

Wireless World

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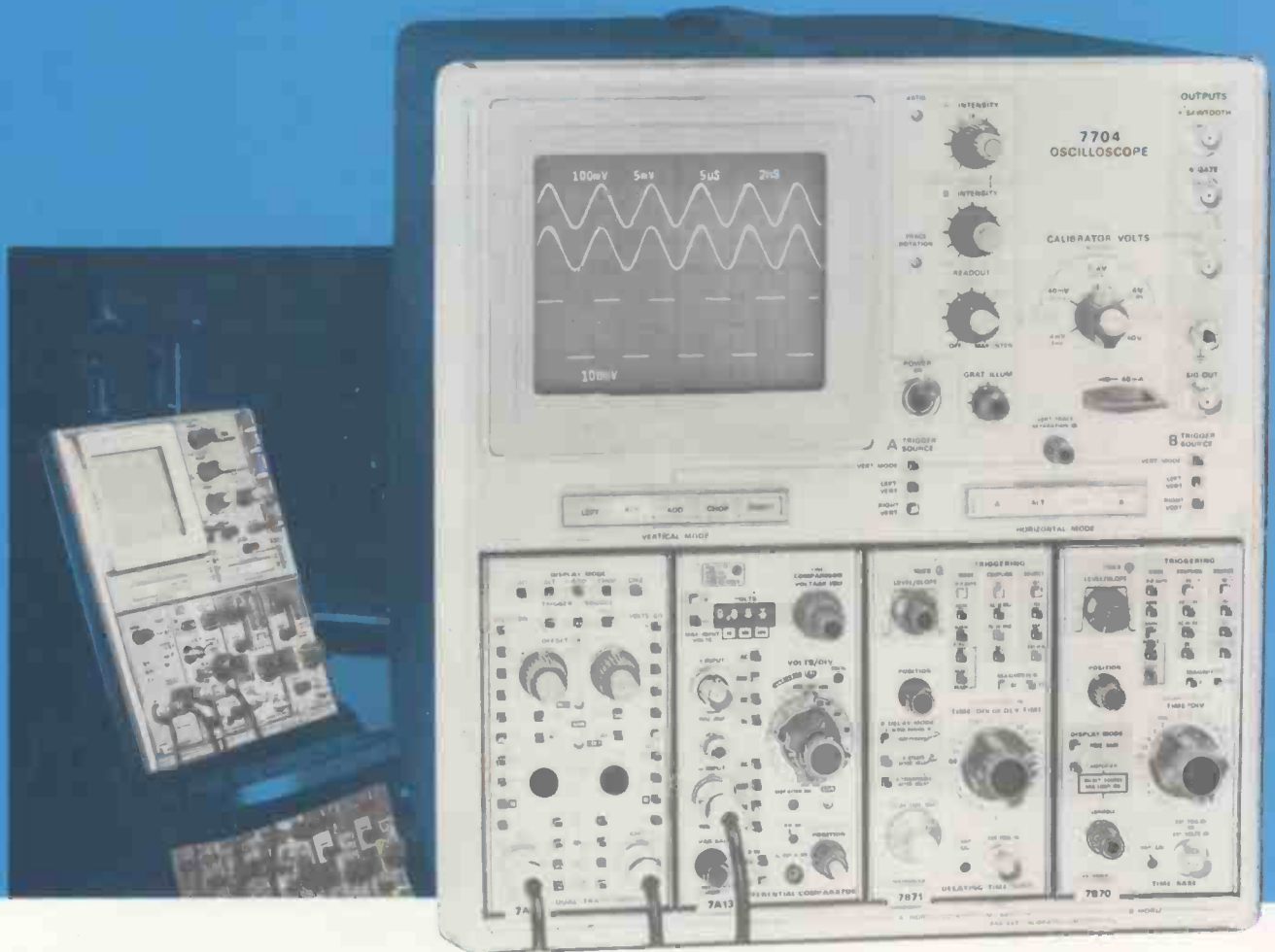
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Wireless World

Electronics, Television, Radio, Audio

Sixtieth year of publication

August 1970

Volume 76 Number 1418

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Although not exclusively associated with the subject of this month's main article (colour EVR) our cover illustration typifies colour television reproduction. The photograph of a Mullard tube was taken by students at the Polytechnic School of Photography, Regent Street, London.

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We regret Pt. 13 of Active Filters has had to be held over.



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H.R.H. the Duke of Edinburgh, speaking at the dinner of the Institution of Electronic & Radio Engineers at the Mansion House, London, in May said “The engineering professions are shirking their responsibilities if they only concern themselves with examinations and qualifications. They must take some part in the teaching process as well. Furthermore, it is quite useless merely laying down the rules for the engineering ‘generals’ and ignoring the qualifications for all the other ranks from ‘private’ upwards. The training and qualifications for each rank must be related to the requirements of the next rank up, and at each stage the vital factors of practical experience and performance in the job must be taken into account”.

Under their present charters neither the I.E.E. nor the I.E.R.E. can embrace non-chartered engineers and technicians in their membership. However, both institutions have associated technician organizations (respectively the Institution of Electrical & Electronics Technician Engineers and the Society of Electronic & Radio Technicians) which they actively support. For some considerable time there has been a movement afoot to give greater recognition to the non-chartered engineer and it was, of course, primarily for this reason that these two technician organizations in our own field were established. It will be recalled that with the setting up of the Council of Engineering Institutions the title “chartered engineer” has been granted to all members of the 14 constituent institutions in the C.E.I. The C.E.I. has been planning for some time the compilation of a register of all chartered engineers—but what of the “non-commissioned officers and other ranks”?

Nearly three years ago an *ad hoc* committee, representative of 42 different organizations with members in the technician and technician-engineer grades, was set up to establish in consultation with the C.E.I. basic qualifications for registration. This committee, the Standing Conference for National Qualification and Title (known colloquially as SQUINT) was faced with the tremendous task of finding a common denominator for technicians in as diverse trades as boilermaking and radio, building and baking, brewing and electrical installation, etc. etc. After two years of preparatory work by this *ad hoc* committee a limited liability company entitled the Standing Conference for Technician Engineers and Technicians was established to expedite the procedure necessary to give legal status to the association of professional bodies representing technicians. On July 1st an announcement was made stating that “today sees the first awards of the designation Registered Technician Engineer” under the authority of S.C.T.E.T. The designatory letters for the registered technician engineer are R.Tech.Eng. The statement goes on to say S.C.T.E.T. intends that these new registrants “shall form part of a single composite national register together with the chartered engineers and eventually with the registered technician. To this end S.C.T.E.T. is urgently pressing for constructive discussions with the Council of Engineering Institutions and other interested bodies”.

It has been known for some time that there has been discontent among certain sectors of the technician fraternity at the way the C.E.I. had been dragging its feet and the move to “go it alone” did not come as a surprise. However, six days after the S.C.T.E.T. announcement the C.E.I. issued a statement saying that it was proposing changes in its charter and by-laws to enable it “to establish and maintain a composite register for the three sections of the engineering community . . . the chartered engineer, the non-chartered engineer, and the technician”. The statement goes on to give the designatory letters “for those individuals nominated by their institutions or societies to the new sections of the C.E.I. register”. They will be CEI.T.Eng. for non-chartered engineers and Tech.CEI for technicians.

The situation, therefore, is that the “n.c.os and other ranks” of the radio and electronics fraternity, who have been in something of a “no man’s land” for far too long, now find that they are mentioned in despatches—or are they being offered terms for surrender?

Colour Electronic Video Recording

System providing vision and sound records which can be played into the domestic television set

by Peter C. Goldmark* and collaborators

Through a unique combination of photography, optics and electronics, Electronic Video Recording (EVR) allows recorded sound and vision programmes to be played through standard television receivers—truly a visual counterpart of the long-playing record. The nature of the recording medium lends itself to low cost, high volume production in monochrome or colour. The system, developed by CBS Laboratories, U.S.A., is compatible, in that a colour record can be reproduced on a monochrome player while a monochrome record will produce a black-and-white image on a colour receiver.

The recorded programme is contained in a cartridge, 7 inches in diameter, $\frac{1}{4}$ inch thick, with a large centre hole resembling that in a 45 r.p.m. gramophone record (Fig. 1). This cartridge contains 30 minutes of colour vision programme (25 minutes in the U.S.A.) with two sound tracks which may be used for stereophony or for two independent sound programmes. The video information is on a special photographic base, 8.75mm wide and approximately

0.003in thick. The sound is recorded on two narrow magnetic stripes, one on each side of the photographic film.

The EVR player, which operates by flying-spot scanning, can have a number of forms. The one described here (Fig. 1) is a separate unit from which an r.f. signal carries the combined video and audio information to the aerial terminals of a colour or monochrome television receiver. For stereo sound reproduction a separate jack is available in the player. Push-buttons control the threading, stopping, fast forward, and rewinding operations of the cartridge. Methods are available to find a particular part of a programme and then stop automatically or manually to display a still picture for any length of time. Also, slow forward or reverse manual "browsing" is provided for. Since each picture is extremely small—0.130in. \times 0.100in.—the record has a large storage capacity with potential as a reference library of visual information. Picture quality is equivalent to the best seen on European and U.S. television receivers.

On a suitable closed-circuit monitor, the monochrome resolution of EVR can reach 500 television lines in a horizontal direction. On a closed-circuit set-up, where full video bandwidth can be utilized, the resolution limit is set by the phosphor-dot structure of the picture tube.

The wear qualities of the cartridges are extremely good. Many hundred playings are possible without noticeable deterioration.

A major goal in the development of the system was to devise a film recording and duplication method that would permit large-quantity production of inexpensive film cartridges containing high quality programmes. After considerable study a special high resolution silver halide film was developed by Ilford Ltd. (a member of the EVR partnership in Europe). Stringent quality and size requirements resulted in the choice of direct electronography (exposing the film in a vacuum by finely focused electron beam) as the method of creating the master record. Modern films have a high capacity for information storage, and this applies particularly to those very fine grain films which are relatively insensitive to ordinary light but very responsive to the high energy present in an electron beam. The film used as the master for electron beam recording has a crystal size of less than one-tenth of a micron and the definition obtainable is of the order of 800 line pairs per millimetre. This master film too has been developed by Ilford.

