0	3/6	3/6
(28) JASON Valve Voltmeter EM10 (23 ranges)	£18 10 0	3/6	2/6
(29) NEW JASON F.M. TUNER FMT2 with built-in power supplies and cabinet	£8 19 6	3/6	2/6
(30) NEW JASON FRINGE F.M. TUNER FMT3, as above	£10 19 6	3/6	2/6
(32) R.C. Super Personal Portable 1-valve (phone extra)	£1 15 0	2/6	2/-
(33) R.C. Super Personal Portable 2-valve (phone extra)	£2 1 0	2/6	2/-
(34) R.C. TRANSETTE 2-Transistor Personal Portable	£3 9 6	2/-	2/-
(35) JASON EVEREST 6-Transistor 2-wave Portable	£13 19 9	3/6	3/6
(36) JASON EVEREST 7-Transistor 2-wave Portable	£15 18 9	3/6	3/6
(37) CLYNE Cathode Ray Oscilloscope	£12 19 6	5/-	10/-
(38) Compact Multi-range Test Meter	£2 19 6	1/6	1/6
(39) CAR RADIO, Printed Circuit, 5-valve S'het. NEW LOW PRICE	£11 19 6	3/6	2/6
(40) JASON Audio Generator AG10	£14 5 0	3/6	2/-
(41) JASON Oscilloscope OG10	£22 10 0	5/-	3/6
(42) Super SHORT WAVE RADIO, 1 valve	£1 15 0	2/-	2/-
(43) "WAVEMASTER" 7-Transistor Luxury Portable	£10 19 6	3/6	2/6
(44) "GOLD STAR" De-Luxe 1-valve Portable	£1 17 6	2/6	1/6
(45) "PAGEBOY" 2-Transistor Pocket Portable ('phone extra)	£1 12 6	1/6	2/-

Instruction Books which contain full description, easy-to-follow practical wiring diagrams theoretical diagrams itemised price lists, etc., are free of charge with all parcels but may be purchased separately as shown above.

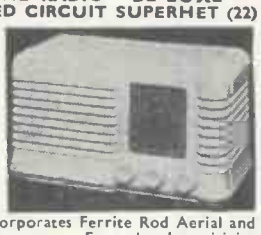
PLEASE NOTE:—A selection of the above items are described more fully in this advertisement!!

PRINTED CIRCUIT CAR RADIO


(39)

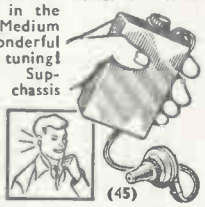
(for Home Construction). We are proud to be able to offer this New type Car Radio employing up-to-the-minute circuitry, special 12 volt valves and transistorised out-put stage. The highest degree of sensitivity is assured by the incorporation of Permeability Tuning and a tuned R.F. Stage. Covers Medium and Long Wavebands.
NO VIBRATOR PACK IS REQUIRED. This is a really compact receiver that will fit any car. Comprehensive assembly Instructions are provided with all necessary components, including valves and transistor at a Special New Low inclusive Price of Only £11/19/6 plus 3/6 P. & P. Instruction booklet with itemised price list, full description dimensions, etc. available separately at 3/6 post free.

THE CLYNE RADIO "DE LUXE" PRINTED CIRCUIT SUPERHET (22)



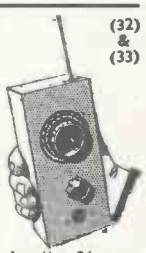
A new two-wave band (L and M) Superhet using the latest miniature valves: ECH81, EF85 and ECL80, plus contact cooled Rectifier. Incorporates Ferrite Rod Aerial and is of unit construction. Exceptional sensitivity and selectivity. Outstanding performance and quality T.C.C. condensers throughout. Easily constructed in one evening. Brown or ivory Bakelite or wooden Walnut finish cabinet. A.C. mains 200/250 v. All necessary components at special inclusive price of £7/19/6 plus 3/6 P. & P. Instruction Book with itemised price list available separately at 1/6 post free. Also available in De Luxe Cabinet (as "Economy Four" at 5/- extra).

NEW! "PAGEBOY" 2-TRANSISTOR POCKET PORTABLE


(45)

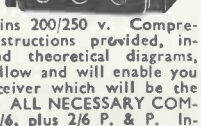
Completely portable—NO EXTERNAL AERIAL OR EARTH REQUIRED. This is an amazing little receiver with built-in aerial and small enough to be held in the palm of the hand. Medium wave reception at wonderful volume. No fiddley tuning!—condenser tuned! Supplied with drilled chassis and colour coded components. Easily assembled with the aid of the easy-to-follow assembly instructions provided. Total cost of all necessary components, including transistors, wiring wire and even solder **ONLY** 32/6 plus 1/6 P. & P. Battery 3/- extra. Ardente type deaf-aid earpiece complete with cord and plugs extra at 12/6. Parts price list and Easy Lay-out Plans 2/- post free. Callers welcome to hear this set demonstrated at any of our branches. Our reputation is your guarantee.

SUPER PERSONAL PORTABLE. (32) & (33)



A wonderful little set you can take anywhere. Ideal for camping, etc. Detachable aerial rod supplied. Covers Medium waveband 200-500 metres. Can be built in approx. 1 hour. All necessary components available at the following SPECIAL INCLUSIVE PRICES: 1-valve version **ONLY** 35/- plus 2/- P. & P. Super 2-valve version **ONLY** 41/-. Plus 2/- P. & P. Send for point-to-point wiring diagram and parts price list 2/- post free. Extra for use with the above DLR5 balanced armature headphones, 7/6 pair.

"FAMILY FOUR" (5)



Our supersensitive T.R.F. Receiver for home construction. Covers Long and Medium Wavebands, is housed in very smart plastic table cabinet in Brown or Black. For A.C. mains 200/250 v. Comprehensive assembly instructions provided, including practical and theoretical diagrams, which are easy to follow and will enable you to complete this receiver which will be the envy of your friends. ALL NECESSARY COMPONENTS ONLY 79/6, plus 2/6 P. & P. Instruction book available separately if you wish to study before purchase at 1/6 post free.

● TURN OVER FOR MORE CLYNE BARGAINS ➔

CLYNE RADIO LTD. THE COMPONENT SPECIALISTS

18 Tottenham Court Road, London, W.1.
162 Holloway Road, London, N.7.
99 Cheapside, London, E.C.2.

★ MORE CLYNE RADIO BARGAINS ★

CATHODE RAY TUBES. Unrepeatable offer! 17in. MW 43/69 by leading British Manufacturer. Brand new in original cartons. Not regunned. Full 12-month guarantee. Limited quantity at **£7/10/-** each only, plus 10/- P. & P. Send stamp for comprehensive Valve and Tube List.

METERS. Large selection of panel mounting meters at competitive price. Send stamp for new list now ready.

ANOTHER PORTABLE CABINET! Ex leading manufacturer's battery portable attache type case. Attractive two-tone grey rexine finish. Size closed 13¼ in. × 9¼ in. × 3¾ in. Complete with fittings and handle. Including Medium and Long Wave frame aerial which fits in lid. Limited quantity only at bargain price of **19/6** plus 2/- P. & P. Brand new.

AUDIO GENERATOR AG10. Covers from 10 c/s to 100 Kc/s in four ranges. Max. output 10 volts. Min. output 100 microvolts. Square wave output with excellent rise time makes this generator very

(40)

useful for checking all Audio equipment. Housed in attractive metal shelf mounting case measuring 11¼in. x 6½in. x 5¼in. high. All necessary components available, including valves, at a Special Price of **£14/5/-**, plus 3/6 P. & P. Fully descriptive booklet with comprehensive assembly instructions available at 2/- post free.

CABY UNIVERSAL TEST METERS

These pocket-size multi-range test meters are of excellent quality and cover all the most useful ranges (A.C. Volts, D.C. Volts, resistance and current). Supplied complete with test prods, instruction book and batteries. Model A.10 (2,000 ohms per volt) **£4/17/6**

Model B.20 (10,000 ohms per volt) **£6/10/-**. Plus P.&P. 3/6 on ea. Fully detailed and illustrated leaflet available on request

"PIFCO" INSTRUMENT BIT SOLDERING IRON with integral Stand and built-in Spot-light for illuminating work 200/250 v. **ONLY 22/6.** P. & P. 1/6.

VIBRATOR PACKS. Limited quantity of both 6 volt and 12 volt types available. Output 300 volt. 100 m/a. Fully smoothed. Brand new ex-Govt. surplus. Price **35/-** ea., plus 2/6 P. & P. Please specify input voltage required.

12 VOLT VIBRATOR PACK. (Mallory). Output 150 v. @ 40 mA. Complete with synchronous vibrator. Brand new. **ONLY 12/6,** plus 2/- P. & P.

12in. BAKERS SELHURST LOUDSPEAKER. 15 ohms, 15 watt 30-14,000 cps. Brand new, **£4/10/-.** P. & P. 3/6.

12in. RICHARD ALLAN P.M. LOUDSPEAKER. 3 ohm speech coil. Brand new. Only **32/6** plus 2/6 P. & P.

DEAF AID TYPE EARPIECES. Ardente Standard magnetic type complete with lead and plug. Only **12/6.** P. & P. 1/-.

MINIATURE CRYSTAL DEAF-AID TYPE EARPIECE. Supplied with ear insert, 3ft. lead, subminiature jack plug and socket at **8/- only,** plus 1/- P. & P. **Subminiature two-way Jack Plug and Socket only 3/6, plus 6d. P. & P.**

LIMITED IMPORT QUOTA ONLY! OUTSTANDING BUY!

MODEL U.1 MULTI-RANGE TEST-METER. Ideal for amateurs and service engineers. Incorporates 3 inch rectangular meter. Ranges: A.C. and D.C. voltage. 0-10-50-250-500-1,000 v. D.C. current 0-100-500 m/a. 0-1 m/a. (used at 0-10 v. range). Resistance 1-2,000 ohms (centre 24 ohms). 100-200,000 ohms (centre 2.4 k.). Sensitivity 1,000 ohms per volt A.C. and D.C. Size: 5in. x 3in. x 2½in. Weight 22 ozs. only. Fully guaranteed. Supplied complete, and ready to use with test leads, at the very low price of only **79/6** P. & P. 3/6.

(Bona fide trade enquiries invited).

★ **TAPE RECORDER CONSTRUCTORS** ★

TELEPHONE PICK-UP COIL. Designed to feed into the microphone input of either a tape recorder or any high gain amplifier. Easily attached to telephone by rubber suction attachment. The coil is electrostatically shielded to minimise hum pick-up. When positioned on telephone this model is more than adequate for a fully modulated tape recording. Brand new complete with 5ft. shielded cable. ONLY 14/- P. & P. 1/6.

COLLARO TAPE PRE-AMPLIFIER AND BIAS OSCILLATOR. Complete with power pack for use with Collaro Mk. IV deck. 4 valve plus EM81 magic eye. 110-240 v. A.C. Input sensitivity: microphone socket 5 m/v., auxillary socket 500 m/v. Speed equalisation switch gives compensation at all 3 speeds. Full wiring instructions included. List price £21. Limited quantity only at **£15/19/6.** P. & P. 5/-.

LATEST COLLARO STUDIO TAPE TRANSCRIPTOR. 3 motors, 3 speeds, 1⅞, 3¾, 7½ i.p.s. takes 7in. spools. Push-button controls, **£12/19/6** plus 5/- P. & P. Usual H.P. facilities.

LATEST B.S.R. "MONARDECK." Single speed Tape Deck. Takes 5¾in. spools—3¾ i.p.s. At only **£8/19/6** plus 5/- P. & P.

TAPE RECORDER AMPLIFIER Suitable for use with either of the above Tape Decks, and most other types. For A.C. mains, 4 watts output. 40-12,000 CPS at 7½ i.p.s. ± 3 db. Facilities for superimpose. Valves: 6BW6, ECL82, 12AX7, EM84, and contact cooled metal rectifier. Radiogram input, microphone input, monitor facilities (can be used as straight through amplifier), volume control and separate treble and bass controls. Chassis measurement 11½ x 3 x 4¾in. Supplied complete with attractive grey/blue escutcheon plate finished in black and gold. Circuit diagram and connecting instructions included. Price **£11/5/-** only, plus 3/6 P. & P. If purchased with either of the above decks, both items post free!

ATTRACTIVE TWO-TONE PORTABLE CARRYING CASE Suitable for above amplifier and Collaro, Studio deck. Limited quantity only at **72/6** plus 3/6 P. & P.

MIC 45-1 Acos latest flat pistol-grip crystal microphone. Attractive black and gold finish. OUR PRICE **29/6** plus 1/- P. & P. **ACOS MIC 39-1.** Crystal stick microphone. List price 5 gns. Our price **39/6** plus 1/6 P. & P. **MIC 40.** General purpose crystal microphone with desk stand. Our price **25/-** only plus 1/6 P. & P. **M.C.24.** Imported, crystal, attractive streamlined polished metal case, incorporates muting switch. List price 64/-. OUR PRICE **42/-** only. 1/- P. & P. **ANOTHER HAND MIKE BARGAIN!** Lightweight crystal with built-in desk stand at only **19/6.** P. & P. 1/-.

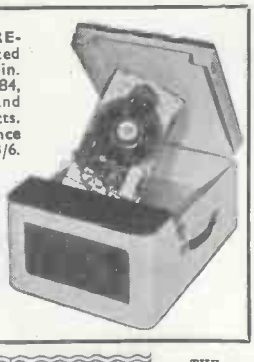
SUPER MAGNETIC RECORDING TAPE SPECIAL!!!

Famous American Ferrodynamics **"BRAND FIVE"** An enthusiast's "must." Brand new (NOT SUB-STANDARD) High grade Acetate Base, 5in. 600ft. **16/-**, 5in. 900ft. **18/6**, 5½in. 1,200ft. **23/6**, 7in. 1,200ft. **25/-**, 7in. 1,800ft. **35/-**. Extra quality Mylar Dupont. 3in. 300ft. **13/-**. 5in. 1,200ft. **37/6**. 7in. 1,800ft. **44/-**. 7in. 2,400ft. **60/-**. Each on plastic spool. All Post free. *Trade enquiries invited.*

EXTRA SPECIAL OFFER !!

A small three-valve **PORTABLE RECORD PLAYER AMPLIFIER** mounted on baffle 12 x 7in., with High Flux 6½in. Loudspeaker. Valve line-up ECC83, EL84, EZ80. Incorporates separate bass and treble controls. Max. output 3 watts. Will match all types of high impedance pick-up. Ready to use, **£5/12/6.** P. & P. 3/6. **NEW STYLE CABINET** finished in two-tone Leatherette. Will accommodate above Amplifier and Baffle without modification, also most types of Ancillary Equipment. Overall size 18 x 13½ x 8½in. Fitted with carrying handle, **£3/9/6** plus 5/- P. & P.

NOTE. If both items purchased together they will be supplied at a special inclusive price £8/7/6 plus 6/6 P. & P.



TRANSISTORS!!!

SURPLUS P.N.P. RED SPOT (Audio/Experimental Application) ..... **3/6** ea.

WHITE SPOT, R.F. up to 2.5 M/cs. ..... **5/-** ea.

OCI69 VHF PNP JUNCTION TRANSISTOR. Drift-type, Alpha cut-off frequency 80 Mc/s. 18/- ea. Attractive discounts for bulk purchases. The above is a selection only. Full range in stock by all leading manufacturers. Let us have your enquiries. (ALL POST FREE).

FRUSTRATED EXPORT. Not repeatable! L., M. and S.W. SUPER-HET RECEIVER. Manufactured by McCarthy for export. At present for operation on 6 volts, but conversion details supplied free.

Valve line-up: 6K8G, 6K7G, 6Q7G 6F6G, 6X5G and 6 volt 4-pin non-synchronous vibrator 8in. P.M. Speaker, 4 watts output, P.U. socket Ext. L.S. socket, etc. Tone control. Fitted in polished wood cabinet, size 21¾in. x 10½in. x 10½in. These cabinets are slightly soiled owing to storage, but each is guaranteed unused, in serviceable condition, tested prior to despatch. Price **£5/19/6** only plus P. & P. 7/6, plus 27/6 for A.C. Mains Conversion Components if required. **OUTSTANDING BUY!**

ACOS GP73-2A: Turnover cartridge for Stereo and Monaural Standard and L.P. Few only at **29/6,** also GP67-3 Mono at **18/-.** Both plus 9d. P. & P.

LOUDSPEAKERS. EX. CHASSIS. As new guaranteed perfect, by leading manufacturers. 5in. high flux. **9/6;** 6½in. **10/6;** 8in. **13/6;** also 10in. with O/P transformer (5,000 ohms), **17/6.** All 3 ohm speech coil, also 8in. available, in attractive cloth covered cabinet, ideal for extension speaker, **22/6.** Each item plus 1/6 P & P. Complete list of new speakers on request.

No. 38 AFV WALKIE-TALKIE. A wonderful offer. This famous transreceiver unit, with relay operated SEND/RECEIVE switch covering 7.4-9 Mc/s band, range approx. 5 miles. Good condition. ONLY **22/6** plus 2/6 P. & P. per unit (less accessories). Quantity export inquiries welcomed.

AERIAL TUNING UNIT ZA0841. This well made ex-W.D. unit contains a host of useful components including: 1 mA. 2in. flush round M/C meter, 1 mA. Westinghouse full-wave meter rectifier. 5-pole 5-way heavy-duty silver plated wavechange switch. 3in. dia. silver plated rotary tuning indicator, 350 pF tuning condenser with insulated coupler and 3½in. calibrated dial (0-180 deg.) etc., etc. Contained in strong metal carrying case 9in. x 9in. x 8in. with hinged lid. ONLY **27/6** plus 5/- C. & P.

WIRING WIRE. 5 coils 10 yds., each coil, in different colours, contained in cellophane bag, **5/-,** plus 9d. postage.

SOLDER. New boxed 1 lb reels, 16 S.W.G. 50/50 at **8/6** only, plus 1/- P. & P.

TRANSFORMER SPECIAL. Superior quality half-shrouded drop thro' mains transformer. Input 200/250 v. Output 350-0-350 v. 80 mA; 6.3 v. 3 amps. 5 v. 2 amps. Ex-equipment but guaranteed O.K. ONLY **9/6,** plus 1/- P. & P.

CLYNE RADIO LTD.

THE COMPONENT SPECIALISTS

18 Tottenham Court Road, London, W.1.
162 Holloway Road, London, N.7.
99 Cheapside, London, E.C.2.

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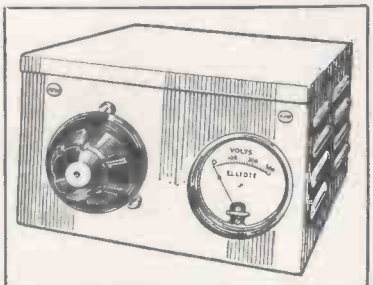


BRAND NEW VARIABLE VOLTAGE TRANSFORMER. 230 volt A.C. input. Fitted in steel hammer finish case complete with 0–300 volt M.C. A.C. Meter, fuse and neon indicator light. Output constantly variable from 0–270 volt A.C. Type 1. 2.2 amp. Price £8/10/-, carriage 10/-. Type 2. 5 amp. Price £12, carriage 10/-.

BRAND NEW VARIABLE VOLTAGE TRANSFORMER. For 230 volt A.C. input. In cases as above with meter, fuse and indicator light. Output constantly variable from 0–230 volt A.C. Type 15. 15 amp. Price £22/10/-. Carr. 15/-.

W. W. RHEOSTAT. New. 3.5K or 5K. 25 watts. Price 7/6. P. & P. 1/6.

NEW WIRE WOUND RHEOSTAT ON CERAMIC. 58 ohm, 50 watt, complete with instrument knob. Price 8/6. P. & P. 1/6.

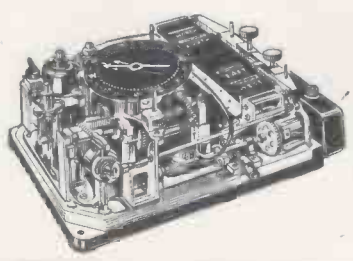
EX P.O. MAGNETIC COUNTER. 500 ohms type for 24 volt also 3 ohm type for 6 volt D.C. operation. Price 6/6 each. P. & P. 1/-.

AUTO TRANSFORMERS. Step up, step down. 110–200–220–240 v. Fully shrouded. New. 300 watt type £2/2/- each. P. & P. 2/6. 500 watt type £3/3/- each. P. & P. 3/9. 1,000 watt type £4/4/- each. P. & P. 6/6.

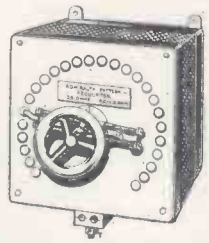
HEAVY DUTY L.T. TRANSFORMER. Very conservatively rated for continuous duty. New. In manufacturer's cases. Input 110–260 volt multi-tapped. 50 cycles, single phase. Output 28–29–30–31 volts at 21 ampere. Price £6/15/-, carriage 10/-.

CONSTANT SPEED, HIGHLY PRECISION MADE, BATTERY DRIVEN D.C. GOVERNED MOTORS (Elliott Bros.). Commutator/Brush incorporating Loading Ballast Resistor 2,470 r.p.m. ± 2% at 12 volt. Loss on 8.5 volt only 4%. Size 1 7/8in. dia. x 2 3/8in. long. Spindle .77in. long x .15575in. dia. Weight 4 oz. New. Price 25/-, plus 1/- P. & P.

EX R.A.F. AIR POSITION INDICATOR, containing 3 ball and plate infinitely variable resolving gears, miniature spur bevel and worm gear drives, also toggle, push button and rotary switches, repeater motor, 4 mechanical counters, miniature lamp holders and lamps etc. As new. Illustration below. **Price 22/6.** P. & P. 3/6.



ROTARY SWITCH REGULATOR. 25 ohms, very conservatively rated at 4 amp., will handle 8 amp. Overall size 7 x 8 x 6in. Price 15/-. P. & P. 2/6.



TWELVE PLATE F.W. BRIDGE CONNECTED RECTIFIER mounted on 200/250 volt A.C. input transformer. Output 36/40 volt D.C. at 1.2 amps. New, perfect. Price 16/6. P. & P. 3/6.

MINIATURE INSTRUMENT RECTIFIERS. Bridge Type 1 milliamp. Guaranteed perfect 7/6 each.

S.T.C. RECTIFIER. 36 plates by 120 mm. Bridge connected. Maximum A.C input 60 volt. D.C. output 15 amp. New, perfect. Price 60/-. P. & P. 3/6.

BRAND NEW FREQUENCY METERS manufactured by Nalder & Thompson Ltd. Calibrated 45 cycles to 55 cycles per second. 6in. dial. Panel mounting type. In original manufacturer's boxes. PRICE £10/15/- ea. Postage 3/6.