With electronographic recording, modifications can be made to the original vision signal before the recording process so that the resolution and grey-scale produced on the film by the electron beam recorder are such as to give optimum overall performance. Thus, by adjusting the characteristics of the signals driving the electron beam it is possible to apply frequency pre-emphasis and to introduce grey-scale correction while restricting the density range to desired values. All these are not possible in a purely optical method of exposing the film.

The resulting picture on the film looks different from that on normal cinematography film, especially as colour pictures appear in monochrome and the colour information content is coded

*President, CBS Laboratories, U.S.A.

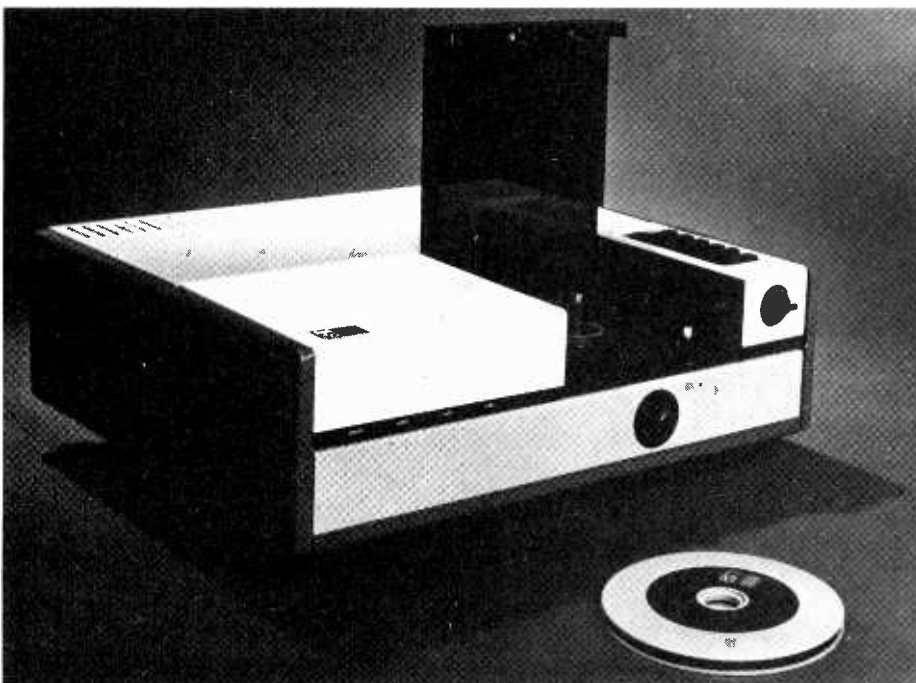


Fig. 1. Prototype EVR colour player with cartridge in front. The machine is 22in wide, 9in high and 19in deep.

(Fig. 2). An important further difference is in the number of pictures per second. In electron beam recording, and by the use of extremely fine grain print material, one is able to produce extremely small images. As a result it becomes economically possible to print 50 frames per second (60 in America). This leads to great simplification in the player machine and tends to provide a high degree of visual integration of spurious signals, such as grain or other imperfections.

The whole philosophy behind the EVR system has been to accept complexity in the recording system so as to obtain the maximum economy and simplicity in the play-back process.

Making the cartridge

There are three principal steps in making the cartridge record: preparing the original programme; making the master negative by electron beam photography; and printing and slitting the films and loading the cartridges.

Preparing the original programme is a matter of electronically pre-correcting the video signal for any losses that will occur throughout the entire system, including the player. Thus compensation is

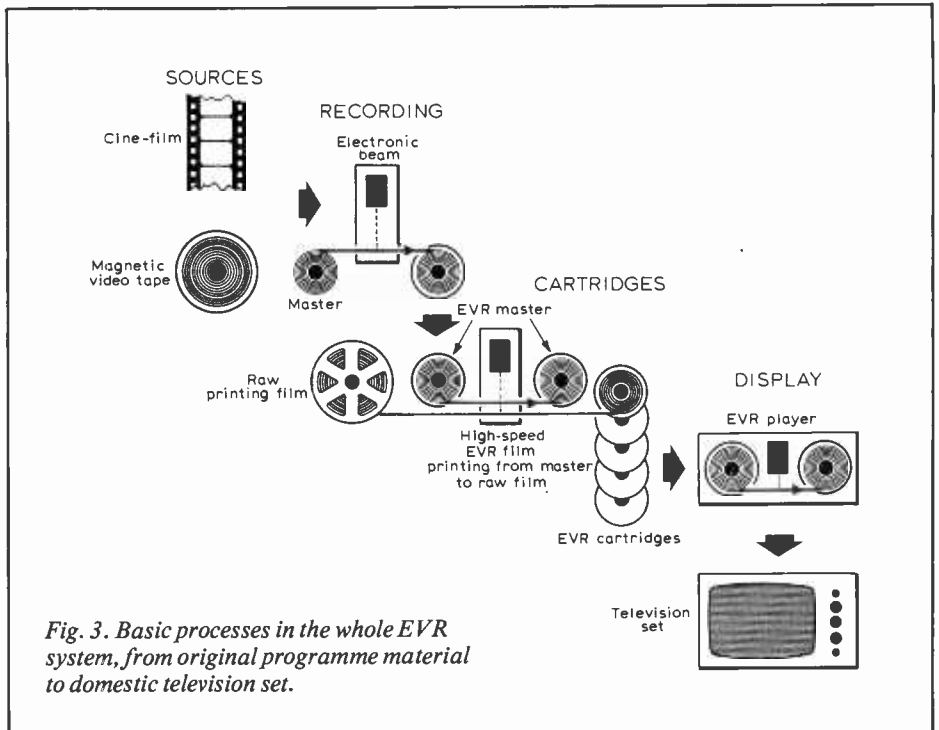


Fig. 3. Basic processes in the whole EVR system, from original programme material to domestic television set.

provided for loss of resolution and divergence from the desired scale characteristic. The original programme material is converted into a colour television signal which is separated into its luminance and chrominance components. Both signals are enhanced by vertical and horizontal aperture equalization and both are gamma corrected to ensure that the entire system approaches unity gamma.

The format of the film can be seen in Fig. 2. There is a series of frames, each having a luminance-information area seen as a picture (left-hand strip) and a chrominance-information area recorded by its side (right-hand strip). Each area is 0.123in. wide and 0.092in. high. Between the frames are small rectangular "windows" (seen as white) spaced 0.100in. apart. These are synchronizing marks indicating the start of each frame, and their purpose is to provide, in the player, a means of synchronization between the film transport and the flying-spot scanner. At the outer edges of the film are the magnetic stripes for sound.

It is essential to record the colour television signal in such a way that it can be reproduced independently of the recording and playback system's scanning linearity. In the chrominance-information areas there is recorded a colour carrier signal whose frequency is an integral multiple of the line scan frequency. In order to provide a reference carrier for the demodulation of the colour signal, an unmodulated pilot signal with a frequency exactly one half that of the colour carrier is also recorded in the chrominance-information areas of the film. Non linearity, raster size changes, film shrinkage, etc., thus will not interfere with the proper demodulation of the chrominance carrier, since the phase relationship between chrominance and pilot carriers is always maintained to the required accuracy.

The synchronizing signal generation is arranged so that the colour carrier signal is the overall system clock frequency. All synchronizing signals, as well as the pilot carrier signal, are counted down from this colour carrier signal. Because of the integral relationship between the chrominance and pilot carriers and the electron beam recorder horizontal scan frequency, the pilot and chrominance signals are recorded on the master film as a series of vertical bars.

Electron beam recorders for commercial production of master films have recently been completed for use in Europe and the U.S.A. For colour EVR the same type of machine will carry the two electron guns necessary for recording side by side the luminance and chrominance signals. A 40-mm wide film is used for the master and 35-mm film for the print. The 35-mm format accommodates four 8.75-mm cartridge films which can carry eight monochrome or four colour programmes. They are printed simultaneously and are subsequently slit. The steps in the whole process are as follows:

Editing. Although the recording system could operate with signals directly from television cameras, video tape or film, the advantages of editing and colour balancing can be obtained by first recording all programme material on video tape. A master tape thus produced can be easily corrected prior to transcription and the technique ensures that the signal input always meets the prescribed standards

Video processing. The commercial system for making a master is shown in the simplified block diagram Fig. 4. First, the video signal from a video tape recorder is separated into luminance and chrominance components. The luminance signal is fed to a video amplifier, from which one output is a direct (undelayed) signal while

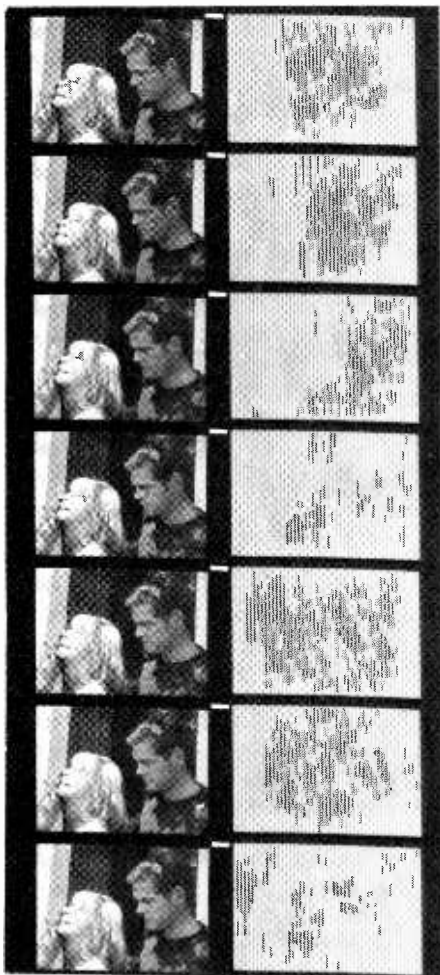


Fig. 2. Section of EVR film, showing luminance information in left-hand track, chrominance information in right-hand track, and small synchronizing windows (white rectangles) running down the middle.

the other is passed through a one-field period delay line. The purpose of this delay line is to permit video sampling at a constant rate between two successive fields. As a result, during each EVR frame, information corresponding to all 625 (or 525) lines of a television picture is recorded. The output from the delay line and the direct luminance signal are applied to independent video processing circuits. These are vertical and horizontal aperture correctors, a gamma corrector and sync "window" adder. Next, the delayed and undelayed video signals are applied to a sampling gate operating at a rate such that both fields are recombined in an EVR frame so that it contains the full 625- (or 525-) line information during a 1/50th sec. (or 1/60th sec.) television field interval. The sampled luminance signal is then applied through a video amplifier to one gun of the electron beam recorder.

The chrominance part of the v.t.r. signal, extracted from the luminance information by a filter, is translated from the television signal standard to the EVR system values. Next the chrominance signal is processed in the same manner as the luminance signal and finally is fed to the chrominance video amplifier and the second electron gun of the electron beam recorder.

The method by which an American 60 frames/sec. film is produced from a 30 pictures/sec. American television signal is shown in Fig. 5. The intercalation occurs in two steps. Using film as the programme source (though it could be video tape), the 24 frames/sec. film in the projector is changed to 30 frames/sec. as in American television and from 30 frames/sec. to a 60 frames/sec. EVR master film (the rate required for playback in the U.S.A.). The

top row shows the film frames, each frame being assigned a letter of the alphabet. Below the film frames the numbers 1, 2, 3, etc. represent successive television camera vertical scan intervals, each 1/60th second. The projector pull-down is such that alternate film frames are scanned by two and three television fields respectively.

The third row down shows the numbered fields together with the letter that represents the frame of film scanned by that numbered field. The corresponding video signal is available at the output of the "direct signal" channel in Fig. 4. The fourth row shows the field information that exists at the output of the delay line. Hence, with information from two successive fields transformed to become available simultaneously during a given 1/60th second interval, it is possible to sample synchronously the information between the successive fields at a rate well above maximum video frequency and so retain the integrity of a given television picture. The bottom row shows the sampled information that will be recorded in each frame of the EVR master.

Electron beam recording. Fig. 6 shows in essence how electron beam recording takes place in a vacuum chamber. As can be seen, the film is exposed by two modulated electron beams. Fig. 7 shows the vacuum chambers and film transport of the recorder. (The film magazine capacity is 1800 feet of 40mm film.) The two electrostatically focused and deflected electron guns can be seen in a gun chamber above the film transport mechanism. The gun chamber is supported on two trunnions and can be indexed to four discrete horizontal positions, thus making it possible to sequentially

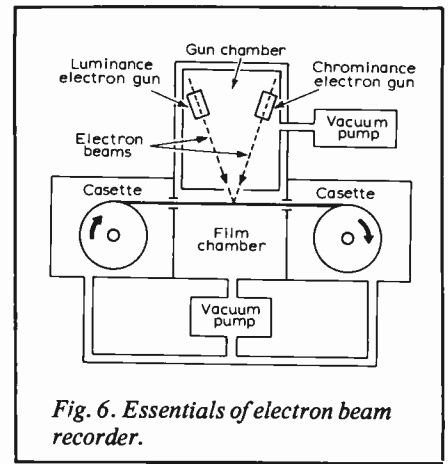


Fig. 6. Essentials of electron beam recorder.

record four dual tracks across the width of the 40mm film.

Vertical deflection of the modulated electron beam follows the direction of film motion with twice the film velocity. As shown in Fig. 8, the vertical scan starts at the top (A) of the film image and after 1/50th (or 1/60th) second reaches the bottom of the frame while the film has moved from position 1 to position 2. During vertical blanking the electron beam returns to start the process over again with film frame No. 2.

During recording the beam is deflected vertically, between two adjacent lines, at a 14MHz rate. The phase of this wobble signal is adjusted so that the video information from the delayed signal is recorded along one horizontal line on the film while the video information from the direct (undelayed) signal is recorded on an adjacent line on the film. A peak white synchronizing window signal and a grey scale test signal are gated in with the video signal and are recorded at the start of each luminance field.

The film drive used in the electron beam recorder provides accurately controlled continuous motion at 5 in./sec. for Europe and 6 in./sec. for the U.S.A. An electronic servo causes the film to be driven at constant velocity while locked to the v.t.r. This servo has three closed loops. In one loop a 7kHz signal from an optical tachometer on the drive motor shaft is fed to a discriminator circuit whose output controls the motor to compensate for speed variations. The same 7kHz signal also provides one of the inputs to the second loop, in which the actual motor speed is set by comparing the tachometer output with a 7kHz reference signal from a crystal controlled oscillator. The third loop establishes the spatial position of each frame on the film with respect to an associated perforation in the film. One edge of the film is perforated along its length at 0.1-in. intervals and is transported past an optical sensor which generates a pulse for each of the perforations. In the loop the phase of the vertical drive signal and a "perforation signal" from the film are compared in order to ensure accurate phase lock between the vertical scan and a given perforation.

Interlocking the electron beam recorder film drive with the v.t.r. is accomplished by

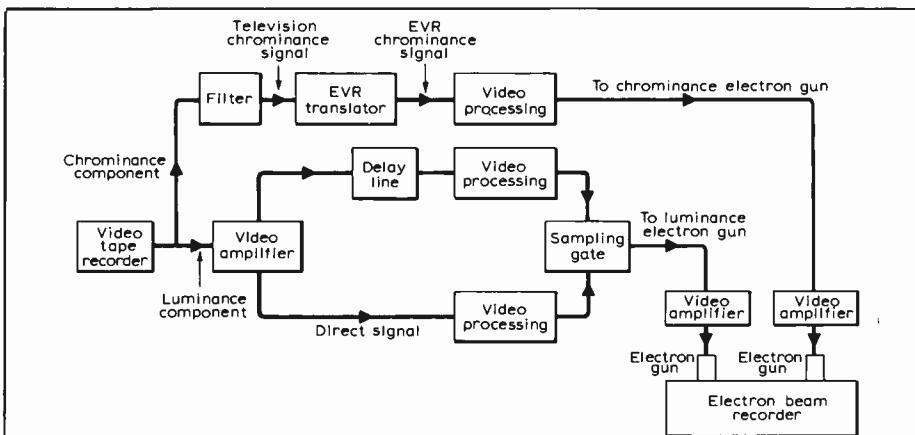


Fig. 4. Simplified block diagram of system for making master film.

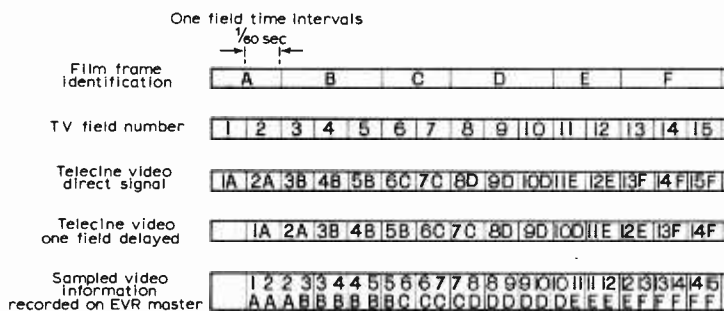


Fig. 5. Intercalation method for making an EVR film from a television (or cine film) programme source.

counting the vertical sync intervals on the magnetic tape and the perforations in the master film. The counts are compared, and the speed of the recorder drive is varied until they are equal. Interlocking between the two drives occurs within 12.5 seconds.

High speed duplication. For the production of EVR cartridges a special multi-head printer has been developed by Ilford Ltd. in the U.K. This equipment is capable of running at speeds of up to 200 feet per minute. The design minimizes light dispersion and protects the master film so that a large number of copies may be made.

Through the use of multiple heads, 16 colour programme reproductions, together with the sound, are obtained each time the master negative passes through the printing machine. Thus, the rate at which the printer produces EVR copies is approximately 125 times (in America 100 times) faster than the actual playing time of the original programme. If the programme is half an hour long it can be duplicated at the rate of one cartridge every 14.5 seconds.

The film is developed in black-and-white continuous film developing machines which will run at speeds of up to 200 feet per minute. The processed film then goes to a slitting machine which divides the 35mm film into four 8.75mm films. These are cleaned and wound directly on to EVR cartridges.

The sound is recorded on the two tracks during the printing process. Magnetic recording was chosen after careful consideration, the important factors being long life with high quality and low noise and the ability to change the sound track when required. The fact that magnetic reproduction in the player is less expensive than reproduction of optically recorded sound was another consideration. The sound recordings are made individually, and synchronizing marks are incorporated in the vision recording and the special sound recording so that when they are brought together in the printing machine the sound can be added in exact lip synchronism.

The player

Fig. 9 shows a laboratory prototype player with the cover removed, exposing

the cartridge deck, c.r.t. and associated circuitry, all of which are mounted on an internal metal frame independent of the cabinet. A cartridge is played by opening the door over the well, placing a cartridge on a hub and closing the top. To the right of the well are six pushbuttons for controlling deck functions. Pressing a "play" pushbutton causes the cartridge leader to thread through the deck. After the leader is securely fastened to a take-up reel (seen behind the cartridge) the machine automatically starts to play. Other controls on the top are a track selector and mains switch. The large knob on the front is for manual searching—to move the film backwards or forwards while viewing still pictures.

The 3-in. diameter cathode-ray tube scans the film image through an optical system and the resulting modulated light is converted by photomultiplier tubes into luminance and colour signals. The c.r.t. scans each picture on the film once per television field. To accomplish this, a capstan and pressure roller pull the film past an optical gate at a constant velocity of 50 frames/sec. or 5in./sec.