20-WAY STRIP containing standard Post Office telephone Jack Sockets, overall size 11 x 3½ x ½in. New. Price 15/- each. P. & P. 1/6.

10-WAY STRIP standard Post Office telephone Jack Sockets, spacing allowing Igranic Jack Plugs. New. Price 10/-. P. & P. 1/6.

19-INCH RACK MOUNTING 20-WAY P.O. JACK STRIPS with 40 terminals at rear. Price 25/-. P. & P. 3/6.

19-INCH RACK MOUNTING 20-WAY P.O. LAMP STRIPS. Price 25/-. P. & P. 2/6.

LATEST MOST MODERN TYPE OF EX W.D. MINIATURE HEADPHONES. As illustrated. Brand new, low impedance. Price: 10/6 plus P. & P. 1/6.

8-day clockwork Time Switch. Contacts 2½ amp., 230 volt, 24 hour phase, ¼ hour divisions, allow setting for one make and one break to be made every 24 hours, complete with key. Used but guaranteed perfect. Price 27/6 each. P. & P. 2/-.

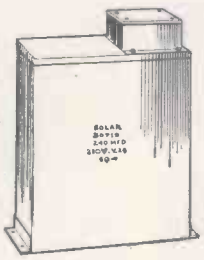
PYE LEVER OPERATING MICRO SWITCHES. Single pole change over. Brand new. 4/- each or 42/- dozen, p. paid.

TANNOY P.A. LOUDSPEAKER. For outdoor use, metal exponential horn with 20in. square flare. Overall length 30in. 5peech coil 15 ohms. Guaranteed in working order and good condition. Price £7/10/-. Carriage 10/-.

PACKARD BELL BRAND NEW RELAYS. 2 pole c.o. 6 volt 80 ohms. 7/6 each. P. & P. 6d.

DIAL THERMOMETER. Made by Short & Mason. Calibrated 0–160 degrees Fahrenheit. 4½in. dial. 6in. rim for flush mounting with 6in. long rod protruding at the back. Brand new. Manufacturer's packing. Price 22/6. P. & P. 3/-.

SOLAR OIL-FILLED CONDENSER. 240 mfd. for 230 V.A.C. or 600 volt D.C. Overall size 14in. x 9in. x 5½in. plus feet. Weight 46 lb. Brand new. Guaranteed perfect. Manufacturer's packing. Price £7/10/-, carriage 10/-.



100 YARD DRUMS GLASS BRAIDED FLEX, 10/.010. New. 10/6 per coil. P. & P. 2/-

18-WAY P.V.C. COVERED 14/36 WIRE, screened overall, covered with P.V.C., all colour coded, 3/6 per yd.; £15 reel of 100 yds. Carriage paid.

LEATHER FLYING HELMETS. Used but in good condition. Complete with Harness, Jack Plug and brand new No. 13466 Earpieces. Price 22/6. P. & P. 2/-.

NEW UNCHARGED UNFILLED 12 VOLT ACCUMULATOR 9 ampere in unspillable plastic cases. Comprises 6 x 2 v. separate cells connected by terminal strips. 6 x 5½ x 4½in. over terminals. Price 19/-, plus P. & P. 2/9.

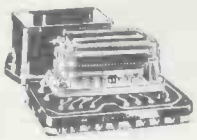
245 AMP. 2 VOLT ACCUMULATOR Admiralty type in wooden casing. Size 15 x 7½ x 7½in. Weight 60lb. Unfilled, uncharged. New. Price £4. Carriage 10/-.

MINIATURE P.M. MOTOR. 12/24 volt, reversible. 1¾in. dia. New. Price 10/6 each. P. & P. 1/-.

AIRCRAFT CINE CAMERA G45B Mk. III. Fully modified, fitted with f/3.5 triple anastigmat lens, takes 25ft. of 16 mm. film, fitted with 24 v. motor. 16 exposures per sec. Brand new, original packing, £4/10/- each. P. & P. paid.

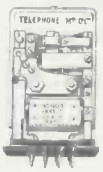
SERVICE TRADING COMPANY

SLIDER RESISTANCES. 2 amp. 500ohms, size 14in. x 6in., plus handle 6in., 27/6. P. & P. 3/6.



SOLENOID OPERATED MAGNETIC RELAY. Type 5CW/3945, 4 pole changeover, 10 A contacts 24 v. operation. Brand new 13/6. P. & P. 1/6.

CARPENTER'S TYPE POLARISED RELAYS. 2 x 9,500 turns at 1,685 ohms. Price 22/6 each. P. & P. 1/-.



HIGH SPEED RELAY. Siemens. Two bobbins 1,000 ohms each. New, 10/6 each. P. & P. 1/-.

SIEMENS H.S. RELAY. Very latest type, sealed. H96E. 1,700 ohms plus 1,700 ohms, single C.O. contacts. Brand new with fixing clip. In maker's cartons. Price 16/6 each, plus 1/- P. & P.

Siemens sealed similar relay to above, but 2.2 ohms plus 2.2 ohms. Minus clips, 12/6 each. Plus 1/- P. & P.

SUPERIOR BRAND NEW RELAY. 7,000 ohms coil. Will pull in at 750 microamp. and out at 450 microamp. Change-over, platinum contacts. Vacuum sealed, will therefore not be affected by oil, moisture or water and never needs adjusting. Weight 2½ oz. Price 18/6. P. & P. 1/-.

MINIATURE MOVING COIL DIFFERENTIAL RELAY. Two coils 350 ohms each. Operating current minimum 140 microamp., nominal 400 microamp, maximum 8 milliamp. One pole two way, or, centre stable. Two way contact current 100 mA at 50 V A.C. or D.C. Size 1¼ x ⅝ x ¾in. Price 22/6 each.

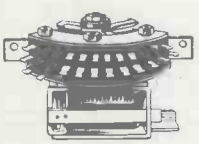
G.E.C. SEALED RELAY. Type M.1090. 180 ohms coil. 6/12 volt. 4 C/O. Brand new. 18/-. P. & P. 1/-.

G.E.C. SEALED RELAY. Type M.1092. 670 ohms coil. 12/24 volt. 4 C/O. Ex new equipment. Unused. 10/-. P. & P. 1/-.

G.P.O. 600 TYPE RELAY. 400 ohms coil. 24 volt. 2 C/O plus 2 M. New 7/6. P. & P. 1/-.

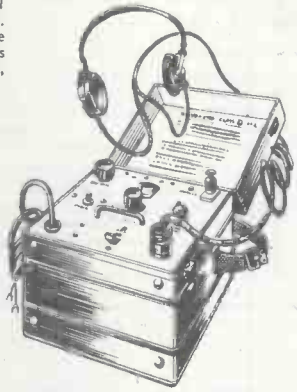
MINIATURE OPEN TYPE RELAY. 700 ohms coils. 24 volt. 2 C/O. Ex new equipment. Unused. 7/6. P. & P. 1/-.

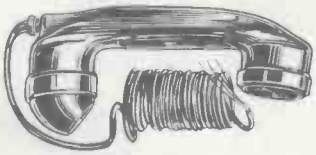
ROTARY RELAY. 12 volt. Heavy duty change-over contacts and one low current for external circuit, plus one break set. Price 7/6. P. & P. 1/6.



MINIATURE UNISELECTOR SWITCH. Two banks of ten plus home contacts one bank continuous of normal. 30 ohm coil for 24 volt operation. Brand new, manufacturer's packing. Price 22/6 each. P. & P. 2/6. As illustrated.

CLASS D WAVE METER. Latest release of these famous Hetrodyne wave meters with directly calibrated illuminated dial, most suitable for amateur transmitters, covers two ranges 1.9–8.0 Mc/s. and 4.0–8.0 Mc/s. Complete with reference crystals for zero settings, two valves, 2 x 6 volt vibrators, MAKER'S instruction book and matched set of headphones for monitoring. Designed for 6-volt D.C. operation, can easily be modified for mains and suitable transformer supplied for 7/6. In spot-on condition as tested by R.E.M.E. In transit case. **Price 5 gns. each,** plus 6/6 carriage.





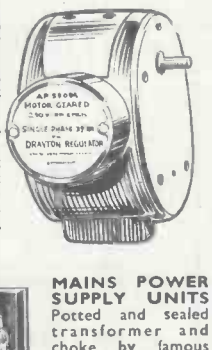
SOUND POWER TELEPHONE HANDSETS. Each couple connected by ordinary 2 core lighting flex will secure instant and reliable intercommunication. No batteries required. **Price** per set of 2 **33/-,** plus P.&P. 3/-.

ENGINE SPEED INDICATOR. On the basis of a special ex-R.A.F. meter which we are able to supply and a few small linking parts which can be purchased anywhere, an inexpensive engine speed indicator can be made up which works on simple pulse counting principles in conjunction with the contact breaker on the distributor. Will give direct reading in R.P.M. Full conversion instructions are supplied by us. Additional standard parts required easily obtainable for about 15/-. R.A.F. meter as offered by us **16/6,** plus 2/6 P. & P.

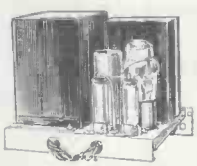
MINIATURE RELAYS 250 ohms. Two makes. For operation on 4.5-9 volt. Ideal for transistor circuits. Weight just over 1 oz. Price 12/6 each.

NEW IMPORTED EXTREMELY EFFICIENT MOTOR with tremendous power weight ratio. For 12 volt D.C. but very efficient on 6 volt. Three position switch. Weight 2.1 oz., size 1⅞in. x 1¼in. dia. Speed 7,000 r.p.m. Self lubricating. 15/-, plus 1/- P. & P.

PRECISION MADE GEARED MOTOR BY DRAYTON REGULATOR CO., for 230 volt 50 cycles A.C.



TYPE R.Q.R., reversible. 37 r.p.m. overall size 5in. x 4in. x 5¼in. Weight 4½ lb. Ex brand new equipment. Unused. Price **£3/17/6.** P. & P. 3/-.



MAINS POWER SUPPLY UNITS Potted and sealed transformer and choke by famous maker. Mounted on metal chassis 6½ x 7½in., complete with 5Z4 rectifier valve and full smoothing.

Input tapped 220–230–240 volts.
Output: 300 V. D.C. at 100 mA.
6.3 V. A.C. at 4.5 amp.
6.3 V. A.C. at 2 amp.
Rectifier supply 5 V. A.C. at 3 amp. Very conservatively rated. Price 47/6 plus P. & P. 6/6.

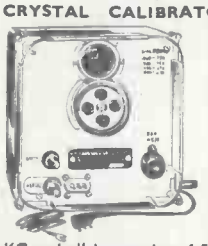
METERS GUARANTEED PERFECT

Charging Types	
2½ amp. D.C. M.I. 2in. fl. rnd.	7/6
5 amp. D.C. M.I. 2½in. fl. rnd.	11/6
7½ amp. D.C. M.I. 3½in. proj. rnd.	12/6
2 amp. D.C. Hot Wire W.R. 2½in. fl. rnd.	6/6
15 amp. D.C. M.C. 2in. rnd.	10/6
30 amp. D.C. M.C. 2in. fl. sq.	12/6
100 amp. A.C. M.I. 4½in. fl. rnd.	32/6
Voltmeters	
20 v. D.C. M.C. 2in. fl. sq.	10/6
30 v. M.I. 3in. proj. rnd.	10/6
40 v. M.C. 2in. fl. sq.	10/6
300 v. A.C. M.C. 2½in. fl. rnd.	27/6
300 v. A.C. M.I., 2½in. fl. rnd.	22/-
400 v. A.C. M.I. 4½in. rnd.	35/-
90–180 v. A.C. M.I. 4½in. fl. iron	25/-
Milliammeters	
1 mA. M.C. 2½in. fl. rnd.	25/-
200 mA. M.C. 2½in. fl. rnd.	12/6
500 mA. M.C. 2½in. fl. rnd.	12/6
Microamp	
50 microamp., scaled 0–100, M.C. 2½in. fl. rnd.	42/6
500 microamp., M.C. 2in. rnd. F.L. scaled 15/600 volt. NEW	16/6

Postage on all meters 1/- each.

Miniature latest type moving coil 0–5 milliamp meter, 1½in. diameter, flush fitting complete with fixing clip. Price 17/6. P. & P. 1/-.

CRYSTAL CALIBRATOR No. 10. A crystal controlled 4-valve high-grade instrument in the same category as the famous B.C. 221. Directly calibrated, does not require cross reference or charts — functions as follows:— (1) A crystal controlled oscillator which provides fixed frequency signals of 500 KC and all harmonics of 500 KC to beyond 10 Meg. and up to 30 Meg.



(2) A variable oscillator from 250 KC to 500 KC, this enables all intermediate frequencies between 250 Kc/s. and 30 Meg. to be produced and modulated.

Supplied complete with 3 spare valves, all leads and maker's instruction book in carrying haversack. The complete outfit is brand new—repeat NEW. Price £4/19/6. Carr. 3/-.

Postages and carriage shown above are inland only. For overseas please ask for quotation. We do not issue a catalogue or list.

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H

R.S.C. HI-FI TAPE RECORDER KIT

Build a high quality recorder in the £70 class for only

25½ GNS. Carr. 17/6.

Can be assembled in ¼ hour.

OR DEPOSIT 25/7/6 and 12 monthly payments of 42/-. Cash price if settled in 3 months.

INCORPORATING THE LATEST COLLARO STUDIO TAPE TRANSCRIPTOR THE LINEAR LT46X HIGH QUALITY TAPE AMPLIFIER. A HIGH FLUX 7×4in. LOUDSPEAKER, Reel of Best Quality TAPE, Spare Tape Spool, a Portable Cabinet, size approx. 16 × 13 × 9in., finished in durable and attractive duo-tone Policrome, and connection diagram for wiring amplifier to transcriptor.

FEATURES INCLUDE

★ 3 SPEEDS ★ FREQUENCY RESPONSE 50-11,000 c.p.s. ★ SWITCHED NEGATIVE FEEDBACK EQUALIZING FOR EACH SPEED. ★ OUTPUT 4 WATTS ★ MAGIC EYE RECORDING LEVEL INDICATOR ★ 3 MOTORS. Fast rewind. ★ TAPE MEASURING AND CALIBRATING DEVICE. ★ TAKES FULL 7in. DIAMETER REELS OF TAPE. ★ NEGLIGIBLE HUM. ★ ENTIRELY EFFECTIVE AUTOMATIC ERASURE.

Full descriptive leaflet supplied on receipt of S.A.E.

HI-FI 10 WATT AMPLIFIERS

BRAND NEW CARTONED MANUFACTURERS DISCONTINUED MODEL. **£6.19.9** Carr. 7/6.

A REMARKABLE OPPORTUNITY

Push-pull output. Latest high efficiency Mullard valves. Dual separately controlled inputs, for mike and gram. Separate bass and treble controls. High sensitivity. Output for 3 ohm or 15 ohm loudpseaker. Guaranteed, tested and in perfect working order. Please state speaker matching required when ordering.

SUPERHET RADIO FEEDER UNIT

Design of a high quality Radio Tuner Unit (specially suitable for use with any of our Amplifiers). A Triode Heptode F/changer is used. Pentode I.F. and double Diode Second Detector, delayed A.V.C. is arranged so that A.V.C. distortion is avoided. The W. Ch. 8w. incorporates Gram-position. Controls are Tuning, W. Ch. and Vol. Output will load most Amplifiers requiring 500 mV. input depending on Ae location. Only 250 v. 15 mA. H.T. and L.T. of 6.3 v. 1 amp. required from amplifier. Size of unit approx. 9-6-7in. high. Send S.A.E. for illustrated leaflet. Total building cost is £4/15/-. Point-to-Point wiring diagrams and instructions 2/6.

CONSTRUCTIONAL ENVELOPES

Repanco 3 Dee Transistor Radio 1/3. Repanco Mini 3 Pocket Portable Transistor Radio 1/6. Repanco Mini 7 Transistor Pocket Portable (total building cost 9 gns) 1/6. R.S.C. All 12-watt High Fidelity amplifier 1/9. R.S.C. STEREO/TEN High Quality Stereo Amplifier 1/9.

RE-ENTRANT LOUDSPEAKERS

For factory or outdoor use.

Tannoy 7.5 ohms 8 watts 25/9.

Parmeko horn type, highly efficient. Handles up to 10 watts. 15 ohm 200 ohm and 600 ohm matching 59/6. R.C.A. 20 watt rating, 3 ohm, 15 ohm., 200 ohm. and 600 ohm matching 6 gns.

ACOS HI-FI CRYSTAL 'MIKES'

Mic 30 hand or Desk type **27/9** (Listed 45/-)

39-1 Stick type **39/6** (Listed 5 Gns.)

Limited number.

R.S.C. BATTERY TO MAINS CONVERSION UNITS

Type BM1. An all-dry battery eliminator. Size 5½ × 4½ × 2in. approx. Completely replaces batteries supply 1.4 v. and 90 v. where A.C. mains 200-250 v. 50 c/s. is available. Suitable for all battery portable receivers requiring 1.4 v. and 90 v. This includes latest low consumption types. Complete kit with diagram 39/9 or ready for use 46/9.

Type BM2. Size 8×5½×2½in. Supplies 120 v. 90 v. and 60 v., 40 mA. and 2 v. 0.4 a. to 1 amp., fully smoothed. THEREBY COMPLETELY REPLACING BOTH H.T. BATTERIES AND L.T. 2 v. ACCUMULATORS when connected to A.C. mains supply 200-250 v. 50 c/s. SUITABLE FOR ALL BATTERY RECEIVERS normally using 2 v accumulator

Complete kit with diagrams and instructions. 49/9 or ready for use 59/6.

TAPE RECORDERS AT WHOLESALE PRICES. Leading makes. 26 gn. model 18 gns. 29 gn. model 20 gns. 40 gn model 27 gns. 42 gn. model 29 gns. 63 gn. model 45 gns. 64 gn. model 44 gns. All brand new with manufacturer's guarantee. Make and model No. on request. No H.P.

VALVES! Full range at really competitive prices.

THE SKY FOUR T.R.F. RECEIVER

A design of a 3 valve 200-250 v. A.C. mains L. and M. wave T.R.F. receiver with selenium rectifier. For inclusion in cabinet illustrated or walnut veneered type. It employs valves 6K7, 6P61, 6F6 and is specially designed for simplicity in wiring. Sensitivity and quality are well up to standard. Point-to-Point wiring diagram, instructions and parts list 1/9. This receiver can be built for a maximum of £4/19/6 including cabinet. Available in brown or cream bakelite or veneered walnut.

EXTENSION SPEAKERS. Handsome walnut veneered cabinets. All standard 2-3 ohms. 6½in. 29/9; 8in. 35/9.

R.S.C. A12 STEREO AMPLIFIER KIT

A complete kit of parts to construct a good quality 3 + 3 watt (total 6 watt) stereo amplifier providing really life-like reproduction. Suitable for use with all stereo pick-up heads at present available. Ganged volume and tone controls. Preset balance control. Outputs for matched 2-3 ohm speakers. For 200-250 v. A.C. mains. Astonishing value.

4 GNS.

Carr. and packing 7/6.

R.S.C. STEREO/TEN HIGH QUALITY AMPLIFIER KIT

Valves EZ81, ECC83, ECC83, EL84, EL84. Separate Bass and treble controls, giving "cut" and "boost." Sensitivity 50 mV. 5 watts high quality output on each channel. Can be used as straight 10 watt amplifier. Controls: Stereo/Monaural switch, ganged volume, ganged treble, ganged bass, and balance. Outputs for 3 ohm speakers. Point-to-Point wiring diagrams and instructions. Carr. 7/9.

8 Gns.

Illustration full constructional details and priced parts list 1/9.

SELENIUM RECTIFIERS

We can quote special prices for quantities of 12 to 10,000 of most types Special types made to order.

L.T. Types		H.T. Types H.W.	
2/6 v. ½ a. h.w.	1/9	120 v. 40 mA.	3/9
6/12 v. 1 a. h.w.	2/9	250 v. 50 mA.	3/11
Following F.W. (Bridge)		250 v. 60 mA.	4/11
6/12 v. 1 a.	3/11	250 v. 80 mA.	6/11
6/12 v. 2 a.	6/11	250 v. 250 mA.	12/9
6/12 v. 3 a.	9/9	Contact Cooled	
6/12 v. 4 a.	12/3	250 v. 80 mA.	6/11
6/12 v. 5 a.	14/6	250 v. 250 mA P.W. (Bridge)	8/11
6/12 v. 6 a.	15/6	250 v. 75 mA. F.W. (Bridge)	10/11
6/12 v. 10 a.	25/9		
6/12 v. 15 a.	35/9		

JUNCTION TRANSISTORS. R.F. Type 9/6. Audio type 5/9. Power type Goltop V15/10P 2 watts, 17/9. OC71 10/-. OC72 16/9. XB102 10/-. XB104 10/-. XA101, XC101, OC44 16/9. XA102. XA103, XA104 12/9 and many other types.

RECORDING HEADS. Baird Record Playback and Erase (housed in one container) 9/6 pair.

SPECIAL OFFER. of R.C.A. replacement styli for Collaro Studio "C" and "P". Ronette and other pick-up heads. Sapphire type standard of L.P. 3/11 each. Diamond type normally 83/5. Only 29/11.

HEAVY DUTY CHARGER KIT

6/12 v. variable charge rate up to 6 amps. Consisting of Mains Trans., F.W. (Bridge) Selenium Rectifier, 0-7 amp. meter, multi-position switch with knob, fuses, fuse-holders, panels, plugs, and circuit. Only 59/6. Post 4/6.

Battery Chargers and Kits for 200-230-250 v. 50 c/s. A/C. Mains

ASSEMBLED CHARGERS

6 v. 1 a.	19/9
6 v. 2 a.	29/9
6/12 v. 1 a.	29/9
6/12 v. 2 a.	38/9

Above ready for use with mains and output leads. Cases well ventilated and finished in stoved blue hammer. Carr. & Pkg. 3/6.

CHARGER TRANSFORMERS

200-230-250 v. 50 c/s.

0-9-15 v. 1½ a.	12/9
0-9-15 v. 2½ a.	15/9
0-9-15 v. 3½ a.	16/9
0-9-15 v. 5 a.	19/9
0-9-15 v. 6 a.	23/9

BATTERY CHARGER KITS

Consisting of Mains Transformer, F.W. Bridge, Metal Rectifier, well ventilated steel case. Fuses, fuse-holders, grommets, panels and circuit. Carr. 2/9 extra.