Optical scanning of the luminance track of the EVR film, shown in Fig. 10, employs a forward raster scanning technique. The colour track of the film is similarly scanned through a second objective lens by the same c.r.t. raster.

At the start of the field the light beam from the c.r.t. spot scans the head of the first picture (a). As the film moves at a constant speed of 5in./sec. the beam also moves in the same direction but at twice the velocity. Thus, by the time picture 1 has moved to the position shown at (b), the light beam has completely scanned it and now rests at the foot of picture 1. At this instant, a vertical sync pulse, derived from light flashing through the clear "window" in the film (Fig. 2), initiates vertical flyback of the c.r.t. electron beam. As a result the c.r.t. spot and light beam returns and comes to rest at the top of picture 2 ready to start the next scanning period, as shown at (c).

Since the timing of the c.r.t. scanning spot is controlled by the film velocity, the film speed can vary within a limited range

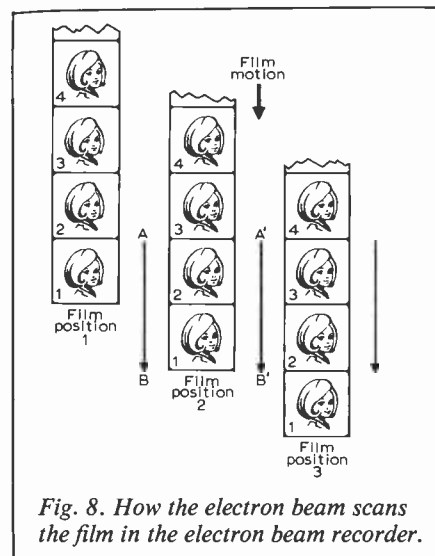


Fig. 8. How the electron beam scans the film in the electron beam recorder.

without affecting the vertical position of the reproduced television picture. Ultimately, of course, the television receiver sets the limit by losing vertical hold if the film departs too much from the nominal speed of 50 fields/sec. To prevent this from happening, the film drive is servo locked to the 50Hz mains by a circuit that compares the recorded film field pulses with the mains frequency.

The sync "windows" in the film are illuminated by a miniature incandescent lamp coupled through a plastic light pipe to the film gate. Each time a sync "window" passes the end of the light pipe, there is a flash of light through the film into a photodiode, the output of which is clipped to generate constant amplitude sync pulses.

Optical system. The luminance and colour tracks of the film are scanned through a dual optical system. The imaging optics (Fig. 11) comprise two lenses, two rhomboidal prisms, a lens mount which provides both focus and position adjustments for the two lenses, and a film gate which holds the film in a cylindrically curved image plane. Each lens images the 1.48in. × 2.08in. raster of the c.r.t. onto an area in the image plane 11.3 times smaller, thus forming two identical side-by-side small rasters with centres 0.141in. apart. The prisms permit separation of the two lenses and a resulting larger lens diameter sufficient to obtain an aperture of $f/1.8$ for each lens. The collector optics are two light pipes which transmit the modulated light from the luminance and chrominance images on the film to two photomultipliers.

Player circuit. Anyone versed in television engineering should be at ease with an EVR player because it resembles a television receiver. Basic elements of a colour player for working into an American television set are shown in Fig. 12. These include: c.r.t. deflection and high voltage supply; transport deck and gate; dual photomultipliers and video amplifiers; chrominance translator for converting EVR signals to N.T.S.C.; pulse generation for blanking and composite sync; sound magnetic head, audio amplifier and intercarrier sound generator; r.f. link video and sound

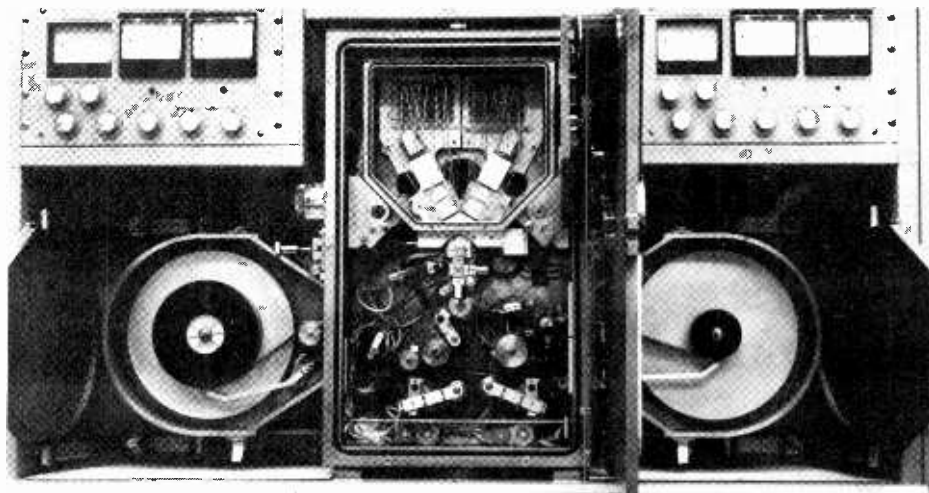


Fig. 7. Details of film transport and vacuum chambers of the electron beam recorder.

modulators and carrier generators; and the motor control circuit.

The 3-in. c.r.t., which is $9\frac{3}{4}$ in. long, has a flat faceplate. The P-16 screen phosphor is uniformly fine grained and glows a dull blue because much of its energy is in the invisible ultraviolet region. Magnetic focusing and deflection are employed. Horizontal deflection is provided by a 15.75kHz oscillator, amplifier, and magnetic yoke. Vertical scanning is from a synchronized multivibrator and amplifier. Unregulated 20kV e.h.t. for the c.r.t. is derived by rectifying the line flyback pulse. Regulation is unnecessary because the unmodulated electron gun is a constant load drawing a maximum of $100\mu\text{A}$. The horizontal deflection circuit also generates -600V for the photomultipliers and $+1\text{kV}$ for the g_2 of the c.r.t. Since failure of either the horizontal or vertical deflection current might burn the phosphor screen, the circuit is protected by a scan fail device that cuts off the c.r.t. beam current before damage can occur.

The raster light output is kept constant throughout the life of the c.r.t. by an automatic brightness control. It is known that the P-16 phosphor, as it ages, has a decreasing light output, and the initial beam current of $10\mu\text{A}$ has to be increased to about $80\mu\text{A}$ after 1000 to 2000 hours to maintain constant brightness. The closed loop of the automatic brightness control includes a photo-resistor, positioned to view the raster, and a circuit for controlling the bias of the c.r.t.

The deck transport in the player is mechanically more complex than an ordinary tape deck because of the automatic cartridge handling functions. The film drive, applied through a smooth capstan and rubber pressure roller, is similar to that of a standard tape recorder. The film runs in a gate, curved to make the film more rigid and with lands to protect the film picture. The capstan drive motor also supplies forward torque to the take-up

reel through a friction clutch. For rewinding, the torque is transferred to the cartridge spindle.

Video circuits. Modulated light transmitted through each light collection pipe is converted by the corresponding photomultiplier to a video signal of about 0.1 volt. As a result the succeeding video amplifiers have little effect on the signal-to-noise ratio. Video signals are pulse clamped to remove hum components and sent through white compressors to linearize the "white-stretched" film transfer characteristic. This is also a simple and effective way to reduce the visibility of c.r.t. phosphor structure and film grain clusters in the television picture (the individual film grain is far smaller than the resolving power of the player). Phosphor grain noise is predominantly visible in the white portions of the picture since the grain modulation is proportional to light output.

A programme selector switch for the user has three positions: Colour, Track A, and Track B. For colour cartridges, the switch directs the clamped luminance video signal into the Y channel and the signal to the translator. When a monochrome cartridge is played, either Track A or Track B can be switched into the Y channel.

Chrominance translator. As already explained, the colour track on the film carries the chrominance information together with the pilot signal. The chrominance is composed of two colour difference signals modulating a suppressed carrier in phase quadrature. The subcarrier frequency is 1.8MHz and the bandwidth of the colour difference signal sidebands is $\pm 0.5\text{MHz}$.

No attempt is made to scan over the lines originally recorded on the film, and each picture is composed of 525 lines (625 in Europe). In order for the chrominance subcarrier to be a series of vertical bars

rather than interleaved dots the EVR subcarrier is made a multiple of the line scan frequency. The scanning width and linearity of the electron beam recorder, as well as of the flying spot scanner, cannot possibly be uniform enough to ensure constant frequency and phase for the chrominance subcarrier in all parts of the picture. Therefore, as already mentioned, a continuous pilot signal is added to the chrominance sidebands during recording to make the system self-correcting on playback.

The EVR chrominance colour difference signal bandwidth is the same as the Q bandwidth in the N.T.S.C. system: -6dB at 0.5MHz. In EVR, the I and Q bandwidths are made equal because nearly all colour television receivers are designed with equally narrow bandwidth colour difference demodulators.

The reproduced chrominance could be demodulated to the baseband colour difference signals and re-encoded to N.T.S.C., but it is appreciably simpler to convert EVR to N.T.S.C. directly by frequency translation. The translator section of the player can be seen in the lower middle part of Fig. 12. The combined signal from the film is first separated into chrominance and pilot signals by filters. The chrominance channel uses a 1-2.5MHz bandpass filter and the pilot channel a 1-2.5MHz band-reject filter. The 0.9MHz pilot signal is doubled to 1.8MHz and applied to mixer A together with a locally generated 3.58MHz sinusoidal oscillation. The 5.38MHz sum signal output of mixer A is selected by a bandpass filter and applied to mixer B together with the chrominance signal centred on 1.8MHz. The difference frequency of 3.58MHz from mixer B is extracted by a bandpass filter and becomes the N.T.S.C. chrominance signal.

An analysis shows that, regardless of a shift in EVR chrominance frequency, the frequency of the chrominance output of the translator will remain constant at 3.58MHz. Furthermore, if the 3.58MHz carrier is frequency interleaved by being an odd multiple of half the line scanning frequency then the resultant N.T.S.C. chrominance is equally frequency interleaved.

Care is taken to keep the phase/frequency characteristics of the chrominance and pilot channels alike to prevent hue errors with scan velocity changes. If the chrominance and the doubled pilot signals undergo equal phase shifts, the errors cancel in the translator. Delay in the pilot channel is approximately $1.6\mu\text{s}$ greater than in the chrominance channel, making it necessary to insert a delay line in the chrominance path.

The translator has a total delay of $2\mu\text{s}$, thus requiring that the luminance channel be delayed an equal amount before the N.T.S.C. chrominance signal is added to the luminance signal. Following this, blanking, sync and burst signals are added to generate the composite N.T.S.C. signal. The colour burst is obtained by gating the 3.58MHz locally generated signal with a pulse. Prior to this, the 3.58MHz source

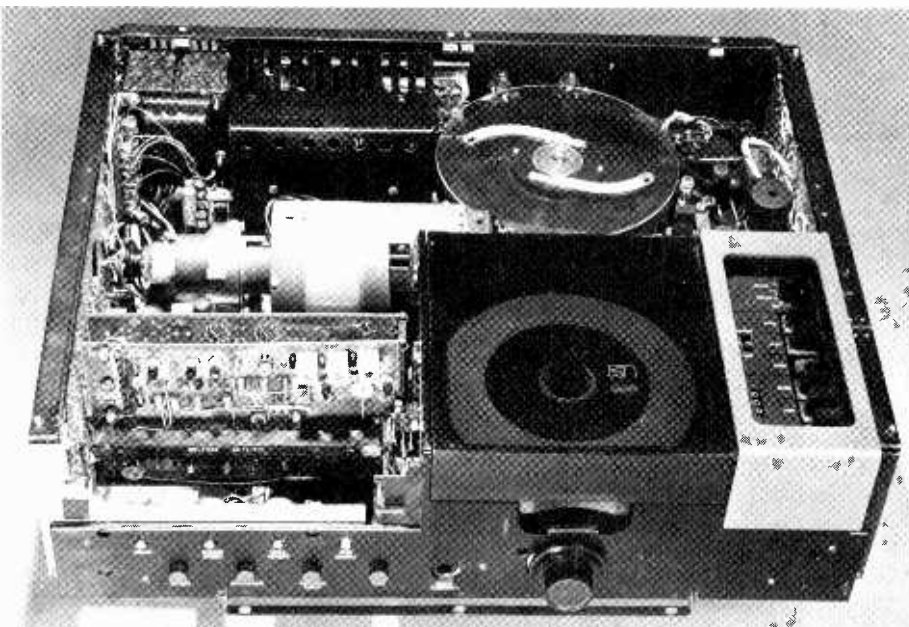


Fig. 9. The prototype player with cover removed and a cartridge inserted. The take-up reel can be seen behind the cartridge. The c.r.t. lies between them.

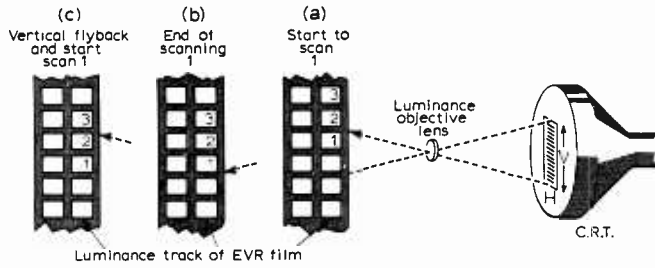


Fig. 10. Method of scanning the luminance track of the EVR film: (a), (b) and (c) are successive moments in time.

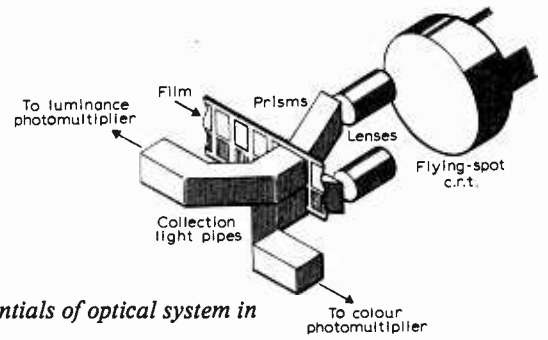


Fig. 11. Essentials of optical system in the player.

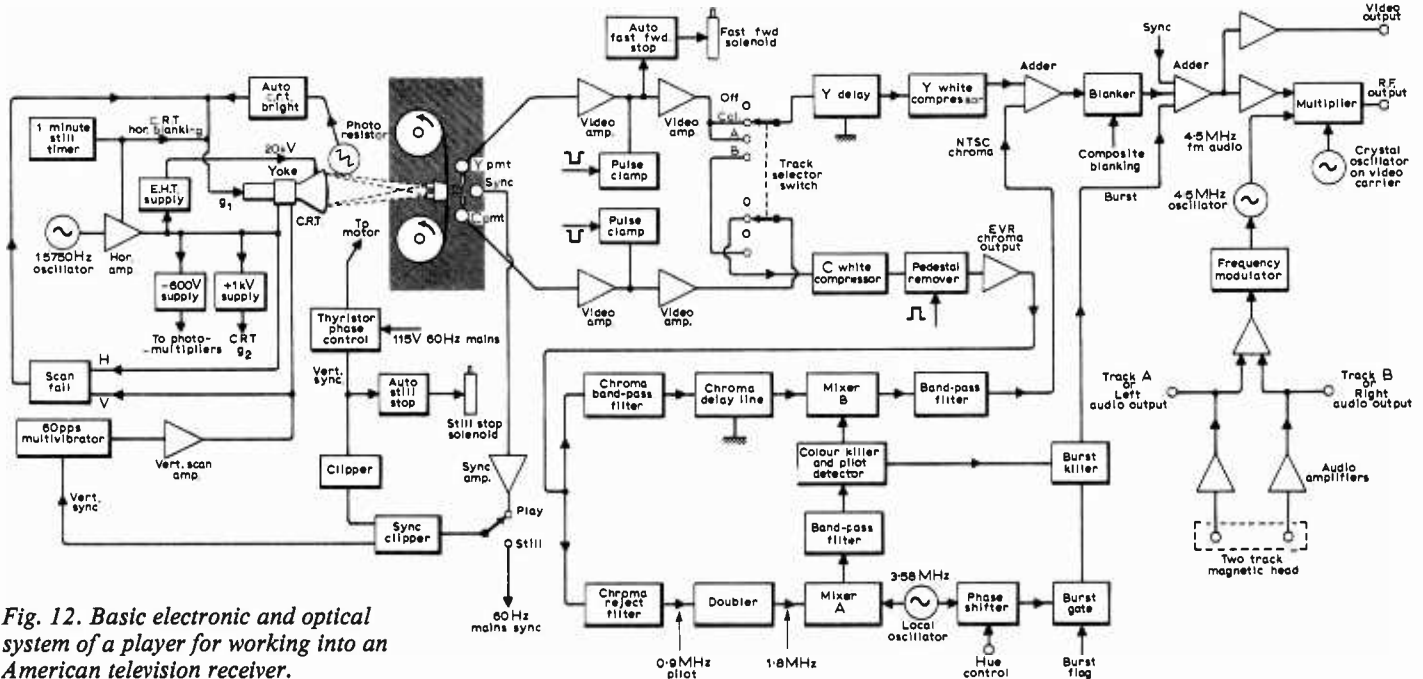


Fig. 12. Basic electronic and optical system of a player for working into an American television receiver.

is set to the correct phase by the player's hue control.

A colour killer is used to disable the colour circuit whenever a monochrome cartridge is played, otherwise spurious beats would show in the picture. With monochrome film, the absence of the pilot signal is sensed and both the chrominance and colour burst are removed from the outgoing video signal. The absence of burst actuates the colour killer in the colour television receiver, thus cleaning up the monochrome picture. This feature is especially important when colour and monochrome portions are intermixed for certain educational programmes

Sound reproduction. For monochrome cartridges, a track selector switch automatically selects the appropriate audio amplifier channel for that programme. A specific recording and playback equalization for 6in./sec. film speed provides a frequency response reasonably flat from 60Hz to 10kHz. Direct audio outputs at 600 ohms impedance are available at the rear of the player. Also, a single-channel audio signal is used to frequency modulate a 4.5MHz oscillator to generate the inter-carrier sound for the r.f. link.

R.F. link. The output of the player is fed to the television receiver through its aerial terminals by means of a miniature television transmitter operating on an unused v.h.f.

channel. Double-sideband video modulation is employed for economy, but television receivers accept the signal as if it were a vestigial sideband signal from a broadcasting station.

An improved r.f. unit is employed in the colour EVR player to satisfy requirements for low phase and intermodulation distortion. An r.f. carrier from a crystal oscillator is applied to one input of an analogue four-quadrant multiplier while the N.T.S.C. video and the 4.5MHz sound intercarrier are applied to the other input. Since the multiplier normally generates a suppressed-carrier signal, the multiplier is intentionally unbalanced to produce the desired carrier.

Power supplies and motor control. Regulated low voltage power supplies keep the player performance constant when the mains voltage varies over wide limits. The all-transistor circuit draws 100 watts with an additional 35 watts for the motor.

Locking the film velocity to the mains reduces the visibility of hum bars. Also, this ensures that the field scanning rate stays within the vertical hold range of the receiver. The vertical stability of the EVR picture is primarily a function of the vertical synchronizing signal derived from the film rather than being dependent on the motor lock. Therefore the motor must be frequency locked, but need not be phase locked, to the mains. During playback, the four pole, shaded-pole, induction motor is servo controlled by a thyristor.