6 v. or 12 v. 1 amp.	24/9
As above, with ammeter...	32/9
6 v. 2 amps.	25/9
6 v. or 12 v. 2 amps.	31/6
6 v. or 12 v. 2 amps. (inclusive or ammeter)	42/9
6/12 v. 4 amps.	49/9
6 v. or 12 v. 4 amps. with variable charge rate selector and ammeter	59/9

CHARGER AMMETERS

0-1.5 amp., 0-3 amp., 0-4 amp., 0-7 amp., 0-25 amp., 0-60 amp. 8/9

ASSEMBLED CHARGER

6 v. or 12 v. 2 amps. Fitted Ammeter and selector plug for 6 v. or 12 v. Louvred metal case, finished attractive hammer blue. Ready for use with mains and output leads. Double Fused. Only Carr. 3/9. **49/9**

As above, but for 3 amp. charging. Only 59/6. Carr. 3/9

ASSEMBLED 6 v. or 12 v. 4 amps.

Fitted Ammeter and variable charge selector. Also selector plug for 6 v. or 12 v. charging Double fused. Well ventilated steel case with blue hammer finish. Ready for use with mains and output leads. Carr. 5/-. **69/9** Or Deposit 13/3 and 5 monthly payments of 13/3.

As above, but for 6 amp. charging 4 GNS. Carr. 5/-. Or Deposit 16/- and 5 monthly payments of 16/-. The 6 amp. model only is slightly store soiled and is being offered at well below usual price.

POWER PACK KITS. Only 18/11. Fully smoothed H.T. output of 250 v. 60 ma. and L.T. supply of 6.3 v. 1.5 amp. Consisting of Double Wound Mains Transformer 230/250v. 50 c.p.s. A.C. primary. Selenium Rectifier. Smoothing Choke. Double Electrolytic Condenser. Aluminium Chassis and Circuit.

W.B. "STENTORIAN" HIGH FIDELITY P.M. SPEAKERS

HF1012, 10 watts, 15 ohm (or 3 ohm) speech coil. Where a really good quality speaker at a low price is required, we highly recommend this unit with an amazing performance. £4/10/9. Please state whether 3 ohm or 15 ohm required.

BASS REFLEX CABINET. Specially designed for above speaker. Acoustically lined and ported. Polished walnut veneer finish. Size 18 × 12 × 10ins. Strongly made. Handsome appearance. Ensure superb reproduction for only £3/19/6.

D.C. SUPPLY KITS. Suitable for electric trains. Consist of mains trans. 200-250 v. 50 c.p.s.; 12 v. 1 amp. selenium rect. (F.W. Bridge); 2 fuseholders, 2 fuses, change direction switch, variable speed regulator, partially drilled steel case and circuit. Very limited number, 33/9.

REPANCO TWINETTE TRANSISTOR PORTABLE RADIO DESIGN. Constructional Envelope and parts list 1/3. Built-in Ferrite Aerial, 7in. × 4in. speaker, Long and Medium waves. Size approx. 7×4×3in. Total cost of all parts 5 gns.

LINEAR TAPE PRE-AMPLIFIER Type TP/1. Switched negative feedback equalisation. Positions for Record 1⅞in., 3¾in., 7½in. and Playback. EM84. Recording level indicator. Designed primarily as the link between Collaro Tape Transcriptor and high fidelity amplifier but suitable almost any Tape Deck.

9 Gns.

LINEAR L45 MINIATURE 4/5 W. QUALITY AMPLIFIER. Suitable for use with any record playing unit and most microphones. Negative feedback 12 D.B. Bass and Treble controls. For A.C. mains input of 200-250 v. 50 c.p.s. Output for 2/3 ohm speaker. Three miniature Mullard valves. Size only 6×5×5½in. high. Chassis fully isolated from mains. Guaranteed 12 months. Only Deposit 22/- and 5 monthly payments of 22/-. Send S.A.E. for leaflet. **£5.19.6** Or

P.M. SPEAKERS. 2-3 ohms 2½in. Perdio 21/9. 5in. Goodmans 17/9. 7 × 4in. R.A. Elliptical 19/9. 6½in. Rola 19/9. 8in. Rola 19/9. 8in. Goodmans 25/9. 8 × 6in. Elac. with high flux magnet 25/9. 10in. R.A. 28/9. 10 × 6in. Elliptical Goodmans 29/9. 12in. R.A. 29/11. 12in. R.A. 3 or 15 ohms. 10 watts. 12,000 lines, 59/6.

TWEETERS. 4in. Plessey, 3 ohms, 18/9. R.A. 15 ohms 25/9.

R.S.C. A10 ULTRA LINEAR 30 WATT AMPLIFIER

HIGH FIDELITY PUSH-PULL UNIT EMPLOYING SIX VALVES. EF86, EF86, ECC38, 807, 807, GZ34. Tone Control Pre-Amp. stages are incorporated. Sensitivity is extremely high. Only 12 millivolt minimum input is required for full output. **THIS ENSURES THE SUITABILITY OF ANY TYPE OR MAKE OR MICROPHONE OR PICK-UP.** Separate Bass and Treble controls give both "lift" and "cut" with ample tone correction for long playing records. An extra input with associated vol. control is provided so that two separate inputs such as "mike" and gram, etc., can be simultaneously applied for mixing purposes. **AN OUTPUT SOCKET WITH PLUG IS INCLUDED FOR SUPPLY OF 300 v. 20 mA. and 6.3 v. 1.5 A. FOR A RADIO FEEDER UNIT.** Price in kit form with easy-to-follow wiring diagrams. **ONLY 11 gns.** Or Factory built with 12 months' guarantee **£13/19/6. TERMS ON ASSEMBLED UNITS. DEPOSIT 31/9** and 9 monthly payments of 31/9. Carr. 10/-.

Cover as illustrated Type 807 output valves are used with High Quality Sectionally wound output transformer specially designed for Ultra Linear operation. Negative feedback of 20 D.B. in main loop. **CERTIFIED PERFORMANCE FIGURES ARE EQUAL TO MOST EXPENSIVE UNITS AVAILABLE.** Frequency response ± 3 D.B. 30-20,000 c/s. Tone Controls ± 12 D.B. at 50 c/cs. ± 12 D.B. to − 6 D.B. at 12,000 c/cs., hum and noise 70 D.B. down. Good quality reliable components used. Chassis finish blue hammer. Overall size 12×9×9in. approx. Power consumption 150 watts. For A.C. mains 200-250 v. 50 c/s. Outputs for 3 and 15 ohm speakers. **EQUALLY SUITABLE FOR THE CONNOISSEUR OR FOR LARGE HALLS, CLUBS OR OUTSIDE FUNCTIONS, IDEAL FOR USE WITH MUSICAL INSTRUMENTS, SUCH AS STRING BASS, ELECTRONIC ORGAN, GUITAR, etc. FOR DANCE BANDS, GARRISON THEATRES,** etc., etc. We can supply Microphones, Speakers, etc., at keen cash prices or on terms with amplifiers. **EXPORT ENQUIRIES INVITED.**

FULL RANGE OF LINEAR HIGH FIDELITY AMPLIFIERS ALWAYS IN STOCK.

GL3A MINIATURE 3 WATT GRAM AMPLIFIERS

For 200-250 v. 50 c.p.s. A.C. mains. Overall size only 11½×2¼×2½in. Fitted Vol. and Tone Control with mains switch. Designed for use with any kind of single player or record changer unit. Output for 2-3 ohm speaker. Guaranteed 12 months. Only **59/6.**

R.S.C. AS 4-5 WATT HIGH GAIN AMPLIFIER

A highly sensitive 4-valve quality amplifier for the home, small club, etc. Only 50 millivolts input is required for full output so that it is suitable for use with the latest high fidelity pick-up heads in addition to all other types of pick-ups and practically all makes. Separate Bass and Treble controls are provided. These give full long playing record equalisation. Hum-level is negligible being 71 D.B. down. 15 D.B. of negative feedback is used. H.T of 300 v. 26 mA. and L.T. of 6.3 v. 1.5 a. is available for the supply of a Radio Feeder Unit or Tape Deck pre-amplifier. For A.C. mains input of 200-250 v. 50 c/s. Output for 2-3 ohm speaker. Chassis is not alive. Kit is complete in every detail and includes fully punched chassis (with baseplate) with the blue hammer finish and point-to-point wiring diagrams and instructions. Exceptional value at only **£4/15/-** or assembled ready for use **25/-** extra, plus 3/6 carriage. Or Deposit **22/-** and five monthly payments of **22/-** for assembled unit.

R.S.C. TRANSFORMERS. Fully Guaranteed. Interleaved & impregnated.

WE CAN QUOTE FOR SPECIAL OR STANDARD TYPES IN ANY QUANTITY. OUR FACTORY HAS SUPPLIED LEADING EQUIPMENT MANUFACTURERS AND GOVT. DEPTS. FOR 15 YEARS.

MAINS TRANSFORMERS. Primaries 200-250-250 v. 50 c/s.

FULLY SHROUDED UPRIGHT MOUNTING.

250-0-250 v. 60 mA., 6.3 v. 2 a., 5 v. 2 a. 24-3-3in... 17/11
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a. 27/11
300-0-300 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a. 27/11
350-0-350 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a. 27/11
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a. 33/11
425-0-425 v. 200 mA., 6.3 v. 4 a., c.t., 5 v. 3 a. 49/9
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350-0-350 v. 80 mA., 6.3 v. 2 a., 5 v. 2 a. 18/11
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350-0-350 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a. 25/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a. 29/9
425-0-425 v. 200 mA., 6.3 v. 4 a., 5 v. 3 a. 47/9

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120 v. 40 mA., 5-0-5 v. 1 a. 14/9
90 v. 15 mA., 6-0-6 v. 250 mA. 9/11

FILAMENT TRANSFORMERS

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6.3 v. 2 a. 7/6
0-4-6.3 v. 2 a. 7/9
12 v. 1 a. 7/9
6.3 v. 3 a. 8/11
6.3 v. 6 a. 17/9
12 v. 3 a. or 24 v. 1.5 a. 17/9

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50-80 watts 110-120 v./230-250 v. 11/9
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Midget Battery Pentode 66:1 for 3Ω, etc..... 3/9
Small Pentode 5,000Ω to 3Ω 3/9
Standard Pentode 5,000Ω to 3Ω 5/9
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80 mA., 10 H., 350Ω 5/6
60 mA., 10 H., 400Ω 4/11
1 amp. 0.5Ω L.T. type 6/6

PARMEKO MAINS TRANSFORMERS. Fully shrouded.

500-0-500 v. 120 mA., 6.3 v. 4 a., 5 v. 3 a. 31/9

R.S.C. (MANCHESTER) LTD. MANCHESTER, LEEDS & BRADFORD

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HIGH FIDELITY 12-14 WATT AMPLIFIER TYPE A11

PUSH-PULL ULTRA LINEAR OUTPUT "BUILT-IN" TONE CONTROL PRE-AMP STAGES

Two input sockets with associated controls allow mixing of "mike" and gram. as in A.10 High sensitivity. Includes 6 valves: ECC85, ECC83, EL84, EL84, 5Y3. High Quality sectionally wound output transformer specially designed for Ultra Linear operation and reliable small condensers of current manufacture. **INDIVIDUAL CONTROLS FOR BASS AND TREBLE "Lift" and "Cut."** Frequency response ± 3 D.B. 30-30,000 c/cs. Six negative feedback loops. Hum level 60 D.B. down. **ONLY 25 millivolts INPUT required for FULL OUTPUT.** Suitable for use with all makes and types of pick-ups and microphones. Comparable with the very best designs. **For STANDARD or LONG PLAYING RECORDS. For MUSICAL INSTRUMENTS** such as **STRING BASS, GUITARS,** etc. **OUTPUT SOCKET** with plug provides 300 v. 30 mA. and 6.3 v. 1.5 a. For supply of a **RADIO FEEDER UNIT.** Size approx.: 12.9-7in. For A.C. mains 200-250 v. 60 c/cs. Output for 3 and 15 ohm speakers. Kit is complete to last nut. Chassis is fully punched. Full instructions and point-to-point wiring diagrams supplied. (Or factory built 45/- extra.) **ONLY 8 Gns.** Carr. 10/-. If required louvred metal cover with 2 carrying handles can be supplied for **18/9. TERMS ON ASSEMBLED UNITS. DEPOSIT 24/3** and 9 monthly payments of **24/3.** Send S.A.E. for illustrated leaflet detailing ready-to-assemble Cabinets, Speakers, Microphones, etc., with cash and credit terms.

R.S.C. PORTABLE GUITAR AMPLIFIERS

JUNIOR 5 WATT. High Quality Output. Separate Bass and Treble "cut" and "boost" controls. Sensitivity 15 mv. High Flux 8in. l/speaker. Input sockets for Radio/Tape or Gram Pick-up and Mike /Instrument Pick-up. Handsome strongly made cabinet (size approx. 14×14×7in.). Finished in attractive and durable polychrome and fitted carrying handle.

£8.19.6 Carr.7/6. Or Deposit £1 and nine monthly payments £1.

Send S.A.E. for leaflet.

SENIOR 10 WATTS. High-Fidelity Push-Pull output. Separate Bass and Treble "cut" and "boost" controls. Twin separately controlled high gain inputs so that two instruments such as Guitar and String Bass can be used at the same time. Two Loudspeakers are incorporated in 12in. P.M. for Bass notes and 1 7×4in. elliptical for Treble. Cabinet is well made and finished as for Junior model. Size approx. 18×18×8in. **15 Gns.** Plus 10/- carr. **H.P. TERMS. DEPOSIT 34/9** and 9 monthly payments **34/9.** Both models for 200-250 v. A.C. mains.

COLLARO CONTINENTAL 4 SPEED DE LUXE MIXER AUTO-CHANGERS with TX88 Transcription Cartridge for standard and L.P. records. For normal 200-250 v. A.C. mains. Few only at unrepeatable price of £10/19/6. Carr. 4/6.

COLLARO CONQUEST 4-SPEED AUTO-CHANGERS. With studio pick-up with turnover head. Latest model for 200-250 v. A.C. mains. £6/19/6. Carr. 4/6.

B.S.R. MONARCH AUTO-CHANGERS. Type UA8. 4 speed T/O Pick-up with sapphire stylus £6/19/6. Carr. 4/6.

Any of the above supplied with T/O stereo/monaural head for **£1** extra.

COLLARO JUNIOR. 4-speed Single Players with Hi-Fi T/O crystal pick-up head, **£3/19/6.**

LOUDSPEAKER IN POLISHED WALNUT FINISHED CABINET. Gauss 12,000 lines. Speech coil 3 ohms or 15 ohms. Only **£4/19/6.** Carr. 5/-. **TERMS: DEPOSIT 11/-** and 9 monthly payments of **11/-.**

12in. 20 WATT 15,000 line l/speakers 15 ohms in Cabinet finished as above. Size 18×18×8in. **27/19/6** or Deposit **17/9** and 9 monthly payments of **17/9.**

ACOS HGP59 Hi-Fi Crystal Cartridges. (Turnover type with sapphire stylus.) Standard replacement for Garrard and Collaro. Only **19/9. B.S.R. Ful-Fi 19/9. Garrard GC2 19/9. Acos Stereo/monaural 49/9.**

ACOS HIGH FIDELTY PICK-UPS, GP54 with **HGP59/52** Cartridge. Turnover sapphire styli, cream finish. Limited number at approx. half price. Only **35/9.**

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PLESSEY DUAL CONCENTRIC 12in. P.M. SPEAKERS

(15 ohms), consisting of a high quality 12in. speaker of orthodox design supporting a small elliptical speaker ready wired with choke and condensers to act as tweeter. This high-fidelity unit is highly recommended for use with our A11 or any similar amplifier. Rating is 10 watts. Gauss 12,000 lines. Price, only **£5/19/6.** Or Deposit, **15/9** and 9 monthly payments of **13/9.**

BARGAIN OFFERS *for the Constructor!*

TAPE RECORDER

Manufacturers' brand new, current production offer. Latest 5-valve circuit based on Mullard's famous design. Magic eye level indicator. Volume and tone controls. T.C.C. printed circuit already wired. Only power pack and controls to assemble and wire. Valves EF86, ECC83, EL84, EM84 & EZ80. A sensitive quality recorder at Special Unit Prices.

Wired printed circuit, power pack components, controls and knobs, etc. P. & P. 3/6 ..... £5 15 0
Set of 5 valves, as above. P. & P. 1/- £2 5 0
B.S.R. Monardeck Tape Unit. P. & P. 4/6 ..... £3 19 6
Bargain reduction for complete kit. Carr. 5/- £16 10 0

Attractive two-tone Cabinet and 9in. x 5in. speaker to house above at special discount price. P. & P. 4/6 ..... £3 5 0
Illustrated Handbook with full details. Post free 2 6
Collaro Studio Tape Deck can be supplied with modified circuit as alternative for approx. (extra) £5 10 0

RECORD PLAYER BARGAINS Latest 4-speed models

NEW RELEASE by E.M.I.—4 speed Single Player Unit fitted with latest stereo and monaural xtal cartridge and dual sapphire styli. Auto stop and start. A fidelity unit and bargain buy at only £6/19/6, carr. & ins. 3/6.

SINGLE PLAYERS. B.S.R. (TU9) 90/-; COLLARO JUNIOR studio P.U. £4/10/-. AUTOCHANGERS. B.S.R. (UA8), £8/19/6; UA8 STEREO £7/19/6. B.S.R. (UA14) latest model, £7/19/6. COLLARO CONQUEST, £7/19/6. COLLARO CONTINENTAL £8/19/6.

BARGAINS GARRARD PLAYER UNITS

SINGLE PLAYERS
Model 4SP £6/17/6. Carr. 3/6.
Model TA Mk. 2, £7/19/6. Carr. 3/6.
Model 4HF, £18. Carr. 3/6.

AUTOCHANGERS. Model RC210, With plug-in GC8 Head. 10 gns. Carr. 4/6. Transcription Auto Changer Model "A" just released £18/19/6. Carr. 5/-.

AUTO CHANGER RECORD PLAYER KIT

A.C. Supply 200v.-250v. Attractive 2-tone cabinet—famous B.S.R. Monarch 4-speed, full mixer, 10-record gram unit. Full-sized pick-up with dual stylus for Std. L.P. recordings. 2-valve amplifier with quality neg. feedback circuit, volume and tone controls. Fully isolated from mains by double-wound transformer, NOT the live chassis type as often offered in cheap commercial models.

A recommended buy while stocks last! Ready wired 2-valve Amplifier, complete with 6in. high flux speaker.
£3/19/6; P. & P. 2/6

Two-tone Cabinet, 18in. x 13in. x 8in.
£3/3/-, P. & P. 3/6

Collaro Conquest (160 v. model).
£5/19/6, P. & P. 4/6

Complete 3 unit kit at special Autumn Bargain price. £12/19/6. Carr. 7/6
Simple assembly, a screwdriver only required.

TRANSISTORS BVA—1st Grade *New Reduced Prices*

MAZDA	MULLARD	G.E.C.
XA101 14/6	OC70 9/6	GET114 9/6
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XA103 15/-	OCT72 15/-	Newmarket "Goldtop" V15/10P 15/-
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Germanium Diodes OA70 2/9; OA81 3/6; GEX34 4/-.

NEW BOXED VALVES ALL GUARANTEED

IT4	6/-	EABC80	8/6	EZ81	7/6
IR5, 1S5	7/6	ECC84	9/6	MU14	9/-
3S4, 3V4	7/6	ECF80	9/6	PCC84	9/6
5Z4	9/-	ECL82	10/6	PCF80	9/6
6K7	5/-	ECL80	10/6	PCL83	12/6
6K8	7/6	EF80	8/-	PL81	12/6
6Q7	7/6	EF86	12/6	PL82	9/6
6V6	6/6	EF91	5/-	PL83	10/6
DAF96	9/-	EL41	9/6	PY80	7/6
DF96	9/-	EL84	8/6	PY81	9/6
DK96	9/-	EY51	9/6	PY82	7/6
DL96	9 -	EY86	10/-	U25	12/6

SPECIAL PRICE PER SET
1R5, 1T4, 185 or 3S4 or 3V4, 25/-
DK96, DF96, DAF96, DL96, 35/-
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JASON FM TUNER UNITS (87-105 Mcs)

Designer-approved kits of parts for these quality and highly popular tuners available as follows:—

STANDARD MODEL (FMT)—as previously extensively advertised. COMPLETE KIT, 5 gns., P. & P. 2/6. Set of 4 spec. valves, 20/-.

LATEST MODEL (FMT2)—attractively presented shelf mounting unit in enclosed Metal Cabinet with Built-in Power Supply. COMPLETE KIT, £7, P. & P. 3/6. Set of 5 spec. valves, 37/6.

MODEL JTV2. Self-powered Switch Tuned B1-B2-B3 AM/FM Unit. 5 preset stations, AFC and AGC circuits. Complete Kit incl. ready-built and valved Tuner, £13/19/6, P. & P. 3/6. 4 spec. valves, 32/6 extra.

MERCURY 2 similar to JTV2 less power pack. Complete Kit inc. ready-built turret unit 10 gns. P. & P. 2/6. 4 spec. valves 25/-.

NEW JASON COMPREHENSIVE F.M. HANDBOOK, 2/6 post free. 48hr. Alignment Service, 7/6, P. & P. 3/6.

MAINS TRANS. AND QUALITY OUTPUT TRANS. Mfd. in our own workshops to top grade spec. Fully interleaved and impregnated. Enquiries welcomed for small production runs, prototypes or individual jobs.

RECORDING TAPE BARGAINS

EMI 1st grade. Brand new sealed boxes.

Standard		Long Play	
3in., 175ft.	7/-	250ft.	9/-
5in., 600ft.	19/-	850ft.	25/-
5½in., 850ft.	25/-	1,200ft.	31/6
7in., 1,200ft.	31/5	1,800ft.	45/-

SPARE REELS: Emitape, new, boxed. 3in. 3/-, 5in. 3/8, 5½in. 4/-, 7in. 4/6.

SPECIAL PURCHASE. Famous manufacturers, 1st grade tape, in sealed white boxes.

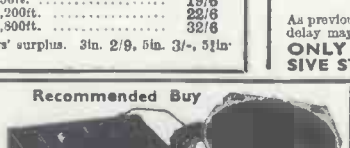
Standard		Long Play	
5in., 600ft.	15/-	850ft.	19/6
5½in., 850ft.	16/6	1,200ft.	22/6
7in., 1,200ft.	21/-	1,800ft.	32/6

Plastic Tape Reels, special offer. Manufacturers' surplus. 3in. 2/9, 5in. 3/-, 5½in. 3/3, 7in. 3/6.

2 WAVEBAND CAR RADIO KIT

12 v. operation Med. & Long Waves

Recommended Buy



Modern development of the famous Brimar Hybrid vibratorless car radio circuit. Five latest type Brimar low voltage valves and power transistor. R.F. stage and permeability pre-aligned Cyldon Tuner Unit provide extremely good sensitivity and signal noise ratio. Printed circuit for easy construction and 7 x 4in. elliptical speaker for fidelity output. Self-contained in neat metal cabinet 8 x 7 x 2½in., with attractive calibrated dial. Speaker and power transistor stage mounted separately approx. 8 x 5 x 3in.