APPENDIX

Characteristics of the EVR encoded colour signal

The EVR colour signal, E_m , consists of the linear sum of a pilot signal, E_p , a chrominance signal, E_c , and a colour difference video signal, E_v :

$$E_m = E_p + E_c + E_v.$$

The pilot carrier frequency, f_p , is the 56th harmonic of the line scan frequency, f_h :

$$f_p = n f_h \quad n = 56.$$

The chrominance carrier frequency, f_c , is the second harmonic of the pilot carrier frequency:

$$f_c = 2 f_p.$$

The chrominance signal consists of the sidebands of two suppressed carriers in quadrature:

$$E_c = E_Q' \sin(2\pi f_c t) - E_I' \cos(2\pi f_c t).$$

The amplitudes of the quadrature carriers are obtained by matrixing the red, green, and blue video signals:

$$E_I' = 0.60 E_R' = 0.28 E_G' - 0.32 E_B'$$

$$E_Q' = 0.21 E_R' - 0.52 E_G' + 0.31 E_B'.$$

The pilot signal is given by:

$$E_p = A_p \sin(2\pi f_p t)$$

A bandwidth limited colour difference video signal, E_v , corresponding to $-E_I'$ of amplitude k relative to $E_I' \max$ is added to the pilot and chrominance signals to achieve minimum peak-to-peak excursion of the composite signal envelope:

$$E_v = -k E_I'.$$

Television Wobbulator

1. Principles

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

Correct alignment of a wideband amplifier, such as a television i.f. amplifier, can rarely be carried out successfully merely by adjusting the various tuned circuits for maximum output at certain specified frequencies. It is usually necessary for the response curve of the amplifier to have a certain required shape, and the circuits must be adjusted to produce this shape. This means that it is necessary to measure the response curve. To do this with a signal generator and an output indicator is quite a laborious process and one which takes a considerable amount of time.

It is not unreasonable to do it once as a check that an amplifier is indeed functioning correctly. To do it frequently, while aligning the amplifier is another matter. Fortunately, it is not necessary to do so if one has the proper equipment. It is not difficult to arrange for the response curve to be displayed on the screen of a cathode-ray tube. One can then see how the shape of the curve varies with the various amplifier adjustments as they are made.

The requirement is to have an oscillator which is modulated in frequency so that its frequency sweeps repetitively over the required range. The output of the detector of the i.f. amplifier is applied after amplification, to the Y-plates of the c.r. tube, and the voltage applied to the X-plates is arranged to vary with time in the same way as the oscillator frequency varies with time. The actual law of variation with time does not matter at all as long as both obey the same law.

The curve is displayed in the usual way with frequency for the horizontal scale, but the vertical scale is normally a linear one. Most curves which are plotted as the result of point-by-point measurements are plotted with a decibel scale, which is a logarithmic scale. It is not impossible to obtain such a scale on a c.r. tube, but it is much more difficult because it requires the use of an amplifier which has an output accurately proportional to the logarithm of its input.

For 625-line television the present standard for an i.f. amplifier is to have the vision carrier at 39.5MHz with the sound carrier at 33.5MHz. The amplifier usually has trap circuits to give specially high rejection at frequencies of 31.5MHz and 41.5MHz. To give a little in hand, therefore, the

frequency sweep needed is from 30.5MHz to 42.5MHz which is a band of 12MHz centred on 36.5MHz. The total sweep is almost one-third of the mid-band frequency and is thus very considerable indeed.

A great many methods have been used in the past in wobbulators, as swept-frequency oscillators of this type are usually called. Most of them are useless for a sweep as great as one-third of the mid-band frequency, especially when that frequency is as high as 36.5MHz, and especially when transistors are used. One method which has been employed is to have the oscillator at a much higher frequency, perhaps 500-1,000MHz, so that the sweep is a much smaller fraction of the mid-band frequency. The output is then mixed with the signal from another oscillator having a frequency which differs by the required intermediate frequency, so that the frequency range is obtained as the difference frequency, just as in the ordinary superheterodyne.

This had the advantage that the output can be brought to any required frequency merely by altering the frequency of the beating oscillator. However, it is rather complicated and there is a risk of spurious responses arising from harmonics.

If it can be done at all, it is much simpler to modulate directly an oscillator operating at the required output frequency. Recently a new way of achieving such modulation has made its appearance as a result of the development of a new semiconductor device, the varactor diode. This is a diode which is specially designed to

provide a capacitance which varies with the voltage applied to it. It can be used, therefore, as a tuning capacitor, tuning being effected by varying a voltage. It is, in fact, becoming increasingly used as a tuning capacitor in domestic receivers.

When reverse-biased to be non-conductive, all semiconductor junction diodes have a capacitance which varies with the applied voltage. To put it rather crudely, a non-conductive diode has internal charges of opposite sign on the two sides of the junction, and the capacitance results from the electric field between these charges. If the reverse bias is increased, the charges are forced further apart and the capacitance decreases. It is as though a parallel-plate capacitor had the separation of its plates varied by some control voltage.

The ordinary diode exhibits the effect, but the magnitude of the capacitance is usually rather small, the range of capacitance variation is much too small, and the capacitance is accompanied by quite high losses. It is another matter with a diode specially designed for use in this way.

One example, and the one which is used in this equipment, is the Motorola 1N5145A. It is rated for a maximum reverse voltage of 60V, and a capacitance of 27pF at 4V with a normal capacitance ratio between these voltages of 3.4:1 and a minimum ratio of 3.2:1, and with a Q of not less than 200. The frequency ratio required is $42.5/30.5 = 1.395$ and the capacitance ratio is thus 1.94, which is almost 2:1.

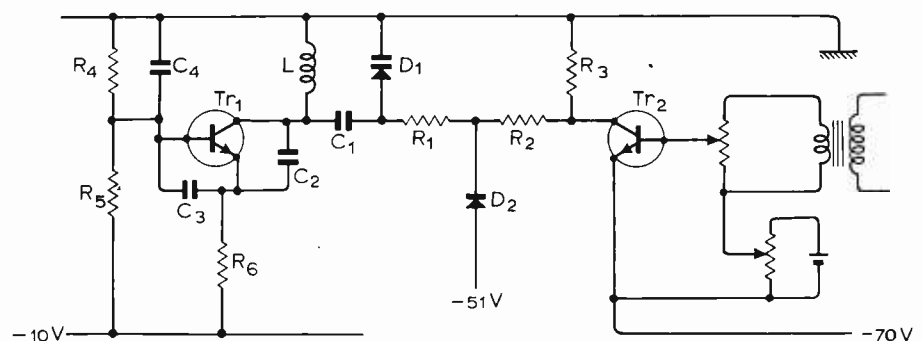


Fig. 1. The heart of the wobbulator is shown here. Tr_1 is a Colpitts oscillator tuned by the varactor diode D_1 . The control voltage for this is applied through R_1 from the collector of Tr_2 ; this produces an output which is the exponential of its input, its base-emitter path acting as the diode of Fig. 3 (b).

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The oscillator circuit itself must have a capacitance which can hardly be much under 12pF and it is necessary to have a blocking capacitor in series with the varactor to permit the application to it of a control voltage. This cannot be very large without causing excessive phase shift in the control voltage, and 330pF is a reasonable compromise. These two capacitance ratios greatly reduce the total capacitance ratio available for a given control voltage swing.

It is, moreover, impracticable to swing the diode to 60V, for this is a maximum rating and it is not possible to operate at this voltage and at the same time guarantee that it will never be exceeded. The varactor is an expensive component and it is necessary to limit the voltage applied to it. Referring to Fig. 1, this can be done by a diode D_2 returned to a zener diode stabilized supply of $-0.51V$. The tolerance on the zener voltage is $\pm 5\%$, so the voltage is anywhere between 53.55V and 48.45V. At full conduction the forward drop across D_2 may be 0.8V, so the maximum voltage which can be applied to the varactor D_1 is 54.35V, which leaves about 5V factor of safety. The maximum control voltage which can be applied to the varactor with a low limit zener is 48.5V.

At the other end, it is not necessary to limit the minimum control voltage to 4V, but the minimum voltage must not be so low that the varactor can conduct appreciably on the peaks of the r.f. waveform. The normal amplitude of oscillation is about 1.5V r.m.s. or some 2.1V peak. Appreciable conduction in a silicon diode does not usually occur until the anode is more than about 0.25V positive to the cathode. This means that a minimum reverse voltage of $2.1 - 0.25 = 1.85V$ is possible. Calculation shows that with 12pF oscillator capacitance and 330pF in series with the varactor, the total capacitance at 1.85V is 45pF and to obtain 22.5pF (2:1 ratio) 29V bias is needed on the varactor. On the other hand, at 48.45V the capacitance is 20.5pF, and to obtain 41pF, 2.9V is needed.

Thus, for the assumed capacitance values a 2:1 capacitance ratio is obtainable for a control voltage change of 1.85V to 29V, (27.15V swing) or from 2.9V to 48.5V (45.6V swing). The maximum possible capacitance swing is from 20.5pF at 48.5V to 45pF at 1.85V, or 2.2:1, with a voltage swing of 46.75V. There is thus a reasonable latitude for component tolerances.

The swing required for the control voltage varies greatly for quite a small change of maximum capacitance, for 45pF it is 27.15V whereas for 41pF it is 45.55V. In practice, there are three variables involved, the coil inductance, the peak-to-peak control voltage of the varactor and a mean bias voltage. The latter two are adjusted to obtain the required frequency range, in conjunction with L and then finally L is adjusted in small steps, each time with readjustment of the other two variables for the proper frequency range, until linearity is secured.

By this is meant a linear relation between frequency and the displacement of the

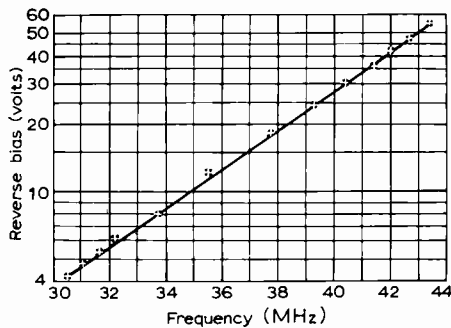


Fig. 2. Measured oscillator frequency plotted against control voltage on the varactor diode. The points nearly all lie on a straight line, showing that the relation is almost perfectly logarithmic.