Complete Kit Bargain Price £12.19.6 P&P 3/6.

Instruction booklet and parts list available. 3/6 post free.

TRANSISTOR PORTABLE

Famous manufacturer's 6 x 1 design based on Mullard and G.E.C. developments. Printed circuit, 6BVA 1st grade transistors, XA102, XA101 (2), OA70, XB103, XC101 (2) or equivalents. Quality components only supplied to ensure best results at attractive price.

Set of 6 BVA Transistors and Diode. P. & P. 6d.. 70/-
Printed Circuit, I.F.'s (3), Osc. coil, Driver Trans. and Ferrite rod aerial. P. & P. 1/6 51/6
Resistors, Condensers, Twin Gang and Volume control. P. & P. 1/6 ..... 37/6
7in. x 4in. Quality 35 ohm matching Speaker. P. & P. 1/6 ..... 25/-
Or
Complete Kit at special offer ONLY (post free) £8/19/6
Handbook and Circuit details, post free 2/

KNOBS. Modern Continental types, walnut and ivory.
1¼in. dia. with GOLD RING 1/- ea. Ditto with GOLD CENTRE 1/3 ea.
1in. dia. with GOLD RINGS 9d. ea. Ditto with GOLD CENTRE 10d. ea.
LARGE STOCKS—SEND YOUR ENQUIRIES.

CRT HTR ISOLATION TRANSFORMERS
New improved types, low capacity, small size and tag terminated, A.C. 200/250 v. Secondaries Nil, +25%, +50% BOOST for 2 v., 4 v., 6.3 v., 10.5 v., 12 v. or 13 v. tubes. 12/6 each. P. & P. 1/6.

COAX 80 ohm CABLE

Now only 6d. a yard.

High grade low loss Cellular Air Spaced Polythene—¼in. diam.—Famous mfr.

BARGAIN PRICES—SPECIAL LENGTHS

20 yds. ..... 9/- P. & P. 1/6
40 yds. ..... 17/6 P. & P. 2/-
60 yds. ..... 25/- P. & P. 3/-

Coax Plugs, 1/-; Coax Sockets, 1/-; Couplers, 1/3; Cable End Sockets, 1/6 Outlet Boxes, 4/6.

RE-GUNNED TV TUBES NEW REDUCED PRICES

. . . and now 12 months' guarantee!

All tubes rebuilt with new heater, cathode and gun assembly — reconditioned virtually as new.

12in. £5, 14in. £5/10/-, 17in. £6, etc.

10/- part exchange allowance on old tube

Carr. and ins. 10/-. Comprehensive stocks—quick delivery.

CONDENSERS—Silver Mica. All preferred values, 2 pf. to 1,000 pf., 6d. each. Ditto ceramics 9d. each. Tubulars 450 v. T.C.C. etc., .001 mfd.-01 and .1/350v., 9d. each. .02-.1/500v., 1/- each. .25 Hunts 1/6. .5 T.C.C. 1/9. .001 6kv. 5/6. .001 20 kv. 9/6.

RESISTORS—FULL RANGE 10 ohms—10 megohms 20%, ½ w. and ¼ w. 3d., ½ w. 5d. (Midget type modern rating), 1 w. 6d., 2 w. 9d., 10% Hi-Stab, ¼ w., 5d., ½ w., 7d., 5% ¼ w., 9d., 1% HI-STAB, ½ w., 1/6 (10-100 ohms 2/-).

PRE-SET W/W POTS. T/V type, 25 ohms—50K ohms 3/-. 50K—2 Meg. (Carbon 3/-).

SPEAKER FRET—Expanded Bronze anodised metal 8 x 8in., 2/3; 12 x 8in., 3/-; 12 x 12in., 4/6; 12 x 16in., 6/-; 24 x 12in. 9/-; 36 x 12in., 13/6, etc., etc.

TYGAN FRET (Contemporary pat.), 12 x 12in. 2/-; 12 x 18in., 3/-; 12 x 24in. 4/-; etc.

LOUDSPEAKERS—P.M. 3 ohms, 2½in., Elac, 17/6; 3½in. Goodmans 18/6; 5in. Rola, 17/6; 6in. Elac, 18/6; 7 x 4in. Goodmans Elliptical, 18/6; 8in. Rola, 20/-; 10in. R. and A., 25/-; 10in. W.B.-HF1012, 35/-; 12in. Plessey 15 ohms with 6/4in. Tweeter and Cross Over Filter, 97/6.

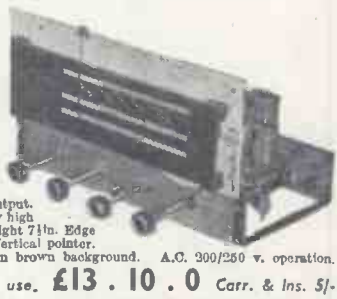
Electrolytics All Types New Stock

TUBULAR		CAN TYPES	
25/25 v. 50/12 v.	1/9	8+8/450 v.	4/6
50/50 v. 100/25v.	2/-	32+32/275 v.	4/6
8/450 v. 4/350 v.	2/3	50+50/350 v.	6/6
16+16/450 v.	5/6	80+250/275 v.	12/6
32+32/450 v.	6/6	100+200/275v.	12/6

Comprehensive range in stock.

VOLUME CONTROLS—5K—2 Megohms. ALL LONG SPINDLES, MIDGET TYPE. 1¼in. diam. Guar. 1 yr. LOG or LIN. Ratios less Sw., 3/-. D.P. Sw., 4/6. Twin gang stereo controls less Sw., 6/6. D.P. Sw 8/-.

7 VALVE AM/FM RADIOGRAM CHASSIS



Valve Line-up: ECC85, ECH81, EF89, EABC80, EL84, EM81, EZ80.

Three Waveband and Switched Gram positions Med. 200-500 m., Long 1,000-2,000 m., VHF/FM 88-95 Mc/s. Philips Continental Tuning insert with permeability tuning on FM and combined AM/FM IF transformers, 460 Kc/s. and 10.7 Mc/s. Dust core tuning all coils. Latest circuitry including AVC and Neg. Feedback. Three watt output. Sensitivity and reproduction of a very high standard. Chassis size 13½ x 6½in. Height 7½in. Edge Illuminated glass dial 11½ x 3½in. Vertical pointer. Horizontal station names. Gold on brown background. A.C. 200/250 v. operation. Magic-eye tuning

Aligned and tested ready for use. **£13 . 10 . 0** *Carr. & Ins. 5/-*

Complete with 4 Knobs—walnut or ivory to choice. Indoor FM aerial 3/6 extra.
10in. Rola (Heavy Duty) 30/-
8in. Goodmans special cone 21/6
Post & Pkg. 1/6.

As previously announced fresh supplies are now being received, but we regret some slight delay may be experienced in fulfilling orders for this popular item.

ONLY A FEW ITEMS ARE LISTED FROM OUR COMPREHENSIVE STOCK. WRITE NOW FOR FULL BARGAIN LISTS, 3d.

Terms: C.W.O. or C.O.D., post and packing up to ½lb. 7d.; 1lb. 1/1; 3lb. 1/6; 5lb. 2/-; 10lb. 2/9.

RADIO COMPONENT SPECIALISTS

70 BRIGSTOCK RD., THORNTON HEATH, SURREY

Established 1946.

Tel.: THO 2188. Hours: 9 a.m.—6 p.m. 1 p.m. Wednesday.

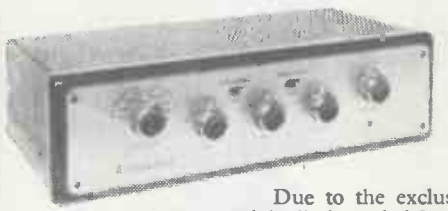
ROTARY RELAY. Superb, fast acting, brand new precision unit made by Price for RCA. Nominally 12 volt, but mighty lively on 6-volt supply. Two heavy duty single pole changeover contacts and one low current for external circuits, plus one break set that extends coil winding to reduce initial energising current to 50 mA. (at 6 v.) for holding. Solid milled armature, laminated steel frame, 2¼ × 2½in. ⅜in. thick, moulded inset dielectric block.
A highly recommended spares box buy at 7/6 each, *post free.*

VENNER TIME SWITCHES

Type T.S.2, first grade precision time switches as supplied to G.P.O. Comprises absolutely silent, self starting, 250 volt 50 c/s synchronous clock mechanism totally enclosed in heavy gauge brass case. Central drive takes detachable dial that revolves to operate sensitive on and off trips for external mains operated circuit. Self contained clock is easily detachable from rear mounting panel (self starting down to 80 v. and keeps running down to 15 v.).
Brand new, in original packings, and with dial and adjustable stops, post paid. **37/6**

HIGH QUALITY POWER PACK

Admiralty Rectifier Unit Design 95, totally enclosed in heavy gauge attractive light grey case size 11½in. high × 6in. wide × 14in. deep. Admiralty ratings: transformer 400–0–400 at 50mA, 6.3 v. at 1 Amp, 5 v. at 3 Amp for 5U4G. Insulation tested to 3 kV. Two 350 ohm 20 henry 80 mA chokes; Two 4 μF at 600 v. ceramic terminal square canned paper smoothing capacitors. Double pole mains switch, two 2A fuses and two spares all in screw-in holders on front panel. 3-pin 250 v. 50 c/s mains input, and 3-pin output with matching plug on short screened cable providing 650 v. D.C. and 6.3 v. A.C. with common earth. An unusually neat, attractive, high quality unit. Brand New, still boxed
for only **50/-** carriage paid.



KIT OF BEAM-ECHO AVANTIC PARTS

Due to the exclusive purchase of a large stock of parts originally intended for the Beam-Echo Avantic combined stereo control unit and power amplifier SPA.11 we are able to offer a kit of all the parts necessary to build this superb piece of equipment—complete to the last nut and bolt, with specially prepared assembly instructions, full circuitry and wiring diagrams, plus a full copy of the handbook—at the BARGAIN PRICE of **£11 plus 7/6 carriage.**

Abridged Specification. Two 7 watt channels switchable for either stereo or 14 watt monaural. Wide-range bass and treble controls, channel and phase reversal. Main and pick-up balance controls. Separate output on each channel for tape. 100-245v mains. Mains outlet socket and tuner power supply provided. Two p.u. and two tape and tuner inputs. 4, 8, and 16 ohms output. Six valves and bridge circuit metal rectifiers. 2xECC83 and 4xECL 82. Less than 1% total distortion at 7 watts. Hum and noise 70 dB.

RF EHT POWER UNIT 846

A small, very neat, lightweight unit of most modern construction providing 1000 volt DC from rectification of self-generated AC. Unit employs a 6C4 oscillator and an EY51 EHT rectifier and incorporates its own HT and EHT smoothing. Requires only 12 or 24v DC for filaments and 250 volts of raw AC to provide the EHT for an oscilloscope etc. Unit also contains a 6J6 arranged as an independent multivibrator with its inputs and outputs connected to a Breeze multisocket on front panel. Size: 4½ × 5½ × 5½in.

Brand New, complete with valves and circuit . . . SNIP . . . **25/-** *post paid.*

1-30-A SIGNAL GENERATOR 100-156 Mc/s
Modern, portable, battery operated, 5 valve Signal Generator with alternative crystal or master oscillator, either optionally modulated by 1,000 c/s Hartley oscillator. Large directly calibrated dial with precision slow motion drive. Five step and variable attenuator. Supplied with matching black crackle carrying case for 6 and 135 volt batteries with 10ft. supply cable, and metal cased 1 mA. test meter for checking crystal resonance, etc. Brand new. £2/17/6 *plus* 7/6 *packing and carriage.*

1-95-A FIELD STRENGTH METER 100-156 Mc/s
Self-contained, tunable-input, valve-voltmeter with telescopic aerial and battery-fed diode rectifier and pentode amplifier for measuring field strength, presence of modulation, and approximate frequency of transmitter. Compensating circuit for state of 1½ and 45 volt batteries. In attractive black crackle case. Brand new.
£2/5/- *plus* 5/- *packing and carriage.*

INVERTERS

28 Volt DC To 115v 1 phase AC
Self-contained motor generator unit with complementary carbon pile voltage regulator, contactor and associated rectifier in separate compartment on same base. Continuously rated for 25/28 volts D.C. input with 360 VA output at 115 volts single phase A.C. at 1,600 cycles with a power factor of 1.0. Fan cooled with end plate for blast or internal cooling as required. Type 200. Ref. 5UB/5083.
In first class condition. **£4.10.0** carriage 7/6

24 Volt DC To 115v 3 phase AC
Output 260 Watts. In first class condition.
£12.10.0 carriage paid

200/220 Volt DC To 200/250v 1 phase AC
Output 260 Watts. New, in soundproof cabinet. **£9.10.0** carriage paid

24 Volt DC To 26v 1 phase 400 c/s AC
Output 6 VA. Size 2½in. dia. x 4in. long on 1½in. high pedestal base. Instrument quality. As new. **£1.10.0** carriage paid

BC.929 SCOPE UNIT
Neat, modern indicator unit especially suitable for quick conversion to attractive general servicing scope. **(Suitable circuit diagram and all component values supplied.)** Contains fully mumetal screened 3BP1 tube, intensity and focus controls, 3-position rotary switch and 8 pre-set, potentiometers, plus 2×6SH7, 2×6H6, 6G6, 6X5 and 2X2 valves. Designed for 24 v. D.C. or 400 c/s A.C. input. Size 14 × 8½in. square. Well known and deservedly popular buy. Offered new, less (unwanted) motor driven aerial switching unit, for post paid. **50/-**

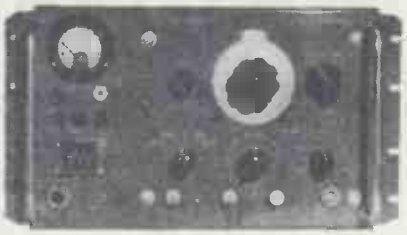
400 CYCLE CHOPPER

Latest version of U.S.A. Servomechanisms 400 c/s chopper. High quality 6 v. vibrator oscillating between twin contacts for chopping external circuit. Hermetically sealed in octal based can.

Brand New **£2** *post paid.*

CHROMEL/ALUMEL THERMOCOUPLE LEADS
7, 10 and 21 foot lengths of flat twin lead —90% nickel, 10% chrome and 95% nickel, 5% aluminium. Total resistance 0.875 ohms. For use with millivoltmeter to read 0 to 1,000°C. Sheathed in heat resisting silicon rubber that will stand 200°C. Price, post paid, 7/6, 10/6 and 21/- respectively.

PRECISION SIGNAL GENERATOR CT53. A modern laboratory standard instrument still in current use



FEATURES

- Vernier tuned, Triple screened, 6-Band coil turret covering 8.9 to 300 Mc/s with 72 ohm output from 100 mV down to 1 μV.
- Precision decade ladder and silver slide wire attenuator calibrated in voltage and 0–90db.
- Variable carrier level monitored by cathode follower and VTVM.
- CW or modulated 30% by 1,000 c/s Sine or Square wave (variable mark/space ratio).
- External mod, by sine wave from 50 c/s to 10 kc/s. or pulses down to $\frac{1}{2}\mu$ Sec.
- Seven B7G Valves, Potted "C" core transformers, Paper capacitors, Stabilised H.T.
- Selected spare oscillator, pre-aged spare monitor, 100μA meter.
- Mains, H.T., Bias and Filament supplies fully RF filtered.
- Combined cabinet/rack mounting case, Pressure sealed, Desicator, Panel Mains voltage adjustment, Triple fused, in fact, "the lot"!

Offered straight from Service use, complete with calibration book, cables, circuit diagram and principal technical information, checked serviceable and fully guaranteed. Plus 15/- for careful packing and carriage **£17.10.0**

TWIN TUBE CRT INDICATORS

Attractive, lightweight, black crackle box 11 × 7 × 13½in. deep with 4 × 2½in. and 3½ × 3in. square windows on front panel for twin 5FP7 tubes. Neat arrangement of appropriate (independent) controls and variable scale illumination. Totally enclosed detachable magnetic focusing coils. All connections to rear sockets. Ideal TV monitoring unit as used by many amateurs. Used, but in very good condition, tubes guaranteed O.K. £1/10/0 carriage paid.

MOBILE PUBLIC ADDRESS AMPLIFIERS

Output 10 watts. Made by B.S.R. 12 v. D.C. Supply. Used but in good working order. £3 . 15 . 0. Carr. 10/-. A few only less power supply at £2 . 10 . 0, Carr. 7/6.

CRYSTALS

British ¾-inch Spacing.

3.5 Mc/s—3.8 Mc/s. inc.
7.0 Mc/s.—7.3 Mc/s. inc. } 9/6 ea. Post Paid.
8.0 Mc/s.—8.1 Mc/s. inc.

American ½-inch Spacing. F.T.241A.

Available from 20.1 Mc/s.—27.9 Mc/s. in 100 Kc/s. Steps. Fundamental Frequencies 1/54th of the above. 9/6 ea. Post Paid.

Any Crystal Between 2.2 Mc/s.—9.0 Mc/s. Excluding those listed above..... 7/- ea. Post Paid.

Brand New, Individually Tested, Fully Guaranteed

LOW-VOLTAGE, HALOGEN-QUENCHED, GEIGER-MUELLER TUBES 25/- post free

Working voltage 400–450. Highly sensitive. Effective length 11.8 cm. Background count 90/minute. Response 30,000 counts/minute. 80-volt plateau. Standard British 4-pin base, stainless iron electrode. Ideal for basic experimentation and instructional demonstration. Circuits of simple all transistor and conventional valve counter circuits supplied on request with each tube.

WALKIE-TALKIES Type 46

This is a later type than those previously available. A really serious job of sound design, crystal controlled, 10 mile range, transmitter and receiver covering any one frequency between 4125 and 7100 kcs in 25 kcs steps with standard crystal supplied—or any spot frequency between 3600 and 9000 kcs with special crystal supplied to order. Brand new, complete with headphones, throat mic., whip-antenna, plugs and leads. Size: 12 x 4 x 6½in. Weight 8½lb.

Price, with standard crystal ..... **£3/10/0** *carriage paid*
with chosen spot frequency crystal ..... **£7/15/0** *carriage paid*
Batteries required: 150, 15, and 3 volts. Transistorised converter to operate from 6v. or 12v. D.C. ..... **£8/10/0** *extra*

ELECTRIC STOP-WATCH OPERATOR

Simple aluminium stand 4in. square and high with powerful twin solenoids operating a pivoted bar that depresses knob of stop-watch when it is fitted into clips provided on front panel. Designed for precise remote control by 24 volt line to terminals at rear, but works satisfactorily off 12-volt supply. A very useful buy (without watch) for **11/6** post free.

TRANSISTOR AMPLIFIER KIT

Printed circuit, 500 milliwatt push-pull output. Input and output transformers of 3 ohms impedance with two OC.71 and two OC.72. Supplied complete with all condensers, resistors, volume control, etc. Input 9 volts. for only **52/6** post paid

Cold Cathode Trigger Tubes

A sub-miniature cold cathode valve developed by Ericsson primarily for computor work, these GTR.120W tubes have great possibilities in a number of experimental electronic automatic control circuits. They have an Anode-Cathode running voltage of 95 to 140 at 4.5 mA, and at 290 anode volts require a trigger current of only 250 microamps to cause the anode to take over the discharge. Typical ionization time = 90 micro-seconds. They will withstand up to 310 v. with zero trigger voltage without self-igniting.

Supplied complete with full performance data in original packs of 100 at the Special Price of **£5** *per 100 post paid*

MAINS TRANSFORMERS

200-250 volt 50 c/s. post paid

Type 1.	250–0–250 at 70mA.	6.3v at 2A. 4v at 2A.	10/-
2.	300–0–300 at 70mA.	6.3v at 2.5A. 5v. at 2A.	10/6
3.	350–0–350 at 120mA.	6.3v at 3.5A. 5v at 2A.	17/6
4.	350–0–350 at 300mA.	6.3v at 8A. 5v at 2A plus 4v at 2A and 6.3v at 2A.	27/6
5.	Filament only:	6.3v at 4A.	8/-

1934 & 1935 TRANSMITTER/RECEIVER

TRANSMITTER	£4 10 0	Carriage Paid.
I.F. STRIP ...	£2 5 0	WITH CIRCUIT DIAGRAM
MODULATOR ...	£1 5 0	AND CONVERSION
RECEIVER ...	£1 10 0	DETAILS.

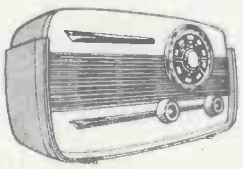
Special offer

Complete Units with control boxes.

FOR EXPORT ONLY. PLEASE ENQUIRE.

PROOPS BROTHERS LTD., 52 Tottenham Court Road, London, W.1.
Head Office and mail order enquiries, Dept. M, LANgham 0141
Shop hours 9 a.m. to 6 p.m. Thurs. 9 a.m. to 1 p.m. OPEN ALL DAY SATURDAY

HARVERSON SURPLUS CO. LTD.



HARVERSON SUPERHET 4 KIT

A medium and long wave superhet, incorporating two I.F. stages modern B9 valves (UCH81, UBF89, UCL83, U785), built-in ferrite rod aerial. All you need supplied, from theoretical wiring diagram to last nut and bolt (main components ready mounted), including an attractive contemporary styled cream plastic cabinet with gold trimmings. Size 11¼ x 4½ x 6¼in.

PRICE **£6.12.6.** Post 3/6

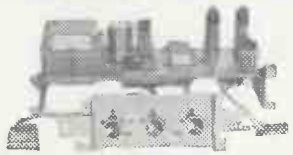
STEREOPHONIC AMPLIFIER £5.10.0

Complete with 2 Loudspeakers

Plus 4/6 P. & P.

This is a compact amplifier embodying the latest features and giving a high standard of reproduction, with ample volume. Supplied complete with valves (ECL82, ECL82, EZ80), panel, knobs, etc., and two specially selected 3 Ω matched loudspeakers. We only have a few, and we will never be able to repeat this offer at such a low price! Don't risk disappointment! Order now!

MONAURAL AMPLIFIER



This amplifier as illustrated, made by a leading manufacturer. Mullard valves—ECC83, EL84 x EL84, EZ80. Bass Treble and Volume on remote panel. Elegant Knobs. OUR PRICE one month only £4/16/6, plus P. & P. 3/6.

CONDENSER/RESISTOR PARCEL

50 mixed P.F. Condensers and 50 mixed Resistors. An assortment of useful values. All popular sizes—all new—a must for the serviceman and constructor **ONLY 10/-** P. & P. 1/-.

COSSOR C.R.T. SNIP

108K 10-inch. New and boxed, **15/-**, plus 6/- P. & P.

75K 10-inch. New and boxed, **15/-**, plus 6/- P. & P.

ION TRAP MAGNETS

To suit the above, **2/9** each. P. & P. 3d.

SPEAKER FRET

Super quality heavily woven fret, 54 inches wide. Usual price, 50/- per yard. P. & P. 1/-. OUR PRICE **12/6** per yard.

TRANSISTOR BARGAINS

ALL MULLARD FIRST GRADE

OC71	8/-
OC72	12/-
OC72 Matched Pair	25/-
OC45 Green Spot	15/-
OC45 Blue Spot	15/-
OC44	15/6
SB305 Semi Conductor	10/6
OA41 Diode	3/6

★ Postage on all above 6d.

SPECIAL OFFER

DON'T MISS THIS

MULLARD OC. 76 MATCHED PAIR 10/6

£1.0.0

Post and packing 6d.

THIS MONTH'S BARGAIN!

SUPERHET CHASSIS

Complete and ready for your cabinet, 4 valve superhet chassis. Complete with valves, ferrite aerial, dial and knobs. Valve line up—UCH81, UBF89, UCL83, UY85. Long and Medium wave coverage.

PRICE **£4.19.6** P. & P. 3/6.

CYLDON 12 CHANNEL TURRET TUNERS

New purchase offered at still lower price. I.F. 33-38 Mc/s. Complete with PCC84 and PCF80 valves and 8 sets of Coils for 5 Band I channels and 8, 9, 10 Band III. New and unused. Value over £7. OUR PRICE, Post paid..... **32/6**

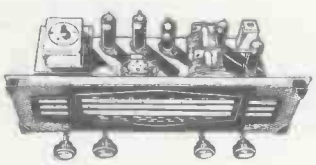
TRANSISTOR RECORD PLAYER CASE

A few only—Transistor record player cases in light grey cloth—complete with motor board. Size: 12 x 8 x 6in. 18/6 each. P. & P. 1/9.

MIDGET I.F. TRANS & COILS

A pair of midget 465 kc/s I.F. transformers, plus LW and MW coils. OUR PRICE 10/- per set. P. & P. 1/9. Set of I.F. transformers for transistor superhet. 12/6. P. & P. 1/9.

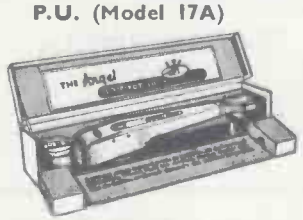
HARVERSON'S A.M. RADIOGRAM CHASSIS



A chassis of distinction, by a famous maker. Covering Long, Med. & Short Waves, plus. gram position, this chassis (Size 15½ x 7 x 6½in. high) incorporates the latest circuitry, using fully delayed A.V.C., and negative feedback. Controls:—Tone, Vol.-On/Off, W/Change (L.M.S. & Gram) Tuning. Tapped input 200-250 v. A.C. only. An attractive brown and gold illuminated dial with matching knobs, make this one of the most handsome, in addition to being one of the best performing chassis yet offered. Complete with valves (ECH81, EF89, EBC81, EL84, EZ81), knobs, output transformer, leads etc. OUR PRICE ONLY **£9.19.6** plus 4/6 post and packing.

BARGAINS IN GRAM & TAPE EQUIPMENT

The WORLD FAMOUS E.M.I. ANGEL TRANSCRIPTION P.U. (Model 17A)



A Pick-up for the connoisseur originally priced at £17/10/0. The last remaining few offered at **£4.10.0** Plus P. & P. 5/-.

PICK-UP CARTRIDGE BARGAINS

STUDIO P	**17/6**
ACOS HIGH G.	**17/6**
E.U. POWER POINT	**12/6**
RONETTE	**18/6**
G.C.Z.	**16/6**

P. & P. 1/-.

RECORD CHANGERS

GARRARD	RC 98 Mk. 4H.	4-speed autochanger	£16 10 0
	RC 120/D Mk. 2	,, ,,	£9 0 0
	RC 120 Mk. 4D	,, ,,	£9 0 0
	RC 120 Mk. 4H	,, ,,	£9 0 0
	RC 121 Mk. 1	,, ,,	£11 0 6
	RC 121 Mk. 4H	,, ,,	£11 0 6
	RC 121/40 Mk. 2	,, ,,	£11 0 6
COLLARO	RC 54	4-speed autochanger ...	£6 19 6
	RC 594	,, ,, ...	£7 19 6
	Conquest	,, ,, ...	£6 12 6
	Challenger	,, ,, ...	£7 19 6
B.S.R.	Monarch UA8 4-speed autochanger ...		£6 19 6
	TU8 4-speed single player less pick up		£2 10 0

NOTE: Any of the above with Stereo Cartridge and Fittings, 16/- extra. Carriage and ins. on each of above 5/- extra.

TAPE DECKS

LATEST B.S.R. MONARDECK (single speed) 3¾in. per sec., simple control, uses 5¾in. spools..... £7 5 0

plus 5/6 carriage and insurance (tapes extra).

TRUVOX MK. III TAPE DECK. New and boxed..... £10 6 6

RECTIFIERS FOR BATTERY CHARGERS

12 v. 1 amp.	5/-
12 v. 2 amp.	8/-
12 v. 3 amp.	10/-
12 v. 4 amp.	14/-
12 v. 5 amp.	16/-

P. & P. 6d.

WIRE WOUND POTS

12 Wire wound Colvern Pots—all different values. P. & P. 9d. **10/6**

SLOW MOTION TUNERS

500-500 Twin gang condensers with geared slow motion drive. 3/6 each. 36/- per doz. P. & P. 6d.

83 HIGH STREET, MERTON, S.W.19

CHErrywood 3285/6/7

HARVERSON'S SUPER STEREO KIT

The product of a world-renowned manufacturer, this stereo amplifier is composed of a number of compact " ready-built " units, only requiring interconnection. This system has the big advantage of being easily adaptable to fit any cabinet. Each unit is extremely well made from first-grade components, and all valves employed (ECL82, EZ80 range) are genuine Mullard. The comprehensive instructions supplied with each kit make the simple interconnection of units easy even for the novice.

THE KIT COMPRISES . . .

TWO MIDGET AMPLIFIERS each capable of 3W output. The reproduction is good, enabling you to get the best from both your stereo or monaural recordings. Both amplifiers are complete with well-designed output transformers providing perfect matching to standard 3-7Ω loudspeakers, and have remote bass, treble and volume controls. Size 5" x 2½" x 3" high (each amplifier).

CONTROL UNIT, this is a flying panel fitted with three 2-gang potentiometers, enabling the bass, treble and volume controls of each amplifier to be positioned in the most convenient place in your layout. These dual controls are equipped with attractive cream and gold knobs and an escutcheon is provided for the complete panel.

SEPARATE POWER PACK complete with valve rectifier, although of midget size (5" x 2" x 3¼" high), provides power for complete amplifier equipment.

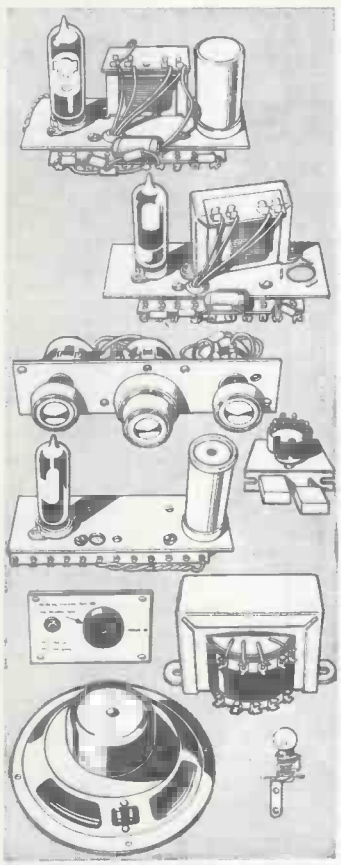
ISOLATED MAINS TRANSFORMER of robust construction is a separate unit and may be mounted independently.

VOLTAGE SELECTION PANEL. Consisting of a panel fitted with the " valve base " type of mains input selector and a channel output socket.

ONE LOUDSPEAKER, a good quality 5-Inch speaker, specially selected for this equipment. (**Note:** The second speaker may be purchased from us for an additional 14/6.)

CREAM DOUBLE PUSH BUTTON SWITCH of attractive design gives positive on/off switching action.

INDICATOR LIGHT. This pilot light provides visual indication that the equipment is operating, and is complete with an attractive gold-finished escutcheon.



This kit, which is complete in every way, is exclusive to HARVERSON'S. who are proud to present it at the amazing price of ... ...

59/6

PLUS 6/6 POST AND PACKING

THE PERFECT PARTNER!

B.S.R. MONARCH U.A.12 STEREO CHANGER

Especially suitable for the above amplifier. A few only.

OUR BARGAIN PRICE ONLY £9.0.0 plus 5/- carr.

GUARANTEED VALVES ★ NEW and BOXED ★ PROMPT DESPATCH ★ POST 6d. per valve extra

ACHLDDD 9/3	EBF80 9/-	EF91(BVA) 8/6	KT24 4/6	PX25 11/9	U25 13/-	VP13C 3/3	1H5GT 10/-	6AT6 8/-	6K8GT 6/6	7B8 5/6	12BG7 7/-	35W4 7/-
AC/P 7/-	EBF89 9/-	KT32 9/3	PY80 7/-	U26 11/9	VP23 6/-	1L4 6/-	6AU6 9/9	6K7GT 5/6	7C5 7/6	12BH7 5/6	35Z4GT 7/6
AC/P4 7/-	EBL21 22/-	EL32 4/3	KT33C 8/-	PY81 8/-	U37 25/-	VP41 8/-	1LD 3/-	6B8G 3/9	6K8GT 9/9	7C6 7/6	12SJ7 5/6	42 7/8
AC5PEN	EBL31 22/-	EL33 13/-	KT36 28/-	PY82 6/6	U45 14/-	VP133 14/-	1N5 9/6	6BA6 7/-	6K95 18/6	7D6 12/6	12SK7 5/6	35Z3 15/6
DD 25/9	EC31 7/-	EL38 24/6	KT55 10/3	PY83 8/-	U50 7/6	VR22(PM 2A) 2/9	1R5 7/-	6BE6 7/6	6L1 14/6	7H7 8/6	12SN7 7/6	35Z5GT 8/6
AC6PEN 6/-	EC81 7/6	EL41 9/6	KT61 9/6	PZ30 18/6	U76 7/6	VR105/30 1S5	1S4 9/9	6BG6G 22/-	6L6G 7/6	7Q7 8/6	12SL7GT 50C5 10/9
AC6PEN 6/-	EC82 7/-	EL42 9/6	KT63 7/-	PEN4DD U191 10/6	6/-	6BH6 8/6	6L6M 9/-	7S7 9/- 14/-	50CD6G
ACVP1/50/3	EC83 8/6	EL81 15/6	KT66 16/-	U339 11/9 7/6	1T4 5/6	6BJ6 8/6	6L7G 7/-	7Y4 8/-	12SQ7 8/- 28/6
ATP4 3/3	EC84 9/3	EL84 5/6	KT88 21/-	PEN4VA U403 15/6	VR116 3/9	2C26 1/3	6BR7 11/9	6L18 10/3	8D2 2/6	14S7 15/9
AZ1 9/3	EC85 9/-	EM84 8/9	KTW61 6/-	U404 10/6	VR150/30 2P 25/-	6BW6 8/6	6L19 14/-	9D2 3/3	15D2 7/3	50L6GT 8/-
AZ41 11/2	ECF80 11/3	EM80 9/3	KTW63 5/-	U801 28/- 7/-	2X2 4/-	6BW7 8/-	6N7GT 7/-	10C1 11/9	19AQ5 9/-	75 10/9
B36 14/-	ECF82 12/5	EM81 9/6	KTZ41 3/3	PEN45 6/6	UABC80 9/6	6C4 3/9	6P28 25/-	10C2 16/9	19BG6G 3/-	77 7/-
CBL31 22/9	ECH21 22/-	EY51 9/3	MH41 6/6	PEN38322/-	VU120A 3/3	3A4 8/6	6Q7G 7/-	10F1 14/6	20D1 5/-	80 8/-
CCH35 22/9	ECH42 9/-	EY86 9/3	ML4 8/-	PEN220A	UAF42 8/9	VU39(MU 12/14) 8/6	3A8GT 5/6	6C5GT 6/-	10F9 14/6	20P2 25/-	142BT 3/3
CL4 11/9	ECH81 8/6	EZ40 7/-	M84B 16/- 3/9	UBF80 8/9	3D6 4/6	6C6 4/6	6Q7GT 9/-	10L1 9/-	20L1 25/-	185BT 30/-
CL33 18/-	ECL80 9/3	EZ41 7/-	M8P4/5 7/-	PEN45DD	VU111 2/3	3Q4 7/6	6C31 7/-	6SA7GT 7/6	10LD11 9/6	20P1 25/-	210DDT 4/3
CY31 15/9	ECL82 9/9	EZ80 6/6	M8P4/7 7/- 25/-	UCC85 10/6	W76 7/-	3S4 7/-	6D6 4/6	6S7 7/-	10P13 16/6	20P3 22/-	210VPT 3/3
CV73 5/9	EF22 8/-	EZ81 6/8	MV8/PEN PENA4 14/8	UCC80 15/6	W77 8/-	3V4 8/-	6CH6 9/9	6S8 7/-	6SH7 5/6	10P14 18/-	20P4 25/-	83 9/9
D36A 6/-	EF36 4/6	EZ90 7/- 9/3	PM12M 7/6	UCH42 9/9	W72 9/9	4D1 2/9	6F6G 7/-	6SK7 5/6	12A6 6/-	20P5 22/-	301 9/9
DAF96 8/3	EF37A 14/-	E1148 1/9	MX40 16/-	QP21 4/6	X22 16/9	5B4GY 9/-	6F6M 7/-	6SL7GT 7/6	12AT6 10/-	25A6G 9/9	302 9/9
DF96 8/6	EF39 5/3	FC13 6/-	N37 18/6	R16 25/-	X41C 16/9	5U4G 6/3	6F1 13/-	6SN7GT 7/-	12AT7 7/-	25L6GT 9/6	305 9/9
DH 63 11/6	EF40 13/6	FW4/500 9/3	N78 18/6	SP41 2/9	X101M 11/6	5V4 10/9	6F13 13/-	6SQ7 8/9	12AU6 7/6	25Z4 9/-	306 9/9
DH101 11/6	EF41 9/3	GTIC 25/6	N339 28/-	SP61 2/9	Y63 8/6	5Y3G 7/6	6F15 13/-	6U4GT 11/3	12AU7 7/6	25Z5 7/6	307 9/9
DK96 8/6	EF42 10/3	GZ32 11/-	OZ4 5/-	SP4/5 9/9	Z21 9/9	5Y3GT 7/6	6F17 11/9	6U5/6G5	12AX7 7/6	25Z6 9/6	308 9/9
DL96 8/6	EF50 3/9	H30 4/6	P61 3/3	SP4/7 9/9	Z309 7/-	5Z4G 8/6	6F33 16/6 16/-	12BA6 8/6	27SU 18/6	309 9/9
DL145 9/3	EF50SYL H63 9/3	PC84 8/6	T41 22/-	UL41 9/6	Z359 7/-	5Z4M 9/6	6H6 2/3	6U5G 8/-	12BE6 8/6	30C1 9/9	807 6/-
DM70 7/- 6/6	HL23DD 8/-	PCF80 9/-	TDD13C 7/-	UL44 25/-	0A7 10/6	6H6GT 2/3	6U7G 8/-	12C8 8/6	30F5 9/9	954 1/9
DN41 16/6	EF54 5/6	HL22 6/-	PCF82 11/9	TH233 17/6	UL46 25/-	6A8G 8/6	6J5GT 4/6	6V6G 5/6	12E1 32/6	30FL1 9/9	955 3/9
EA50 1/3	EF55 9/3	HL41 3/3	PCL82 11/6	TP22 7/6	UL84 8/6	1A5GT 5/6	6AC7 6/-	6J5M 6/-	6V6GT 7/3	12H6 3/3	30L1 18/6	956 3/3
EABC80 8/6	EF80 7/-	HN309 23/-	PCL83 13/6	TP25 25/-	UU6 19/6	1A7GT 11/9	6AG5 5/3	6J6 5/6	6X4 7/-	12J5GT 2/9	30P4 19/-	5763 10/9
EAF42 9/6	EF85 7/-	K40N 8/6	PL38 18/6	U10 9/9	UU8 25/-	IC2 11/-	6AK5 6/-	6J7G 6/-	6X5G 6/6	12J7GT 10/-	30P12 11/9	9002 5/-
EB34 1/9	EF86 11/6	KF35 8/-	PL36 14/6	U14 8/-	UY1N 11/9	IC5GT 11/9	6AL5 6/-	6J7M 8/6	6X5GT 6/6	12K7GT 7/-	30P16 9/-	9003 5/-
EB41 8/-	EF89 8/-	KK32 20/6	PL81 11/9	U16 11/9	UY21 11/9	ID5 11/9	6AM5 11/9	6K7G 3/9	6/30L2 11/9	30PL1 11/9	9004 5/-
EBC 33 6/3	EF91 5/6	KLL32 8/-	PL82 8/-	U17 11/9	UY41 7/-	1D6 11/9	6AM6 4/6	6K7M 6/3	7B6 9/9	12K8GT 13/-	35L6GT 9/3	9006 5/-
EBC41 8/9		KT2 4/6	PL83 11/-	U22 7/6	UY85 6/6		6AQ5 7/-	6K8G 7/-	7B7 8/-	12Q7GT 7/-	25Y5 9/3	

TRANSFORMERS

POTTED C CORE

Pri.: 230v. 50 c/s. Sec.: 450-0-450v. 220 mA. 5 v. 3 amps., 6.3 v. 5 amps., 6.3 v. 3 amps. £2/10/-.
Pri.: 230 v. 50 c/s. E.S. Sec.: 500-0-500 v. 500 mA. 6.3 v., 500 mA., 6.3 v. 5 amps., 5 v. 6 amps. £3/10/-.
Pri.: 230 v. 50 c/s. Sec.: 6.8 v. 5 amps., 6.3 v. 1 amp., 6.3 v. 3 amps., 6.3 v. 1.5 amps., 6.3 v. 2 amps., 6.3 v. 3 amps., 6.3 v. 4 amps. £1/12/6. Carr. 5/- each item.

MAINS ISOLATING TRANSFORMER (Gresham). Pri. 230/250 v. Secs. 240-0-240 v. 1.5 amps., 5 v. 12.5 amps. Potted. Size 7in. x 7½in. x 10½in. Weight 50 lb. Ideal for obtaining TWO ISOLATED 240 v. lines at 360 watts each. Perfect condition. 80/-. Carr. 10/-.

L.T. TRANSFORMERS for Battery Chargers etc. All Pri.: 200/250 v. Tapped 50 cycles. Type 048B. Sec. 24, 30, 36 v. 6 amps. 4 x 4 x 4in. £2/9/6. Type 066A. Sec. 18, 24, 30, 36 v. 8 amps. 4 x 4 x 5in. £3/19/6. Type 053A. Sec. 12, 24, 30 v. 10 amps. 4 x 5 x 5in. £4/4/-. Carr. 3/6 each item.

AUTO TRANSFORMERS. 0-110, 205, 225, 245 v. Fully shrouded. Terminal block connectors.
Type 063A. 500 w., 4 x 5 x 5in. £3/7/6. Carr. 3/6.
Type 064A. 750 w. 4 x 6 x 5in. £3/17/6. Carr. 3/6.
Type 065A. 1,000 w. 4 x 7 x 5in. £4/17/6. Carr. 5/-

6 kV/A. AUTO TRANSFORMER. 250/110 v. 50 cycles (fully tapped primary and secondary). Capable of 25% over actual rating. Brand new and unused, £15. Carr. 20/-.

20 kV/A. AUTO-TRANSFORMER. 230/115 v. 50-60 cycles, by Jefferies Transformer Co., U.S.A. Perfect condition, £20. Carr. 20/-

CONSTANT VOLTAGE TRANSFORMER 190-260 v. primary, sec. 115 v. at 1½ kV/A. (listed at 2 kV/A). Brand new and unused. £25 or £45 per pair. Carr. 10/- each.

E.H.T. TRANSFORMER. 8,000-0-8,000 at 400 mA. Primary 230 v. 50 cycles. Oil filled. New and in original crates. £25. Carr. 10/-.

E.H.T. TRANSFORMER. 1,800-0-1,800 at 1 kV/A. 230 v. 50 cycles primary. Fully tropicalised. New and boxed. £6/10/-. Carr. 10/-.

E.H.T. TRANSFORMER. 1,100-0-1-1,100 at 250 mA. plus 4 v. L.T. Pri. 200/250 v. at 50 cycles. £5. Carr. 10/-.

HEAVY DUTY REGULATING RESISTOR. 0.25 ohm. 200 amps. Wheel control. £4/15/-. Carr. 10/-.

CONDENSER, oil filled. 240 mfd. 230 v. A.C. or 600 v. D.C. Made in U.S.A. Size 21in. x 5½in. x 9in. Brand new in original cases. £7/10/-. Carr. 5/-.

ROTARY CONVERTER. 24 v. D.C. input. 230 v. A.C. output at 250 watts. Complete with starting switch. New and unused. £15. Carr. 7/6.

ROTARY CONVERTER. 24 v. D.C. to 230 v. A.C. 50 cycles, 150 watts. Brand new and unused. £8/10/-. Carr. 7/6. Ditto, 100 watts £6/9/6. Carr. 7/6.

ROTARY CONVERTER. Ex-Govt. 12 v. D.C. input, 230 v. A.C. output 50 cycles at 135 watts. Complete in carrying case with lid. Voltage control, sliding resistance, mains switch and 0-300 v. A.C. flush meter. In good condition. £10. Carr. 10/-.

Motor only, without case, etc. Brand new and unused. £8/10/-. Carr. 5/-.

S.T.C. SELENIUM METAL RECTIFIERS. F/B, FOR BATTERY CHARGERS, ETC. NEW AND FULLY GUARANTEED.