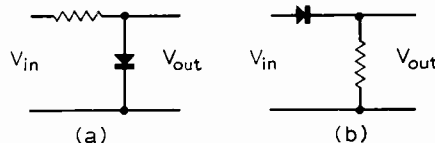


Fig. 3. The use of a resistor and diode to obtain an output voltage which is the logarithm of the input is shown at (a), while the arrangement to obtain an output which is the exponential of the input is shown at (b).

spot on the screen of the c.r.o. The law connecting oscillator frequency with control voltage on the varactor is apparently very complex, but it turns out experimentally to be very simple, at least over the range of interest. Fig. 2 shows a measured curve relating frequency and voltage and it can be seen that the frequency is almost exactly proportional to the logarithm of the voltage. This is very fortunate for a logarithmic relation is one of the easiest non-linear functions to generate.

There are two possible lines of attack. One is to use any convenient control voltage for the varactor and to produce from this voltage another voltage, for the sweep, which is the logarithm of the first. The other is to use any convenient voltage for the sweep and to generate from this another voltage which is the antilogarithm (or exponential) of the first for application to the varactor.

In both cases the waveform alteration can be effected by a junction diode. If the current is kept small, the current is proportional to the exponential of the voltage across the diode and conversely, the voltage across the diode is proportional to the logarithm of the current.

The relation between current I and voltage V is actually

$$I = I_s (e^{kV} - 1)$$

where I_s is the reverse saturation current and K is a factor which is temperature dependent and has a value of about 40 reciprocal volts. The inverse relation is

$$V = \frac{1}{K} \log_e (1 + I/I_s)$$

When the current exceeds a few milliamperes the voltage drop across the ohmic resistance of the semiconductor and its contacts starts to be comparable with the

voltage of the formulae and the law is consequently modified. At high currents the current-voltage relation tends to linearity.

Below a few milliamperes (the exact current depends on the particular type of diode) the exponential relation holds very accurately until the exponential term ceases to be large compared with unity. This is when the diode is approaching cut-off.

To produce a voltage which is the logarithm of another voltage the voltage is applied to the diode through a high series resistance and the output is the voltage developed across the diode, as in Fig. 3 (a). If the voltage drop across the resistance is very large compared with that across the diode, the current through the resistance and the diode is almost proportional to the applied voltage and so the output voltage is almost proportional to the logarithm of the applied voltage.

The practical difficulty is that the change of voltage across the diode is very small, probably no more than 0.2V, and more likely some 0.05V. The X-input of a typical oscilloscope is some 9V peak-to-peak, so an amplifier of at least 45 times gain, and more likely 180 times, is required and must be highly linear.

With the second method an arbitrary sweep voltage is used and some small fraction of it is applied at low impedance to a diode. The diode current is then the exponential of the voltage. A very low resistance in series with the diode enables the current to produce a similar voltage, Fig. 3 (b), which can then be amplified to produce a voltage change of about 47V to control the varactor.

This actually works out much better because the base-emitter path of a transistor can be used as the diode so that the diode current is the base current of the transistor and the collector current is the base current multiplied by the current amplification factor.

Suppose a transistor is used with a 200-k Ω collector load. A maximum change of some 47V across this is wanted, so the change of collector current is $47/200 = 0.235mA$. If the current amplification factor is as small as 20, the change of base current is $0.235/20 = 0.01175mA = 11.75\mu A$. Since the output required is a voltage change of 47V the collector supply voltage must be greater, say 70V. This in turn rules out the possibility of using most transistors. However, there are types rated for 100V and even more, notably types designed for operation in video output stages.

The use of a transistor immediately solves the problem of coupling the current output of a diode to an amplifier. The need for a low impedance voltage feed also turns out to be not too difficult. Because the base current is so small, the source impedance feeding the transistor need be no lower than about 2k Ω . It is not, of course, possible to stabilize the base bias against temperature changes, because the use of an emitter resistance is inadmissible. The input would no longer be applied between base and emitter, but to the input of a feedback amplifier and the desired expon-

ential relation between input and base current would be seriously affected. In theory one could by-pass the emitter resistance, since the input will be some form of repetitive voltage (actually 50Hz sine-wave). It is however, very difficult to do so adequately.

What happens in practice, is that a rise of temperature shifts the oscillator frequencies to lower values. The response curve displayed on the oscilloscope drifts to the left. The drift is quite slow and may amount to a few MHz in normal operation. It can be corrected manually by adjusting a bias control, which is needed in any case to set up the proper operating conditions.

The heart of the wobulator thus comprises a frequency-modulated oscillator

and a wave-shaping stage to provide a linear scale of frequency on the display. The general form of this part of the circuit is shown in Fig. 1. The oscillator is Tr_1 and is of the Colpitt's type; C_2 is made 6.8pF plus the collector-emitter capacitance of the transistor, which is 1.5pF. The other capacitor, C_3 , is 82pF plus the 20 pF base-emitter capacitance. The effective capacitance ratio is thus $102/8.3 = 12.3$ so that in effect the base is well tapped down the tuned circuit.

The base is earthed to r.f. through C_4 . The inductance L is in the collector circuit and has in shunt with it the capacitance of C_2 , C_3 and C_4 all in series. This amounts to 7.5pF. Also in shunt with L is the varactor diode D_1 in series with C_1 of

330pF; this capacitor is needed to prevent L from short-circuiting the frequency control voltage, which is applied through R_1 and R_2 . Its presence slightly reduces the capacitance available from the varactor. The amplitude of oscillation is controllable by the supply voltage to the stage, which is shown in Fig. 1 as a nominal 10V, but it is also controllable by the base voltage, which means the values assigned to R_4 and R_5 . These resistors, with R_6 , provide the usual stabilizing network for temperature effects in Tr_1 . The emitter resistance R_6 is, for r.f., effectively in shunt with the base-emitter path of the transistor. The transistor itself has a base input resistance of about 1.2k Ω . Taking R_6 into account the effective base input resistance is about 550 Ω only. This is one reason for the high ratio of C_3 to C_2 .

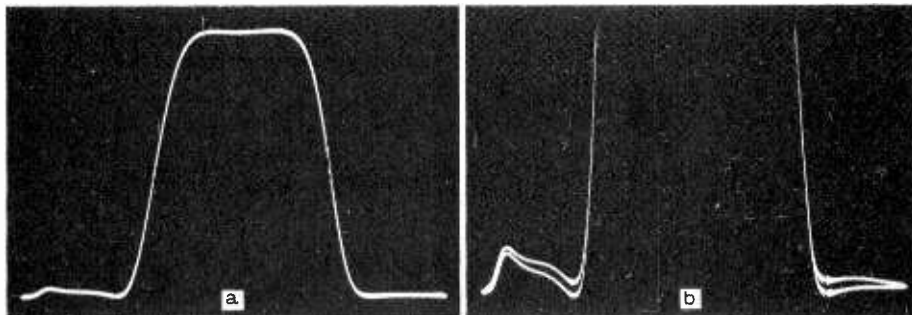
With a supply of 5.5V the oscillator will produce about 0.8V r.m.s. output, and with 10V it gives some 1.5V r.m.s. The output is taken off by a small coil coupled to L and not shown in Fig. 1; quite loose coupling is necessary and it is hard to secure more than 100mV useful output. This is one limitation of the varactor. The minimum bias on the varactor restricts the voltage obtainable across the tuned circuit and so the maximum output of the whole wobulator.

The wave-shaping stage is Tr_2 . This is simply a transistor with a high load resistor R_3 (220k Ω) and its output is applied to the varactor through R_1 and R_2 of 330k Ω each. Its base is fed by 50Hz from a winding on the mains transformer and also with a d.c. bias. These are merely sketched in in Fig. 1. In practice more complex networks are used because the magnitudes of the voltages required are quite small. The a.c. needed is only around 60mV, while the d.c. has to be variable only over a similar range.

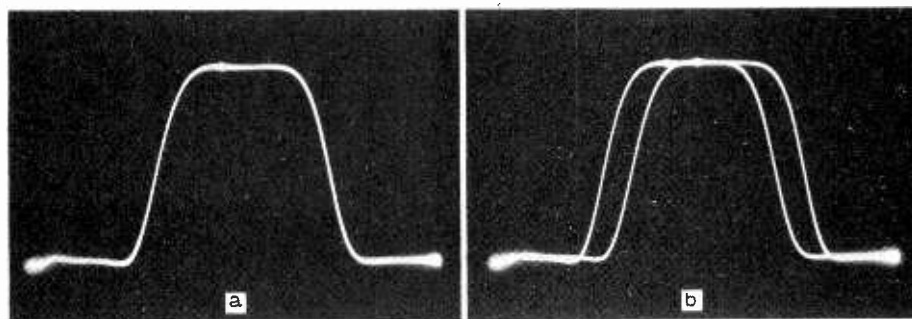
One peculiarity of the circuit must be noted. Two supply voltages are needed, one of some 70V and the other of some 17V and they must have a common positive. This is very unusual for n-p-n transistors, and it arises because of the varactor. It is almost essential to use direct coupling between the wave-shaping transistor and the varactor, because otherwise the two elements would each need variable d.c. bias controls and their proper adjustment would be difficult. Also, an a.c. coupling would introduce appreciable phase shift which would probably be difficult to correct, because the waveform at this point is not sinusoidal.

While it is not necessarily impossible to arrange matters so that the negative supply lines are common, it is much easier to use common positive lines. There is, of course, no objection at all to this apart from the fact that most people are accustomed to thinking of the negative line as the earthy one.