6 or 12 v. 1 amp.	5/-	24 v. 1 amp.	10/-
12 v. 2 amp.	7/6	24 v. 2 amp.	15/-
12 v. 2½ amp.	12/6	24 v. 3 amp.	25/-
12 v. 4 amp.	15/-	24 v. 4 amp.	30/-
12 v. 6 amp.	20/-	24 v. 6 amp.	32/6
12 v. 10 amp.	35/-	24 v. 10 amp.	70/-

A.C.-D.C. RECTIFIER POWER SUPPLY UNITS

110/230 v. A.C. 50 cycles input, 100/110 v. D.C. output max. 2½ amp. Brand new and unused. £4/10/-. Carr. 7/6.
230 v. A.C. 50 cycles input, 200/220 v. D.C. output at 3/4 amps. approx. Good condition. £10. Carr. 10/-.
200/250 v. pri. 110 v. sec. at 4 amps. max. Brand new and unused. £8/10/-. Carr. 10/-.
Type 67. 200/230 v. A.C. 50 cycles input, 240-0-240 v. D.C. output at 1½ amps. (Valve rectification.) Fitted with switch fuses, regulator and overload controls. Brand new in maker's original crates. £10. Carr. 10/-.

R.C.A. AR88-D RECEIVER

Mint condition. Freq. coverage 540 Kc/s., 32 Mc/s. £50. Carr. 20/-. Also L.F.'s available. Freq. coverage 75-550 Kc/s., 1.5-30 Mc/s. £45. Carr. 20/-.

GEE BROS. (RADIO) LTD.

15 LITTLE NEWPORT STREET, LONDON, W.C.2. *GER. 6794/1453*

ADJOINING LEICESTER SQ. TUBE STATION—Open 9-6 Weekdays. 9-1 Sat.

QUALITY TEST EQUIPMENT

WAVEMETER CLASS D. Freq. band 1,900 Kc/s. to 8,000 Kc/s. (158-37.5 metres) in two ranges, 1,900 Kc/s.-4,000 Kc/s. also 4,000 Kc/s.-8,000 Kc/s. Supply 6 v. D.C. input. Complete with twin crystal, spare vibrator, headphones, original instruction manual and transit case. Condition as new. £5/5/-.

EVERSHED AND VIGNOLES MEGGER CIRCUIT TESTER (low reading ohm meter). 2 ranges 0-3, 0-30 ohms. The perfect meter for continuity and polarity testing, complete with test leads and ready to use. Brand new. Only £4/17/6. P. & P. 3/-.

RBIDGE MEGG ERS. Evershed and Vignoles Series 2 in perfect condition. 250 v. £22. Carr. paid. Leather case available at 20/- extra.

MARCONI SIGNAL GENERATOR. TYPE TF511-F/1. Covering 10-18 Mc/s. 33-58 Mc/s. 150-300 Mc/s. In very good condition. Complete with full technical data and instructions. Unrepeatable at only £12/10/-. Carr. 20/-.

BRAND NEW CRYSTAL CALIBRATOR No. 10. (Battery powered 1.4 v. valves.) Complete with full working instructions, circuit diagram, carrying haversack, connecting lead and spare valves. Frequency range: 1.5 to 10 Mc/s. (nominal) but can actually be used up to 30 Mc/s. Weight 5lb. Size 7 x 7½ x 4in. As fully described in "Practical Wireless." Dec. issue, pages 691-693. ONLY £4/19/6. P. & P. 2/6.

MULLARD BRIDGE. Type GM. 4140/1. Mains operated from 100-250 v. A.C. Will test resistances from 0.1 ohm to 10 megohms and condensers from 10pf. to 10mfd. Good condition and complete with instruction booklet. £6/19/6. P. & P. 2/6.

TAYLOR VALVE TESTER Model 47A. Input 200-250 v. A.C. Will test all types of English and American valves with filaments from 1.1 v. to 117 v. Perfect condition. Complete with full instruction manual, £12/10/-. Carr. paid. Also MODEL 45A available at £10/10/-.

VALVE TESTER TYPE 4. 200/230 v. A.C. input. Ex-Govt., in good condition, with descriptive book containing circuit diagram of Instrument and how to test valves from 1.4 v. to 40 v. With valve holders for Brit. 4, 5, 7 pin and Octal, U.S., 5 and 7 pin, 1/Octal, side contact large Brit., 4 and 9 pin. Acorn and diode. Housed in substantial wooden case with hinged lid. Few only, to clear at £5/19/6. Carr. 7/6.

G.P.O. RACKS
19in. Heavy duty all steel Standard drilling.
5ft. 6in. angle uprights.
£3/10/-. Carr. 15/-.
6ft. channel uprights. **£5.** Carr. 15/-.

10-LINE TELEPHONE SWITCH-BOARDS. For the complete control of 10 extensions (Tele. "F" etc.). Complete with jacks, leads and operator's hand set. Good condition. £9/19/6. Carr. 10/6.

TELEPHONE SETS (TELE "F") Housed in Bakelite cases, complete with built-in ringing generators and batteries. Ideal between two or more positions up to practically any distance. Tested before despatched. ONLY 70/-. P. & P. 3/6. 2 sent for £6/10/-. Carr. paid.

TELEPHONE CABLE. Twin one-mile drums (Don 8), £5. Carr. 20/-. Single one-mile drums (Don 3), 50/-. Carr. 7/6.

12 VOLT D.C. AMPLIFIER (Parmeko, Ardente). As new. 15 watt output with 2-EL35's in push-pull. Mike and gram. inputs, tapped output transformer, £9/19/6. Carr. 10/6.
(Suitable hand microphone for above 30/- extra.)

EXPONENTIAL HORNS by famous manufacturer of P.A. systems, 15 watt, 25in. long, 20in. square flare 15 ohms speech coil. (Tannoy). Good condition. £7/10/-. Carr. 10/-.

NEW P.M. HEAVY DUTY SPEAKERS. Complete with O.P. trans., in all steel blue-grey double grilled cabinet. 6in. 30/-. 8in. 32/6. Carr. 3/6 each.

RE-ENTRANT LOUD HAILERS (Ex-Govt.). Heavy duty 20 watts all-metal 15 ohms. Diameter 15in., length 15in. (approx.). Good cond. £6/10/-. Carr. 10/-. Ditto. Brand new, £8. Carr. 10/-.

HEAVY DUTY ALL STEEL TRIPOD STANDS (as illus. Sept. issue). Adjustable every 6in. to approx. 9ft. 6in. when fully extended. (Folds up to only 4ft. 6in. for storage.) Suitable for outdoor speakers, public address systems, flood-lighting, etc. OUR PRICE £3/10/-. Carr. 5/-. (Ideal stand for the above loud hailer.)

TRUVOX/TANNOY LOUD-HAILERS. With 180 ohm line transformer and condenser. Impedance 7½ ohms, handling capacity 8 watts. Complete in slope-front wooden case. Brand new 25/-. Carr. 4/6.

BAKERS "SELHURST" SPEAKERS ALL BRAND NEW.

SPECIAL NEW ARRIVAL! "15in. VISCOUNT AUDITORIUM." 15 ohms at 400 c.p.s., 35 watts. Flux density 18,000. **OUR PRICE £15.**
"12in. P.M." 15 ohms, 15 watts, 30-14,000 c.p.s. Our price £4/10/-.
"AUDITORIUM" 12in., 15 ohms, 12 watts. 35-16,000 c.p.s. Flux density 14,500. **OUR PRICE £7/10/-.**
"SUPER HI-FI 25" 12in., 15 ohms, 25 watts 25-20,000 c.p.s. Flux density 17,600. **OUR PRICE £9/9/-.**
Full descriptive specification available. S.A.E.

MOVING COIL MICROPHONE. Complete with 12ft. screened lead. £2/10/-.

CRYSTAL MICROPHONE. Complete with 12ft. screened lead. £2/2/-. Both are recommended for professional use.

MICROPHONE STAND (Telescopic). With heavy 8in. dome black crackle base, chromium stand with screw top extends to 5ft. 4in. Will fit above mikes, etc., £2/10/-. Carr. 3/6.

CRYSTAL STICK MICROPHONE (G.B.C. MC-24). High fidelity, metal cased, fitted switch and screened lead. 35/-.

COLLARO "STUDIO" TAPE TRANSCRIPTORS. Brand new in original cartons 3 speeds. 1⅞, 3¾, 7½ i.p.s. 3 motors, digital counter, etc. Complete with 7in. spool instructions and fixings. A.C. 200/250 v. operation. **SPECIAL PRICE £12/10/- only.**

RECORDING TAPES. Super quality P.V.C. 1,800ft. L.P. 7in. spools, 30/-; 1,200ft. Std. 7in. 19/-; Empty 7in. spools 3/9 each.
Send S.A.E. for current Tape Bargain List.

NEW AND UNUSED ACCUMULATORS
12 v. 25 A.H. 45/-. Carr. 7/6.
2 v. 100 A.H. 75 actual (ex-Govt.) with carrying handle. Size 6½ x 6½ x 3½in., 15/- each. Carr. 3/6.
2 v. 16 A.H., as above. 7½ x 4 x 2in., 5/- each. P. & P. 2/-. 6 for 24/-. P. & P. 10/-.

AIRBORNE TRANSMITTER RECEIVER TYPE 1986. A mobile 10-channel crystal controlled V.H.F. Tx/Rx. covering 124.5/156 Mc/s. I.F. band width 23 kc/s. Complete (less external attachments) in metal case, with all valves and 24 v. rotary power unit. Used but in first-class condition. ONLY £8/10/-. Carr. paid. Also, complete with control box and all necessary connecting leads, £12, carr. paid.

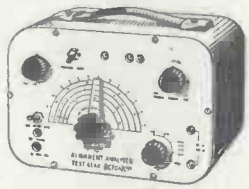
DOUBLE BEAM 'SCOPE'

For D.C. & A.C. APPLICATIONS

Engineered to precision standards, this high-grade instrument is made available at the lowest possible price, incorporating the essential features usually associated with luxury instruments. This "SCOPE" will appeal particularly to Service Engineers and Amateurs. A high gain, extremely stable differential Y-Amplifier (30 mV/C.M.). Provides ample sensitivity with A.C. or D.C. inputs. Especially suitable for measurement of transistor operating conditions where maintenance of D.C. levels is of paramount importance. Push-Pull X amplifier, Flyback suppression; Internal Time base Scan Waveform available for external use: pulse/output available for checking T.V. Line O/P Transformers, etc.; Provision for external X 1/P and CRT. Brightness Modulation. A.C. mains 200/250 v. **£19/19/-** plus P. & P. 7/6 or 50/- deposit, plus P. & P. 7/6 and 12 monthly payments of 33/4.

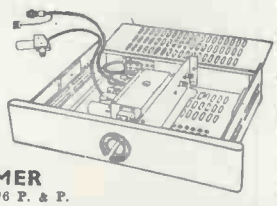
FULL 12 MONTHS' GUARANTEE INCLUDING VALVES AND TUBE

ALIGNMENT ANALYSER TYPE MC12



A.C. MAINS, 200/250 volts. Provides:—"WOBBULATOR" (SWEPT FREQUENCY) OPERATION, for FM/TV alignment linear frequency sweep up to 12 Mc/s. From 400 Kc/s—80 Mc/s. CAPACITANCE MEASUREMENT. Two ranges provided 0-60 pf. and 0-120 pf. SPECIAL FACILITY enables true resonant frequency, of any tuned circuit I.F. transformer, etc. to be rapidly determined. Cash price **£6/19/6** and 5/- P. & P. H.P. terms 25/- deposit and 5/- P. & P. and 6 monthly payments of 21/6.

CHANNEL TUNER



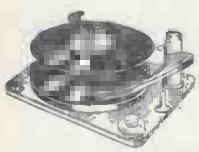
Will tune to all Band I and Band III stations. **BRAND NEW** by famous manufacturer. Complete with P.C.C. 84 and P.C.F. 80 valves (in series) I.F. 16-19 or 33-38. Also can be modified as an aerial converter (instructions supplied).
Complete with knobs.

32/6 Plus 3/6 P. & P.

HEATER TRANSFORMER

To suit the above, 200-250 v. 6/- Plus 1/6 P. & P.

B.S.R. MONARCH UA8 with FUL-FI HEAD



4-speed plays 10 records 12in., 10in. or 7in. at 16, 33, 45 or 78 r.p.m. Intermixes 7in., 10in. and 12in. records of the same speed. Has manual play position; colour brown. Dimensions: 12½in. x 10½in. Space required above baseboard 4½in., below baseboard 2½in. Fitted with Ful-Fi turnover crystal head. **£6/19/6.** Plus 5/- P. & P.

STEREO HEAD £7/19/6 Plus 5/- P. & P.

LINE E.H.T. TRANSFORMER

With built-in line and width control. 14 KV. Scan coil, 90° deflection, on ferrite yokes. Frame O.P. transformer 500 pf. 18 KV. smoothing condenser. Can be used for 14in., 17in. or 21in. tubes.
Complete with cuircuit diagram. **29/6** Plus 4/- P. & P.

As Above, but for 625 lines **£2.10** Plus 4/- P. & P.

FOCUS MAGNET suitable for the above (state tube), 10/-. 2/6 P. & P.

MAINS TRANSFORMERS

All with tapped primaries 200-250 volts.

0-160, 180, 200 v., 60 ma., 6.3 v. 2 amps., 10/6, 280-0-280, 80 ma., 6.3 v., 2 amp., 6.3 v., 1 amp., 10/6. 350-0-350, 70 ma., 6.3 v. 1 amp., 6.3 v. 2 amp., 10/6. 250-0-250, 70 ma., 6.3 v., 2 amp., 10/6. Postage and packing on the above 3/-.

SURFACE BARRIER TRANSISTORS

type SB 305, 15 Mc/s. **7/6** each.

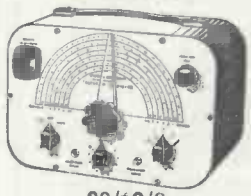
100% AUDIO TRANSISTORS

5/- each.

BATTERY RECORD PLAYER AND AMPLIFIER

Incorporating 45 r.p.m. "Starr" motor, "Acos" crystal pick-up, 3 transistor push-pull amplifier complete with transistors. Output 500 milliwatts, 49/6 plus 3/6 P. & P.

SIGNAL GENERATOR

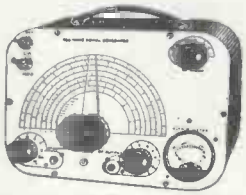


Covering 100 Kc/s.-100 Mc/s. on fundamentals and 100 Mc/s. to 200 Mc/s. on harmonics. Metal case 10in. x 6½in. x 5½in., grey hammer finish. Incorporating three miniature valves and Metal Rectifier. A.C. Mains 200/250 v. Internal Modulation of 400 c.p.s. to a depth of 30%. Modulated or unmodulated R.F., output continuously variable 100 millivolts C.W. and mod. switch, variable A.F. output. Incorporating magic-eye as output indicator. Accuracy plus or minus 2%.

£6/19/6

Or 25/- deposit and 6 monthly payments of 21/6. Post & Packing 5/- extra.

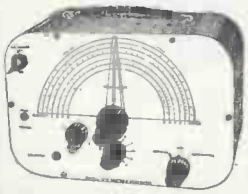
SIGNAL GENERATOR



Coverage 120 Kc/s.—230 Kc/s., 300 Kc/s.—900 Kc/s. 900 Kc/s.—2.75 Mc/s. 2.75 Mc/s.—8.5 Mc/s., 8 Mc/s.—28 Mc/s., 16 Mc/s.—56 Mc/s., 24 Mc/s., 84 Mc/s. Metal case 10in. x 6½in. x 4½in. Size of scale 6½in. x 3½in. 2 valves and rectifier A.C. mains 230-250 v. Internal modulation of 400 c.p.s. to a depth of 30 per cent. modulated or unmodulated R.F., Output continuously variable, 100 millivolts C.W. and mod. switch variable A.F. output and moving coil output meter. Grey hammer finish case and white panel. Accuracy plus or minus 2%. **£4/19/6**

Or 25/- deposit and 4 monthly payments 21/6. P. & P. 5/- extra.

SIGNAL & PATTERN GENERATOR



£6/19/6 P. & P. 5/-.

Or 25/- deposit. P. & P. 5/- and 6 monthly payments of 21/6.
Coverage 7/6 Mc/s.-210 Mc/s., in five bands, all on fundamentals slow motion tuning audio output. 8 vertical and horizontal bars, logging scale. In grey hammer finished case with carrying handle. Accuracy ±1% A.C. mains 200-250 v.

CYLDON TURRET TELETUNER

I F 34/38 Mcs. Brand new complete with biscuit for channels 2, 4, 8 & 9.

less valves **10/-** plus 2/6 P. & P.
(Valves required P.C.C., 84 & P.C.F. 80.)
Pair of knobs to suit above, 3/6.

3-TRANSISTOR POCKET RADIO

INCORPORATING MINIATURE SPEAKER
Plus GERMANIUM DIODE and PRINTED CIRCUIT
Size 3¼ x 4 x ⅞in.

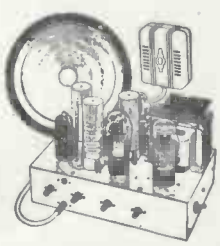
Incorporating Ferrite Rod Aerial. Two Surface Barrier Transistors and one Audio. Tunable over medium and long waves.

To build yourself **39/6** Plus 1/6 P. & P.
ALL PARTS SOLD SEPARATELY
Circuit diagram 1/6, free with kit.

All transistors guaranteed 100%

8 WATT PUSH-PULL AMPLIFIER

COMPLETE WITH CRYSTAL MIKE AND 8in. LOUDSPEAKER



A.C. mains 200/250 v. Size 10½in. x 6½in. x 2½in. Incorporating 6 valves. H.F. pen, 2 triodes, 2 output pens., and rectifier. For use with all makes and types of pick-up and mike. Negative feed-back. Two inputs, mike and gram., and controls for same. Separate controls for Bass and Treble lift. Response flat from 40 cycles to 15 Kc/s. ±2 db.; 4 db. down to 20 Kc/s. Output 8 watts at 5% total distortion. Noise level 40 db down, all hum. Output transformer tapped for 3 and 15 ohm speech coils. For use with 8td. or L.P. records, musical instruments such as Guitars, etc.

£4.19.6 Plus P. & P. 7/6.

Or £1 deposit, plus P. & P. 7/6 and 4 monthly payments of 23/-.

PORTABLE AMPLIFIER

On printed circuit for A.C. Mains 200/250 v. Size 4in. x 3in. with tone and volume control. Valves: ECL82 and EZ80, 39/6. P. & P. 2/6

RADIO AND T.V. COMPONENTS (ACTON) LTD.

23A, ACTON HIGH STREET, LONDON, W.3

GOODS NOT DESPATCHED OUTSIDE U.K. ALL ENQUIRIES S.A.E.
TERMS OF BUSINESS C.W.O.

C.R.T. BOOSTER TRANSFORMERS

For Cathode Ray Tubes having Heater/cathode short circuit and for C.R. Tubes with failing emission. Full installation instructions supplied.

Type A. Low Leakage windings. Optional Boost 25% and 50%. Tapped mains primaries:

2 volt	12/6 each
4 volt	12/6 each
6.3 volt	12/6 each
10.8 volt	12/6 each
13.3 volt	12/6 each

OUR LATEST SUPERIOR PRODUCT. Type A2. High Quality. Low capacity. 10/15 pf. Optional boost 25%, 50%, 75%. ..... 16/6 each

Type B.. Mains input. Low capacity. Multi-Output 2, 4, 6.3, 10 and 13 volts. Optional boost 25% and 50%. Suitable for all Cathode Ray Tubes 21/-.

RESISTORS. All preferred values. 20% 10 ohms to 10 meg., ½ w., 4d.; ¼ w., 4d.; 1 w. 6d.; 1½ w., 8d.; 2 w. 1/-.
HIGH STABILITY. ½ w., 1% 2/-. Preferred values 10 ohms to 10 meg. Ditto 5% 9d., 100Ω to 5 meg.

5 watt, 10 watt, 15 watt } WIRE-WOUND RESISTORS 25 ohms—10,000 ohms. { 1/3, 1/6, 2/-

12,500 ohms.—50,000 ohms. 10 w. 3/3

WIRE WOUND POTS, 3 w. Pre-set Min. T.V. type Knuried Slotted knob. All values 25 ohms to 25K. 3/- ea., 30 K., 50 K., 4/-. Ditto ½ w. Carbon Track, 30 K. to 2 Meg., 3/-.

WIRE-WOUND POTS. 4 w. Standard size Pots. long Spindle High Grade. All values 50 ohms to 50 K. 6/6; 100 K., 7/6.
W/W EXT. SPEAKER CONTROL 10Ω, 3/-.

O/P TRANSFORMERS. Heavy duty 50 mA. 4/6. Multi-ratio push-pull 7/6. Miniature 3V4, etc. 4/6. Hygrade Push-Pull 10 watts, 15/6. Push-pull 20 w. 6 k. or 8 k. 30/-.
L.F. CHOKES. 15/10H 60/65 mA. 5/-. 10H 85 mA., 10/6. 10 H 120 mA., 12/6. 10H 150 mA., 14/-.

MAINS TRANSFORMERS 200/250 v. A.C.
STANDARD 250-0-250, 80 mA., 6.3 v. 3.5 a. tapped 4 v. 4 a. Rectifier 6.3 v. 1 a., tapped 5 v. or 4 v. 2 a. Ditto 350-0-350 ..... 22/6
MINIATURE 220 v. 20 mA., 6.3 v. 1 a..... 10/6
MIDGET, 220 v. 45 mA. 6.3 v. 2 a..... 15/6
SMALL, 200-0-200 50 mA., 6.3 v. 2 a..... 17/6
STANDARD, 250-0-250, 65 mA., 6.3 v. 3.5 a..... 17/6
HEATER TRANS., 6.3 v. 1½ a., 7/6; 3 amp..... 10/6
GENERAL PURPOSE LOW VOLTAGE. Outputs 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30 v. at 2 A..... 22/6
AUTO. TRANS. 150w., 0, 10, 120, 200, 230, 250 v. 22/6

ALADDIN FORMERS and cores, ½in. 8d.; 1in. 10d. 0.3in. FORMERS 5937 or 8 and Cans TV1 or 2½in. sq. × 2½in. or ½in. sq. × 1½in., 2/- with cores.
SLOW MOTION DRIVES. Epicyclic ratio 6 : 1, 2/3.
SOLON. Midget Soldering Iron, 230/40 v. 25 w., 24/-.
REMPLOY INSTRUMENT IRON. 220/40 v. 25 w., 17/6.
MAINS DROPPERS. 3 × 1½in. Adj. Sliders 3 amp. 1,000 ohms 4/3. .2 amps 4/3. .1 amp. 2,000 ohms. 5/-.
LINE CORD. 3 amp. 60 ohms per foot .2 amp. 100 ohms per foot, 2-way, 6d. per foot; 3 way 7d. per foot.

CRYSTAL MIKE INSERT by Acos 6/6
Precision engineered. Size only ½ × ⅜in.
ACOS CRYSTAL STICK MIKE 39-1. Bargain 35/-.

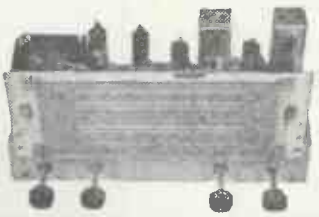
MIKE TRANSF. 50 : 1, 3/9 ea., 100 : 1 Potted 10/6.
LOUDSPEAKERS PM. 3 OHM. 5in. Rola, 17/6.
6in. × 4in. Rola, 18/-. 7in. × 4in. R.A., 21/-.
10in. × 6in. Rola 27/6. 8in. Plessey, 19/6.
6½in. Rola 16/6. 8in. Rola, 21/-. 10in. R.A. 30/-.
HI-FI TWEETERS, 4in. 25/-. 12in. Plessey, 30/-.
12in. Baker 15 wt. 3 ohm. and 15 ohm models, 90/-.
12in. Baker foam suspension 15 w. 15 ohm, £6.
12in. **HIGH-FI** Master £17/10, 20 c.p.s. to 17 k.c.s.

I.F. TRANSFORMERS 7/6 pair
465 kc/s, slug tuning miniature can 1½ × ½ × ½in. High Q and good bandwidth. By Pye Radio. Data sheet supplied
Weymouth I.F. Standard size 465 kc/s., 12/6 pair.

CRYSTAL DIODE G.E.C., 2/-. GEX34, 4/-. 40 Circuits 3/-
H.R. HEADPHONES. 4,000 ohms, brand new, 15/- pair.
SWITCH CLEANER Fluid, squirt spout, 4/3 tin.
TWIN GANG CONDENSERS. 365 pf. Miniature, 1½in. × 1½in. × 1½in., 10/-. .0005 Standard with trimmers, 9/-; less trimmers 8/-. Midget 7/6; Single 50 pf. 2/6; 100 pf., 150 pf., 5/6. Solid dielectric 100, 300, 500 pf., 3/6.
VALVE HOLDERS. Pax. int. Oct. 4d. EF50, EA50. 6d. B12A, CRT, 1/3. Eng. and Amer. 4, 5, 6, 7 pin, 1/-.
MOULDED Mazda or Int. Oct. 6d. B7G, B9A, B8G, B9A, 9d. B7G with can, 1/6; B12A, 1/3; B9A with can, 1/9.
CERAMIC, EF50, B7G, B9A, Oct. 1/-. B7G, B9A Cans, 1/-.
SPEAKER FRET. Gold Cloth 17in. × 25in., 5/-; 25in. × 35in., 10/-. Tygan 54in. wide, 10/- ft., 27in. wide 5/- ft. Brown, Green or Red. Samples S.A.E.
WAVECHANGE SWITCHES
2 p. 2-way, or 3 p. 2-way; short spindle 2/6
5 p. 4-way, 2 wafer, or 3 p. 11-w. 3 wafer, long spindle 6/6
2 p. 6-way, or 4 p. 2-way, or 4 p. 3-way, long spindle 3/6
3 p. 4-way or 1 p. 12-way, long spindle..... 3/6
Wave change "MAKITS" 1 wafer, 8/6; 2 wafer, 12/6; 3 wafer 16/-; 4 wafer, 19/6; 5 wafer 23/-; 6 wafer 26/6.
TOGGLE SWITCHES. S.P., 2/-; D.P., 3/6; D.P.D.T., 4/-;
MORSE KEYS, good quality, 2/6.
SUB-MINIATURE ELECTROLYTICS (15 v.), 1, 2, 4, 5, 8, 25, 50 mfd., 100 mfd., 3/- each.

THE HI-GAIN BAND 3 PRE-AMP
Cascode circuit using Valve ECC84. 17db gain. Kit 29/6 less power; or 49/6 with power pack. Plans only 6d.
Also Ban I version same prices.
(PCC84 Valve if preferred)

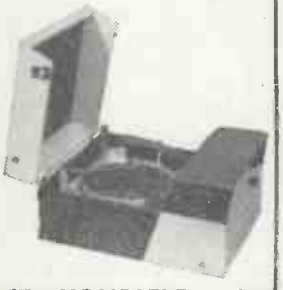
1961 RADIOGRAM CHASSIS



THREE WAVEBANDS — FIVE VALVES
S.W. 16 m.—50 m. — LATEST MULLARD
M.W. 200 m.—500 m. — ECH81, EF89, EBC81.
L.W. 800 m.—2,000 m. — EL84, EZ80
12-month Guarantee. A.C. 200-250 v., 4-way switch.
Short-Medium-Long-Gram. A.C.C. and Negative Feedback, 4.2 watts. Chassis 13½in. × 5½in. × 2½in. Glass Dial Size 10 × 4½in. horizontal or vertical. Two Pilot Lamps. Four Knobs. Walnut or Ivory. Aligned and calibrated. Chassis isolated from mains.

BRAND NEW £9.10.0 Carr 4/6
MATCHED SPEAKERS 8in. 17/6; 10in. 25/-; 12in. 30/-

MONARCH RECORD PLAYER



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MONARCH AUTOCHANGER U. A. 8
READY BUILT 3W. AMPLIFIER
HANDSOME PORTABLE CASE
HIGH FLUX 6in. LOUDSPEAKER
FULL INSTRUCTIONS supplied
Total Price Carr. and ins. 5/-. **£12.10.0**

RECORD PLAYER BARGAINS

4 Speed Autochangers, BSR, U.A.8
Stereo or Monaural..... £6 15 0
Collaro Model 457..... £7 19 6
Garrard Model 210 ..... £10 10 0
4 speed Single Players, EMI Stereo or Monaural £6 19 6
Garrard TA Mk. II £8 8 0
Garrard 4 HF Transcription ... £17 19 6
Garrard Stereo Heads £2 extra.

AUTOCHANGER ACCESSORIES
Suitable player cabinets (uncut boards) 49/6
Amplifier player cabinets with cut boards 63/-
2-valve amplifier and 6½in. speaker for above.. 79/6
Ready mounted on baffle 12in. × 7in., 8in. deep.

MINIATURE 2-STAGE Hi-Fi AMPLIFIER. A.C. only, 200-250 v. Valves ECL82 and EZ80. 3 watt quality output. Mullard tone circuits, bass boost, treble and volume controls. Separate engraved Perspex front panel with de luxe finish. Heavy duty output transformer, 3 ohm. and shrouded mains transformer. Stove enamelled chassis size 6 × 5 × 3in. Bargain price £4/15/-. Circuit supplied.

CYLDON TURRET TELETUNER
I.F. 33/38 megs, complete with frame-grid valves, 30C1 and 30L15. (LT 16v. .3a.) With coils for channels 1 to 5 & 8 to 11. Latest model. Brand new price. 45/-, operating data & circuit supplied. Ideal for "P.T." Olympic.

VOLUME CONTROLS
Midget size:
Long spindle. Guaranteed 1 year. All values.
5 K. ohms up to 2 Meg.
No switch. D.P. 8w. 3/- 4/6
Linear or Log Tracks.

80 Ohm Cable Coaxial
Semi air spaced, ½in. dia. Ideal Band III Losses cut 50% **6d.** yd.
FRINGE QUALITY
AIRSPACED .... 1/- yd.

COAXIAL PLUGS .. 1/- LEAD SOCKETS .. 2/-
PANEL SOCKETS .. 1/- OUTLET BOXES .. 4/6
BALANCED TWIN FEEDER per yd. 6d., 80Ω or 300.
TWIN SCREENED BALANCED FEEDER 1/6 yd., 80 ohm

ALUMINIUM CHASSIS. 18 s.w.g. Plain, undrilled, with 4 sides, riveted corners and lattice fixing holes with 2in. sides 7 × 4in. 4/6; 9 × 7in., 5/9; 11 × 7in. 6/9; 13 × 9in., 8/6; 14 × 11in., 10/6; 15 × 14in., 12/6 and 18 × 16 × 3in., 16/6.

BLACK CRACKLE PAINT. Air drying, 3/- tin.
P.V.C. CONN. WIRE, coloured, single or stranded 2d. yd.
NEON MAINS TESTER SCREWDRIVERS, 5/-.
CORED SOLDER RADIOGRADE, 4d. yd., ½lb. 2/6.
PAXOLIN 1/16in. × 8in. × 10in., 1/6. **ION TRAPS** 5/-.

AMERICAN MAGNETIC RECORDING TAPE FERRODYNAMICS "BRAND FIVE"

5in. 600 feet	16/-	MYLAR DUPONT	
5in. 900 feet	18/6	Super High Fidelity	
5½in. 1,200 feet ..	23/6	Double Play	
7in. 1,200 feet	25/-	5in. 1,200 feet	37/6
7in. 1,800 feet.....	35/-	7in. 2,400 feet	60/-

Illustrated leaflet S.A.E.
Spare Reels, plastic, all sizes 3/-

RECTIFIERS, RM1, 5/-; RM2, 6/-; RM3, 8/-; RM4, 16/-; RM5, 20/-; FC31, 27/6; 14A86, 17/6; 14A100, 21/-.
MINIATURE CONTACT COOLED RECTIFIERS. 250 v. 50 mA., 7/6; 60 mA., 8/6; 85 mA., 9/6; 200 mA., 21/-; 300 mA., 27/6; Full Wave 250 v. 120 mA., 15/-.
COILS. Wearite "P" type 3/- each. Osmor Midget "Q" type adj. dust core from 4/- each. All ranges.
TELETRON. L. and M. T.R.F. with reaction, 3/6.
FERRITE ROD AERIALS. M.W., 8/9; M. & L. 12/6.
T.R.F. COILS. A/HF, 7/- pair. **H.F. CHOKES,** 2/6.

JASON F.M. TUNER COIL SET, 29/-. H.F. coil aerial coil. Oscillator coil two I.F. transformers. 10.7 Mc/s. Detector transformer and heater chokes. Circuit and component book, using four 6AM6 2/6. Complete kit FMT1 with Jason Calibrated dial and 4 valves, £6/5/-. With new Jason Cabinet FMT2, £2 extra.

CONDENSERS. New Stock. .001 mfd. 7kV. T.C.C., 5/6: 20 kV., 9/6. .1 mfd. 7 kV. 9/6. 100pf, to 500 pf. Micas. 6d. Tubular 500 v. 0.001 to 0.05 mfd., 9d.; 0.1, 1/-; 0.25, 1/6; 0.5 1/9; 0.1/350 v., 9d.; 0.1/1,000 v., 1/9; 0.1 mfd., 2,000 v., 3/6; 0.001 mfd., 2,000 v., 1/9. 500 pf., 20 kV., 9/6: CERAMIC CONDS. 500 v. 0.3 pf. to 0.01 mfd., 9d.
SILVER MICA CONDENSERS. 10% 5 pf. to 500 pf., 1/-; 600 pf. to 3,000 pf., 1/3.
CLOSE TOLERANCE (1± pf.) 1.5 pf. to 47 pf., 1/6. DITTO 1% 50 pf. to 815 pf., 1/9; 1,000 pf. to 2,000 pf., 2/-.
TRIMMERS. Ceramic 30, 50, 70 pf., 9d.; 100 pf., 150 pf., 1/3. 250 pf., 1/6. 500 pf., 750 pf., 1/9. Philips, 1/- ea.

NEW ELECTROLYTICS. FAMOUS MAKES

TUBULAR		TUBULAR		CAN TYPES	
1/350 v. ..	2/-	50/350 v. ..	5/6	16/500 v.	4/-
2/350 v...	2/3	100/25 v. ..	2/-	32/350 v.	4/-
4/450 v. ..	2/3	250/25 v. ..	2/6	100/270 v. ..	5/6
8/450 v. ..	2/3	500/12 v. ..	3/-	2,500/3 v. ..	4/-
8/500 v. ..	2/9	8+8/450 v.	3/6	5,000/6 v. ..	5/-
16/450 v.	3/-	8+16/450 v.	3/9	8+16/500 v. ..	7/-
16/500 v. ..	4/-	8+16/500 v.	5/6	32+32/450 v.	6/-
32/450 v. ..	3/9	16+16/450 v.	4/3	50+50/350 v.	7/-
25/25 v. ..	1/9	16+16/500v.	6/-	64+120/350v.	11/6
50/50 v. ..	2/-	32+32/350v.	4/6	100+200/275v.	12/6

FULL WAVE BRIDGE SELENIUM RECTIFIERS. 2.6 or 12 v. 1½ amp., 8/9; 2 a. 11/3; 4 a., 17/6; 6 a., 22/6.
CHARGER TRANSFORMERS. Tapped input 200/250 v. for charging at 2, 6 or 12 v., 1½ a., 15/6; 2 a., 17/6; 4 a., 22/6. Charger circuit free. AMMETERS, 4 a., and 5 a., 13/6.

NEW and boxed VALVES 90 day guarantee

1R5 ..	7/6	6L6G	10/6	EA50..	1/6
1S5 ..	7/6	6N7M	6/6	EABC80	8/6
1T4 ..	6/-	6Q7G	7/6	EB91 ..	6/-
2X2 ..	3/6	6SA7M	6/-	EBC33 ..	8/6
3B4 ..	7/6	6SJ7M	6/6	EBC41 ..	8/6
3V4 ..	7/6	6SN7	6/6	EBF80	10/-
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5Y3 ..	7/6	6X4 ..	7/6	ECF80 ..	9/6
5Z4 ..	9/6	6X5 ..	6/6	ECH42	10/6
6AM6	5/-	12A6	7/6	ECL80	10/6
6BE6	7/6	12AT7	8/-	ECL82	10/6
6BH6	9/6	12AU7	8/-	EF39 ..	5/6
6BW6	9/6	12AX7	8/-	EF41 ..	9/6
6D6 ..	6/-	12BA6	8/6	EF50 ..	5/6
6FG6	7/6	12BE6	8/6	EF80 ..	8/-
6H6GT	3/6	12K7 ..	6/6	EF86..	14/6
6J5 ..	5/6	12Q7	6/6	EF92 ..	5/6
6J6 ..	5/6	35L6 ..	9/6	EL32 ..	5/-
6J7G	6/6	35Z4..	7/6	EL41 ..	9/6
6K6GT	6/6	80	9/6	EL84 ..	8/6
6K7G	5/-	807 ..	5/3	EZ40 ..	7/6
6K8G	7/6	954 ..	1/6	EZ80 ..	7/6
				EY51 ..	9/6
				EY86 ..	10/-
				HABC80	12/6
				HVR2A	6/6
				MUI4 ..	9/-
				P61	3/6
				PC84	9/6
				PCF80 ..	9/6
				PCL82 ..	11/6
				PEN25 ..	6/6
				PL82 ..	10/6
				PY80 ..	7/6
				PY81 ..	9/6
				PY82 ..	7/6
				8P61 ..	3/6
				UBC41 ..	9/6
				UCH42 ..	9/6
				UF41 ..	9/6
				UL41 ..	9/6
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48-HOUR MAIL ORDER
337 WHITEHORSE RD. WEST CROYDON
THO 1665 Buses 133 or 68

POSTAL SERVICE 1/-, OVER £2 FREE. C.O.D. 1/6. (EXPORT C.W.O. POST EXTRA.) Wed. 1 p.m.

RADIO POLICE

INSPECTORS OF POLICE (SIGNALS)

required by GOVERNMENT OF NYASALAND

Choice of contract terms for 1 tour 2-3 years with 10% gratuity or permanent and pensionable terms. Commencing salary according to age and experience in scale rising to £1,285. Initial outfit grant and annual uniform allowance. Free passages. Liberal leave on full salary.

Candidates of good education and physique, normal vision without glasses, must have sound knowledge of H.F. and V.H.F. fixed and mobile simplex and duplex radio telephone systems and low power petrol/electricity chargers and alternators.

Apply to Crown Agents, 4 Millbank, London, S.W.1, for application form and further particulars, stating, age, name, brief details of qualifications and experience and quoting reference M2A/50901/WF.

RADIO MAINTENANCE TECHNICIAN

Police Department, GOVERNMENT OF NORTHERN RHODESIA

requires Radio Maintenance Technicians on agreement for one tour of 3 years with prospect pensionable employment. Salary according to experience in scale rising to £1,260 a year. Pending the outcome of salaries review a special interim allowance at rate of 5% of salary is at present payable. Prospects of promotion to Telecommunications Officer (maximum salary £1,315) and Chief Telecommunications Officer (maximum salary £1,490). Married accommodation, with heavy furniture available immediately at sub-economic rent, e.g., on salary of £745 rent is £45 a year. Free passages. Liberal leave on full salary.

Candidates should be between 22 and 35 years, of good physique, and possessing maths. and physics at G.C.E. "O" level standard. They should have sound knowledge of installation and maintenance of modern low and medium power V.H.F. static and mobile equipment, H.F. transmitters and receivers including S.S.B. and petrol generator and diesel electric sets.

Apply to CROWN AGENTS: 4, Millbank, London, S.W.1. for application form and further particulars, stating age, name, brief details of qualifications and experience and quoting reference M2A/50829/WF.

ELECTRONICS ENGINEER

There is a continuous demand for test equipment caused through the increasing complexity of modern valves. We require an experienced electronics engineer to design such test equipment.

Experience of pulse circuits and a sound fundamental knowledge of oscilloscopes is essential.

Preferably applicants should possess a degree in electrical engineering or physics or equivalent qualifications and be within the age range 25 to 40.

Salary will take into account experience, qualifications and age.

Send brief résumé of experience, qualifications, etc., to:—

Group Personnel Services,
THE ENGLISH ELECTRIC COMPANY LTD.
English Electric House, Strand, London, W.C.2
quoting ref WW1590C.

BROADCASTING ENGINEER TRAINING

Required by the GOVERNMENT OF UGANDA Information Department. Appointment on contract for 1 tour of 30/36 months in first instance. Commencing salary according to age and experience up to maximum in scale rising to £1,566 a year. Salary scales under review. Outfit Allowance £30 payable in certain circumstances. Free passages. Liberal leave on full salary.

Candidates must have teaching experience, ability to give theoretical instruction in telecommunication subjects and practical instruction in maintenance and operation of medium-power broadcasting transmitters, studio control and recording equipment.

Apply to CROWN AGENTS, 4, Millbank, London, S.W.1, for application form and further particulars, stating age, name, brief details of qualifications and experience and quoting reference M2A/50941/WF.

TECHNICAL CORRESPONDENT

(25/50)

required to join existing team in busy Service Department office. Sound knowledge of good-class domestic radio and TV receiver principles and defects and ability to dictate advisory letters to dealers essential.

38½-hour week (Monday/Friday); staff canteen; pension and insurance scheme.

Please apply by letter giving age, education, experience, salary required, to

M. J. H. BRADY, ESQ.,
BUSH RADIO LIMITED,
MORTLAKE ROAD,
KEW, SURREY

The Manchester College of Science and Technology

Sackville Street, Manchester, 1

A Senior Technician or a Chief Technician required in the Chemistry Department to join a chemistry research group and specifically to control and operate a High Resolution Nuclear Magnetic Resonance Spectrometer. Previous experience in this technique is not essential, but candidates should have a good knowledge of electronics or applied physics, and be interested in the further development of the technique for use in chemical research.

Salary—Senior Technician £700-£765 per annum (with additions for approved qualifications).

—Chief Technician £825-£925 per annum.

40-hour week. Superannuation scheme.

Applications with full details quoting reference No. C.6, to The Bursar.

Closing date: 14th February, 1961.

ELECTRONIC INSTRUMENT MAINTENANCE AND TEST ENGINEERS

Experience Tektronix and Hewlett-Packard preferred but not essential. This is a Staff appointment with 37½-hour week and non-contributory pension and life insurance scheme. Employment initially at Highgate, after April at Camden Town, where canteen facilities will be offered. Write in confidence or telephone.

F. R. G. Webb
LIVINGSTON LABORATORIES LIMITED
Retcar Street, London, N.19.
ARC 6251

ASSISTANT ENGINEERS (RADIO)

URGENTLY REQUIRED BY DIRECTORATE OF CIVIL AVIATION EAST AFRICA HIGH COMMISSION

Appointment on contract for one tour of 36 months in first instance. Salary according to age and experience in scale, (including Inducement Pay) rising to £1,341 a year. A Salaries Revision Commission is in East Africa and this salary scale is likely to be increased early in 1961. Gratuity 13½% of total salary drawn. Outfit Allowance £30. Free passages. Liberal leave on full salary.

Candidates over 28 years of age, should possess at least two second year and preferably one third year C. & G. Certificate in Telecommunications Principles or Radio and have had at least 3 years' experience in erection and maintenance of ground station transmitters, radio and radar navigational aids and aerial systems.

Apply to CROWN AGENTS, 4 Millbank, London, S.W.1, for application form and further particulars, stating age, name, brief details of qualifications and experience and quoting reference M2A/51200/WF.

FOR THE FIRST TIME IN THIS COUNTRY

THE WORLD'S FAIRY TALES DRAMATIZED ON TAPE

Told by MELANIE SCOTT

Complete Set of 4 Reels containing 16 different stories

Price: 29/6 per 5" Reel of Four Stories

Postage: 1/6 per tape

From: H. B. TRADING CO.
60-66 Wardour Street, W.1

AVO ELECTRONIC TESTMETERS

Mains operated Electronic Universal Test Instrument offering the following facilities:—
Current: D.C. 25-100-250μA-1-2.5-10-25-100-250mA-1A
Voltage: D.C. 250mV-1-2.5-10-25-100-250-1000V
A.C. 1-2.5-10-25-100-250V.
Resistance: 1000MΩ, 100kΩ, 1000Ω.
A.F. power: 500mW and 5W into an impedance of 5000, 2000, 600, 25, 10 and 5Ω.
Capacity: .5μF and 50μF.

PRICE, fully overhauled and guaranteed.. £25 0 0
Packing and carriage ..... 10/-.

AVO CR BRIDGES

Portable Mains Operated Serviceman's Component Bridge. Ranges of measurements; Capacity from 5mmF. to 50 mF.; Resistance from 5 ohms to 50 megohms. Valve Voltmeter from 0 to 15 V. RMS: Neon Leakage Indicator. Power Factor measurements in %.

PRICE ..... pp.. 10/- £9

NEW FOREIGN MADE POCKET MULTIMETERS

Basic Movement 300μA. Sensitivity 1,000Ω/V. A.C. and D.C. Ranges: 10-50-250-500-1,000V. D.C. and A.C. 1-100-500mA. D.C., 2K/200K ohms. Accuracy: 3% FSD and D.C., 5% FSD on A.C. 10% on. Resistance scale. Dimensions: 5½in. × 3¼in. × 2¼in. Complete with test leads with prods and 1.5V cell, fully guaranteed 80/-.

REVERSIBLE 12 V. D.C. MINIATURE MOTORS

Power approx. 5 watts at 7,000 R.P.M. Dimensions 1¾in. long × 1¼in. dia. Shaft .077in. dia. × 4in. long. Centre of reversing switch integral with the motor. Self-lubricating sintered bronze bearings. PRICE, brand new, 15/6 post free.

TYPE 3 POWER UNITS

Mains operated fully smoothed power supply unit providing 180-270 H.T. and 6.3V. 4A A.C. 19in. H.T. Milliametre and Voltmeter. Rack Mounting. Second-hand, good condition and guaranteed. p.p. 15/-. £3 10 0

WESTINGHOUSE SELENIUM RECTIFIER POWER UNITS

Input 115/230V., fully smoothed and fused. Output adjustable from 80 to 140V. D.C. by means of fine and coarse tap switches in the secondary winding. Maximum current 400mA. continuous. Dimensions: 17¼in. × 10¼in. deep × 3¼in. high..... p.p. 7/6. 40/-

STILL AVAILABLE

BC-624 RECEIVER UNITS AND BC-625 TRANSMITTER UNITS as illustrated and described in the previous issues of the "Wireless World". PRICE 25/- and 22/6 respectively plus 5/- p.p. Chassis only, less valves but complete with all other components 7/6 each, plus 3/6 p.p.

RATCHET MOTORS 12 v

1 Amp. (Impulse Motors).. 5.75
ohms. .....3/6 each
Packing and postage 1/6

P.O. BUZZERS

Post Office Buzzers model T Mk. I. Minimum operating voltage 3 volts. PRICE (p.p. 1/6)..... 4/6

P.O. RELAYS

Type 600. 600Ω Coil. 2 C.O. Contacts..... 6/6
Type 3000, 500Ω Coil, 2 C.O. contacts..... 6/6
p.p. 1/6 per relay.

HIGH SPEED RELAYS

SIGMA 4C1 or ALLIED TYPE "G" 1B, 5000Ω. Current 4 mA. ± .5 mA.; 2in. dia. × 2in. high. Second-hand ..... 5/6. p.p. 1/6.
VENNER 8-day clockwork time switches, 24-hour dial with one make and one break, 1 amp. 230V. contacts. Second-hand, good condition, complete with winding key ..... p.p. 2/-. 27/6

200μA PORTABLE ADMIRALTY PATTERN METER

2½in. Round Flush Mtd. Modern Movement Meter enclosed in a waterproof die-cast case fitted with rubber feet and carrying strap. Phone jack connection. Unused. p.p. 2/6 ..... £2 0 0

METERS

50μA DC MC 2½in. Rd. Fl. Panel Mtd. 45/-
50μ DC Mc 4½in. Sq. Fl. Mtd. SIFAM..... 65/-
200μA DC MC 2in. Rd. Fl. Mtd. 32/6
200μA DC MC 2½in. Rd. Fl. Mtd. 35/-
200μA DC MC 2½in. Sq. Fl. Mtd. 35/-
500μA DC MC 2½in. Rd. Fl. Panel Mtd..... 17/6
1-0-1mA DC MC 2½in. Rd. Fl. Mtd., Sealed, Calibr. 0-100/200/400 Volts/mA..... 22/6
10-0-10mA DC MC 2½in. Rd. Fl. Mtd..... 15/-
30mA. DC MC 2½in. Rd. Fl. Mtd. 15/-
50mA DC MC 2½in. Rd. Fl. Mtd..... 15/-
200mA DC MC 2in. Rd. Fl. Mtd..... 12/6
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1 Amp. DC MC 2½in. Rd. Fl. Mtd. 17/6
2 Amps DC MC 2½in. Rd. Fl. Mtd..... 17/6
5 Amps DC MC 2½in. Rd. Fl. Mtd..... 17/6
8 Amps R.F. Th-C., 2½in. Sq. Fl. Mtd. 10/-
10 Amps DC MC 2½in. Rd. Fl. Mtd..... 17/6
20 Amps DC MC 2in. Rd. Proj. Mtd..... 6/6
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30-0-30V DC MC 2½in. Rd. Fl. Mtd..... 15/-
18-36V DC MC 2in. Rd. Fl. Mtd., Suppressed Zero, reading range 18-36V. 15/-
150V AC MI 2in. Rd. Fl. Mtd..... 20/-
150V AC MI 2½in. Rd. Fl. Mtd..... 20/-
150V DC MC 2½in. Rd. Fl. Mtd..... 20/-
300V AC MI 2½in. Rd. Fl. Mtd..... 20/-
Please add 2/6 in £ for packing and postage.

3-RANGE MICRO-MILLIAMMETER

Basic movements 50μA D.C. M.C. Ranges of 50μA, 250μA and 1mA switched by a trigger switch in the back, geared with sliding scale having separate graduations for each range. Instrument is fitted with leads for soldering to test prods or crocodile clips (not supplied) 50/-

TESTED AND GUARANTEED VALVES

OA2 ..	6/-	4X150A		6J5G	4/-										
OB2 ..	6/-		30/-	6J6	3/6										
OB3	8/-	4X150G		6K6GT/G		12H6	2/-	39/44	3/-	808	12/6	1629	6/-	5634	10/-	5947	15/-
OC3	5/6		120/-		7/-	12J5GT	3/6	54HK	25/-	813	70/-	1632	6/-	5670	10/-	5963	7/-
OD3	5/6	5B/252M		6K7	4/-	12K8Y	10/-	76	5/-	815	40/-	2050	7/6	5687	10/-	5980	40/-
OZ4A	5/6		10/-	6K8	9/-	12SC7	4/-	83	10/-	829	25/-	2051	7/6	5702	15/-	5998	15/-
1A3	3/-	5B/500B		6L6GA	7/-	12SG7	3/-	83V	9/-	832	15/-	4024B	20/-	5725	10/-	6005	9/-
1AH4	5/-		10/-	6L7	5/-	12SH7	3/-	249B	25/-	832A	35/-	4033AF	15/-	5726	7/-	6096	9/-
1B24	30/-	5B/502A		6N7	6/-	12SJ7	5/-	301A	10/-	866A	10/-	4033I	30/-	5751	8/-	6097	7/-
1B32	5/-		80/-	6N7G	5/-	12SL7GT		356A	80/-	927	15/-	4033X	25/-	5783WB		6101	7/-
1G6GT/G	7/-	5R4GY	9/-	6Q7G	6/-		6/-	357A	80/-	931A	60/-	4043A	15/-		25/-	6213	15/-
1L4	3/6	5T4	9/-	6R7	6/-	12SN7GT		393A	20/-	955	4/-	4046A	3/-	5786	200/-	6278	80/-
1LA6	6/-	5U4G	5/-	6SA7GT	7/-		12/6	559	3/-	956	2/-	4061A	12/6	5787	10/-	7193	2/-
1LD5	6/-	5V4G	10/-	6SC7	7/-	12SR7	5/-	571AX	12/6	957	5/-	4242A	35/-	5829	5/-	8016	5/-
1LN5	5/-	5Y3GT	6/-	6SH7	4/-	12SY7	8/-	703A	30/-	1005	2/6	5517	6/-	5852	10/-	8020	10/-
1Q22	100/-	5Z3	7/-	6SJ7	3/-	14E6	6/-	705A	15/-	1625	6/-	5544	100/-	5899A	10/-	9001	4/-
1R4	7/-	5Z4	9/-	6SK7	5/6	28D7	7/-	807	6/6	1626	3/-	5651	8/-	5933	15/-	9002	5/6
1R5	6/-	5Z4G	7/-	6SK7GT													
185	6/-	6AB4	5/-		5/-										
1T4	4/-	6AB7	4/-	6SL7GT	6/6										
1T5GT	6/-	6AD4	20/-	6SN7GT	4/-										
1U5	7/-	6AG5	3/6	6SQ7	6/-										
1V	4/-	6AG7	7/-	6SS7	3/6										
1V2	4/-	6AK5	5/-	6SU7GTY											
2A3	5/-	6AK6	5/-		10/-										
2C26	2/-	6AK7	9/-	6T8	4/-										
2C26A	5/-	6AL5	4/-	6U5	4/-										
2C34	4/6	6AM5	5/-	6V6G	5/-										
2C39A	90/-	6AM6	4/6	6X4	5/-										
2C50	30/-	6AQ6	7/-	6X5GT	5/-										
2C51	15/-	6AR5	4/-	6Y6G	6/-										
2C52	12/-	6AT6	5/-	6Y7G	4/-										
2X2	4/-	6AU6	7/-	6Z4	6/-										
3A4	5/-	6AV6	6/-	7AG7	5/-										
3A5	5/-	6B4G	4/-	7B6	4/-										
3B22	20/-	6B7	6/-	7C4	4/6										
3B24	4/-	6B8	6/-	7C5	7/-										
3B26	20/-	6BF6	6/-	7C7	5/-										
3B28	15/-	6BN6	7/-	7E5	5/-										
3B29	30/-	6C4	2/6	7F7	5/6										
3C24	20/-	6C8G	7/-	7Q7	7/-										
3C45	30/-	6C5G	7/-	7W7	6/-										
3CX100A5		6C8	4/-	7Y4	5/-										
	200/-	6D4	10/-	10Y	10/-										
3D6	4/-	6F4	17/-	11E2	20/-										
3E29	60/-	6F6	5/-	12A6	3/-										
3LF4	6/-	6F7	6/-	12AH7GT											
3Q4	7/-	6F8G	6/6		5/-										
3S4	5/-	6F33	7/-	12AT7	6/-										
3V4	6/6	6G6G	2/6	12AU7	6/-										
4B28	15/-	6H6	1/6	12AX7	7/-										
4B31	120/-	6H6GT	1/3												
4C35	60/-	6J4	8/-	12C8	3/-										
4E27	60/-	6J5	4/6	12E1	20/-										

9003	6/-	EF92	3/6	VR54	1/6										
9004	4/-	EF95	5/-	VR56	4/6										
9006	2/6	EL84	7/-	VR65	4/-										
AC/HL	5/-			ES U150											
ACT9	80/-		30/-	VR78	5/-										
ARP4	3/6	EY51	9/-	VR91	1/6										
ARP34	4/-	EY86	10/-	VR92	1/-										
ARTH2	7/-	EZ80	6/-	VR100	6/-										
ATP4	5/-	FW4/800		VR106	3/6										
ATR387			8/6	VR108	3/6										
	70/-	KT33C	6/-	VR135	2/6										
BT83	60/-	KT63	6/-	VR136	4/-										
C1K	35/-	KT81	17/-	VR137	4/6										
C3R14	15/-	KTW61	7/-	VR150	4/-										
DA60	80/-	KTW62	7/-	VR110	4/-										
DA100		L63	6/-	VT31	40/-										
	100/-	ML6	6/-	VT50	3/-										
DAF91	6/-	NGT1	3/6	VT52	4/6										
DAF96	7/6	PCC84	9/-	VT61	7/-										
DF33	9/-	PCF80	9/6	VU33	3/-										
DF91	5/-	PCL82	11/-	VU39	7/-										
DF92	3/6	PCL84	10/-	VU111	4/-										
DF96	7/6	PEN44	20/-	VU120	4/6										
DH63	6/-	PL36	13/-	VX3208	5/6										
DK91	6/-	PL81	10/-	VX8122	5/6										
DK92	9/-	PL82	8/6	VX8142	5/6										
DK96	7/6	PL83	11/-	VX8190											
DL92	5/-	PT15	10/-		5/6										
DL94	6/6	PY81	8/6	X66	10/-										
DL95	7/3	PY82	7/-	Z21	10/-										
DL96	7/6	QQV06-40	60/-	CV66	2/6										
DL810	4/-	Q892/10	3/6	CV52	80/-										
EABC80		Q895/10		CV54	5/-										
	8/-		3/6	CV57	10/-										
EAC91	4/-	QV04-7		CV92	40/-										
EC91	5/-		15/-	CV100	15/6										
ECC81	6/-	RKR72	6/-	CV117	30/-										
ECC82	6/-	RZ1-150		CV193	30/-										
ECC83	7/-		15/-	CV233	3/-										
ECC84	8/-	S130	5/-	CV239	30/-										
ECC85	8/-	S130P	5/-	CV338	6/-										
ECC91	3/6	TT11	3/-	CV980	5/-										
ECF80	10/6	TT15	40/-	CV1029											
ECF82	10/6	TTR31	60/-		30/-										
ECL80	10/-	TZ40	40/-	CV1256	10/-										
EF50	1/6	U19	17/6	CV4014											
EF55	5/-	U50	7/-		10/-										
EF70	5/-	UF80	7/6	CV4025											
EF71	10/-	UL94	8/-		10/-										
EF72	5/6	VR21	3/6	CV4034	5/-										
EF73	5/6	VR40	10/6												
EF86	9/-	VR53	4/-												
EF91	4/6														

CATHODE RAY TUBE

Type	Dia.	Vh	Va_1	Va_2	Vg_2	$-Vg_1$	Screen	Focus	Defl.	Price
2AP1 ..	2	6.3	250	1000	—	60	Green	ES	ES	25/-
3JP1, 3JP7 ..	3	6.3	690	2000	—	90	Green	ES	ES	70/-
5CP1 ..	5	6.3	575	2000	—	60	Green	ES	ES	50/-
5FP7 ..	5	6.3	250	7000	—	45	Green/Yellow	ES	EM	12/6
8SP7* ..	5	6.3	430	1500	—	45	Green/Yellow	ES	ES	140/-
7BP7 ..	7	6.3	250	7000	—	45	Green/Yellow	ES	EM	60/-
10UP1 ..	10	6.3	10000	—	300	55	Green/Yellow	EM	EM	70/-
12SP7 ..	12	6.3	—	9000	250	50	Green/Yellow	EM	EM	40/-
DG7/5	2½	6.3	—	800	—	—	Green	ES	ES	55/-

STEEL SCREEN FOR 3in. TUBES..... 5/- P.P. 9d.
* Twin Gun, Double Beam.

KLYSTRONS

Type	C.V. equiv.	Vh	V. Res.	−V Ref.	Ia mA	Input W	O'put mW	Frequency	Base	Price
KRN6/3	CV238	4.0	250	138	—	8	100	3030 mc/s mean	Octal	£5 0 0
	CV36	4.0	1250	230	—	10	150	2842 mc/s mean	Octal	£6 0 0
	CV228	6.3	220	—	500	—	450	4615 mc/s mean	BTG	£9 0 0
KRN3	CV237	4.0	1350	255	7.4	10	15	9738 mc/s mean	Octal	£2 0 0
KRN2A	CV129	4.0	1600	420	—	10	75	9375 mc/s mean	Octal	£4 0 0
2K25		6.3	300	400	—	—	32	8500-9660 mc/s	Octal	£3 0 0
723A/B	CV1725	6.3	330	400	—	—	20	8702-9548 mc/s	Octal	£2 10 0
	CV35	4.0	1250	275	8.0	10	100	3033 mc/s mean	Octal	£5 0 0
707B	CV1768	6.3	—	—	—	—	140	3315-3680mc/s	—	£5 0 0
726A	CV676	6.3	330	400	—	—	100	3290 mc/s mean	Special	£4 0 0
6BM6	—	—	—	—	—	—	50	580-3800 mc/s	—	£12 0 0

MAGNETRONS

4J50: Vh—7-13V; Va pk.-22kV; Output 225kW peak. Frequency 9345-9405mc/s £35 0 0
714A/Y: Vh—6.3V; Va pk.-22kW; Field 22250 gauss; Frequency 3300mc/s. mean £10 0 0
3J31: Vh 6.3V; Va pk. 16kV; Field 8000 gauss; Frequency 23744-24244mc/s. £10 0 0

We have hundreds of other types in stock. Please send s.a.e. for current price list. Please add 2/6 in £ for packing and postage.

WE URGENTLY REQUIRE AND PAY HIGHEST PRICES FOR MODERN TEST EQUIPMENT (e.g., Signal Generators, Oscillators, Microwave Test Sets, etc.). COMMUNICATIONS RECEIVERS (especially U.H.F. and E.H.F. Ranges), AIRCRAFT RADIO COMMUNICATION AND RADIO NAVIGATION EQUIPMENT, SPECIAL VALVES, MAGNETRONS, KLYSTRONS, ETC.
EX A.M. RECEIVERS TYPE R-1359, HALLICRAFTER S27C RECEIVERS (Range 130-210 Mc/s) AND UNMODIFIED BC-348 RECEIVERS REQUIRED IMMEDIATELY.

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DELUXE TAPE RECORDER

LISTED ~~29~~ gns. our price **18 gns.**

Beautifully styled rexine covered cabinet in Red/Beige with carrying handle. Size 14½×13×9½in. Storage comp. in lid for tapes and mike. Speed 3¾in. per second. Compact set using latest 5 valve amplifier with 4-stage amplification and separate valve for Bias osc. 2 controls. Contains 7×4in. elliptical speaker and incorporating B.S.R. Tape deck. 5in. standard tape. 3 months' guarantee. Ins. and carr. 12/6. Deposit £8 plus ins., Carr., and 20 payments of 17/-.

B.S.R. MONARCH
4-speed autochanger £6 19 6

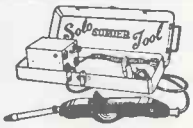
COLLARO CONQUEST
4-speed autochanger..... £7 19 6

Insurance and carriage 5/6.

TELEPHONE SETS 7'9

X.W.D. Wireless remote control unit. E.M.K.II (ZA11954). Including morse tapper, switched, jack plugs, etc. Less phone. Ins. and carr. 3/6.

SOLO SOLDERING TOOL ONLY 12'6



110 v., 6 v. or 12 v. (special adaptor for 200/250 v., 10/- extra). Automatic solder feed including 20ft. reel solder and spare parts. It is a tool for electronic soldering or car wiring. Revolutionary in design. Instantly ready for use and cannot burn. In light metal case with full instructions for use. Post 3/6.

"STUDIO TWIN"

LISTED ~~40~~ gns. NOW **29 gns.**

Quality Tape Recorder at this amazing reduced price. 7in. 1,200ft. Standard reels. Latest Studio 3-speed Deck, 1⅞, 3¾, 7½ I.P.S. Includes Twin Tracks, Reverse counter, Pause control and magic eye recording indicator. Volume and tone control, superimpose switch. 3 watts output. Attractive design cabinet in beige. Size 19in.× 13in. × 8in. Ins. & carr. 12/6.

EXTRAS: Microphone 27/6. Tape 25/-.

AMPLIFIERS.

12 months' guarantee

MK. D5. 39/6

Simple circuit employing ECL80 triode pentode output valve giving 3 watts output. A.C. only. Mains isolated. Single control for volume and on/off switch with knob. P. & P. 3/6.

MK. D2A. 79/6

Latest design incorporating negative feedback, giving 4 watts undistorted output. Valves: ECL82, triode pentode and contact cooled metal rectifier. Tone and volume control panel on flying leads with compact amplifier chassis suitable to mount under modern autochangers to give easy mounting in small cabinet. A.C. only. Mains isolated. Output for 2-3 ohms.

MK. D3A. 89/6

As above de luxe model, with separate tone controls for treble and bass.

PORTABLE AMPLIFIER (Salvage) 69/7

3 valves. 5 watts output. Size 7×5×4in. An ideal amplifier for stereo record players, Tape Recorders, Microphone, Baby Alarm, etc. Volume and tone controls. 200-250 v. A.C./D.C. P. & P. 4/6.

TAPE RECORDER AMPLIFIER

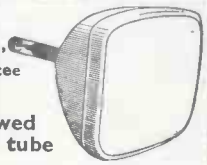
Compact, well designed 5 valve amplifier. Output 3.5 watts. Valves: ECC83, ECL82, 6BW6, EL84, EM84, EZ80. Input for mike, radio and gram. Dia. 8½×3×4¾in., ins. and carr. 4/6. Terms. **£7.19.6**

EXTRAS: Knobs 2/6 per set. Beautiful Perspex dial plate. Complete with sockets for mike, radio and superimposed switch 3/6.

NEW LOOK AMPLIFIER 59/6

Ideal stereo attachment. Brown/Ivory cabinet, carrying handle. Contains high flux 8in. speaker. A.C. mains. 3 valves: 10F3, 10P14, U404. Max. output 5 watts. 14×11×6½in. Completely converted. Ideal stereo, Mike, Guitar, Records. 2 units give world of amusement and special stereo effects. 12 months' guarantee. P. & P. 5/6. Deposit 30/- plus P. & P., 10 weeks at 8/-.

REPLACEMENT, REBUILT T.V. TUBES 12 months' guarantee



GUN etc. Carr. & Ins. 15/6.

21 in. TUBE £8.10.0
17 in. TUBE £7.10.0
£2 allowed on old tube

12, 14, 15 in. TUBES £5.10.0 **£1** allowed on old tube

—TERMS AVAILABLE OVER 20 WEEKS—

RECORD PLAYER CABINET R.P.9 19/6

Exceptional offer. A lightweight portable player Cabinet in Rust or Cream. Famous manufacturer. Size 14½×11½×6in. Complete with moulded deck board of attractive design. Takes B.S.R. TU9 single player; 2 control Amplifier; 5in. round Speaker. Post, packing and ins. 4/6.

BARGAIN SPEAKER 5/9
8in. P.M. Repaired cone defect not affecting reproduction quality.

8in. P.M. SPEAKER 6/9
As above but with output transformer.

8in. P.M. SPEAKER 9/9
Perfect quality. Fitted output transformer.

ELLIPTICAL SPEAKERS 15/9
8×3in. and 7×4in. Brand new. P. & P. on each 2/9.

EXTENSION SPEAKERS 19'9

8in. P.M. Speakers fitted into polished cabinets. Standard matching to any receiver. (Complete.) Switch and flex included. P. & P. 3/9.

17" T.V.'s 17½ gns.

Modern CHASSIS, modified.
Complete 17in. TUBE. VALVES — SPEAKER — KNOBS. Tuned ITV/BBC. Ready to use, fully guaranteed, TUBE 12 months, CHASSIS and VALVES 3 months. Cabinet to fit £1/11/6 if ordered with set. Salvage. Set—tube—cabinet despatched separately. Carr. & Ins. on set £1/5/-; on Cabinet 8/6.

Fully assembled sets delivered 75 miles London.

PLESSEY T.V. CHASSIS FOR SPARES 9'6

56 resistances. 54 condensers. 13 valve holders. 4 transformers. Chokes 250 m/a. Metal rectifiers 300 volts @ 250 m/a. Fuse panel. Focus magnets. Plugs. Sockets. Carr. 7/6.

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Beautifully made Tape Recording Cabinet. Size: 13×10½×7in. Covered in two-tone coloured rexine cloth. Stylish design. Carrying handle with detachable lid. Easily adapted to Record Player Cabinet. Exceptional value at this very low price. P. & P. 4/6. **ONLY 29'9**

STEREO RECORD PLAYER CABINET

with extension speaker cabinet

AT THE AMAZING OFFER OF 99'6

Portable 1960 Show Model in two-tone colours. Extension speaker cabinet secured in lid. Size 18×14×8½in. high. This stereophonic player complete, retails at 35 gns. in the shops today. Ins. and carr. 5/6.

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