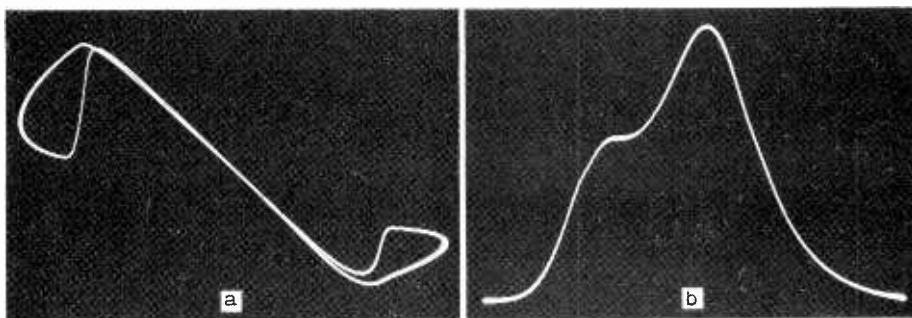
With proper design and adjustment the arrangement of Fig. 1 produces a linear relation between the base voltage of Tr_2 and the frequency generated by Tr_1 . In some measurements a frequency marker, of which more anon, was varied in steps of 0.5MHz from 30.5 MHz to 42.5MHz and the displacement of the marker on



Typical vision i.f. response curve with markers at 34.5MHz and 39.5MHz (a). These markers do not show well in the photograph but are easily seen on the c.r.o. because a beat effect gives them movement. The second photograph is identical but with the c.r.o. gain increased about 10 times and Y-shift applied to show the effect of the trap circuits. The markers at 33.5MHz and 41.5MHz are visible (b). There is a double trace on the skirts due partly to mains hum and partly to the input coupling time constant (0.25s) of the oscilloscope.



Here the marker is at 36.5MHz (a) and in (b) the phase control has been deliberately misadjusted to illustrate the effect.



These photographs were taken with outputs from the sound channel. At (a) the output was taken from the a.f. output point; at (b) it was taken via a rectifier probe from the collector of the last i.f. stage. The circuit was not returned to correct for the probe capacitance.

the trace was measured using the calibrated X-shift control of the oscilloscope. The calibration of this control was not checked. There were also, of course, the usual setting and reading inaccuracies of the controls.

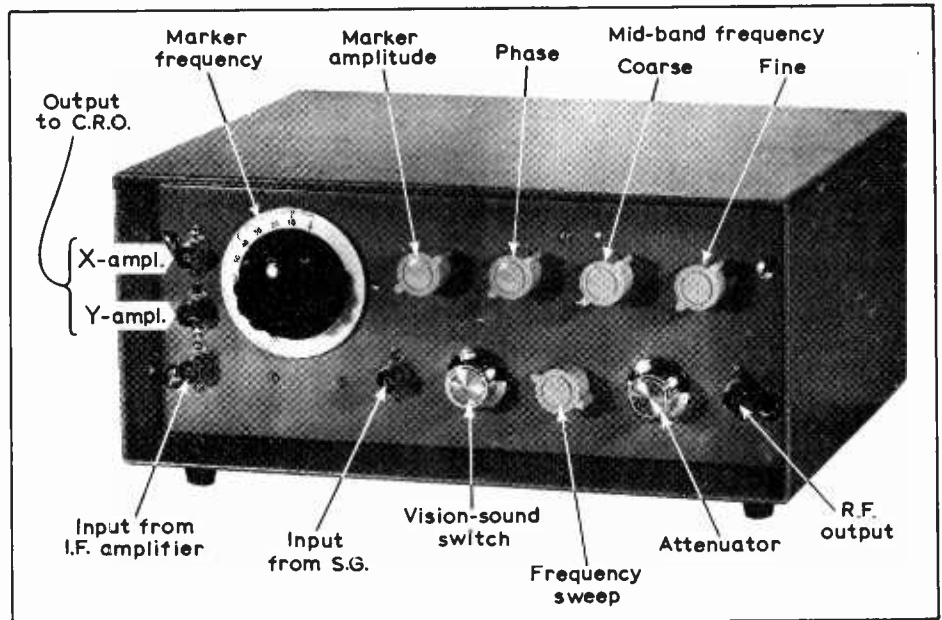
As one would expect, therefore, when the points were plotted on linear scales of frequency and marker displacement no straight line could be drawn through all of them. However, the maximum displacement of any point from a straight line drawn between 30.5MHz and 42.5MHz was 0.3% only. One would, in fact, be satisfied with an error of 1%, or even more.

A linear relation between frequency and displacement is one essential. Another is that the amplitude of oscillation should be the same at all frequencies. It does not matter at all if the amplitude varies slowly with time, temperature or voltage, but for an undistorted response curve it is necessary that the amplitude be independent of frequency. The basic oscillator of Fig. 1 does by many standards provide a fairly constant amplitude. The output varies by about 1dB over the band, but this is not good enough.

In actual fact, it is not essential that the output be constant over the whole frequency range. Where constancy is important is over the range of frequencies lying between the -6 -dB points of the passband of the amplifier under test. With television amplifiers these will never be more than 5.5MHz apart and in practice, constancy of amplitude between 39.5MHz and 34MHz will suffice. The shape of the response within the pass-band will then be accurately depicted. Outside the pass-band the response falls rapidly and quickly reaches -25 -dB to -50 -dB levels, an odd dB or so extra variation due to the instrument is there trivial and probably quite undetectable on the display.

Nevertheless it has been thought desirable to include a measure of stabilization. The output of the oscillator is fed to a diode detector and the output of this is fed to a single-stage d.c. amplifier which controls the base voltage of the oscillator. There is thus a negative feedback loop. The loop gain is not high because the detector efficiency is low and the gain of a single stage d.c. amplifier is also low if it is stabilized against temperature changes. It is sufficient, however, to keep the amplitude reasonably constant.

It is essential to have at least one frequency marker. The usual procedure is to couple the output of a signal generator loosely to the oscillator. Its output then passes with the f.m. signal through the i.f. amplifier under test and a beat between the two signals is produced in the detector of this i.f. amplifier. Assume that the marker is set at mid-band, 36.5MHz. The difference frequency is 6MHz when the oscillator is at 30.5MHz, but as this frequency is outside the passband of the i.f. amplifier it is not appreciably passed. When the oscillator reaches 34MHz, however, this frequency will usually be passed appreciably and the beat produced in the detector will be 2.5MHz. As the frequency increases, the beat frequency falls and its amplitude increases. At exactly the



The completed prototype, showing the layout of the controls.

marker frequency the frequency and amplitude drop to zero, but the beat frequency is produced again when the oscillator becomes higher than the marker frequency. Instead of the trace on the oscilloscope being a line drawing out the response curve, therefore, it is wobbled vertically about this line by the beat frequency.

A marker with a total width of some 5MHz is much too wide, of course, and a simple RC filter is included between the detector of the i.f. amplifier and the oscilloscope to restrict the bandwidth to about 0.5MHz at most. The appearance of the marker is then of a narrow blip on the trace, the centre of which gives the true frequency. In practice, there is usually a gap in the centre. In some cases, the width of this gap can be considerable, and this is undesirable. It arises because when the frequencies are nearly alike one oscillator pulls the other into synchronism and the two move together at zero beat until the natural frequencies become too far apart for the lock to hold. If both forward and return traces are presented on the screen, which can be done with a sinusoidal sweep, and the two are phased so that the two traces of the response curve coincide, then when oscillator pulling is present the two marker blips will not usually coincide. This is because two oscillators, once they are locked, normally hold in synchronism over a wider range of frequencies than the band over which one can capture the other. This means that when a gap appears its mid-point is not at the actual frequency of the marker.

A certain amount of locking around zero beat is not uncommon but it is not important as long as the gap between the two halves of the blip is small.

A major disadvantage of this form of marker is that with a constant amplitude of signal from the marker generator it is possible to obtain a reasonable marker blip only between the -6 -dB points of the amplifier. If it is desired to use a marker on the skirts of the curve, the marker disappears because its frequency is atten-

uated by the amplifier, and the signal from the marker generator must be greatly increased. It does have the advantage, however, that as the marker need be only one-tenth or so of the f.m. signal, its actual strength in the pass-band need be only a few millivolts.

In the equipment to be described in subsequent articles in this series, a somewhat different system is adopted. The marker signal is not passed through the i.f. amplifier. A buffer amplifier of roughly 12-MHz bandwidth at -3 -dB is used and is fed through a simple attenuator with the signal from the winding on the oscillator coil L of Fig. 1 which feeds the i.f. amplifier. The impedance level at this point is only 75Ω and the variations of the input impedance of the buffer stage over the band do not seriously affect the oscillator output. The collector load of the buffer is a heavily-damped single-tuned circuit to which a signal generator is loosely coupled for the marker. A diode detector then rectifies the mixture to provide the beat and a simple low-pass filter restricts the bandwidth. This signal is then mixed with the output of the detector of the i.f. amplifier under test in another simple filter.

The marker blip then appears on the trace as before, but with an amplitude which is substantially independent of frequency. What amplitude variations do occur are those caused by the variation of gain of the buffer amplifier and are trivial. The marker appears on the trace independently of the i.f. amplifier.

The deflection due to the marker is, of course, entirely vertical but it is drawn out by the X-deflection to have width. As a result the appearance of the marker is quite different on the sides of the curve from what it is on the near horizontal parts. The sides are nearly vertical and so the vertical movement due to the marker tends to get lost in the near vertical movement due to the response curve. The writing speed of the spot, too, is higher, and the

marker is drawn out over a greater length of trace. When one has become accustomed to it, the marker is quite readable on the sides of the curve, although not so easily as on the flat parts. Unfortunately, there is no simple remedy.

In practice, it is useful to have two markers, which can be set at the two required 6-dB points. Alignment can then be carried out so that the two markers come at the half-height points on the two sides of the curve, the correct shape of the curve between them being judged by eye.

The equipment thus has a built-in marker oscillator. This is a transistor oscillator which is basically the same as that of Fig. 1, but having a variable capacitor for tuning. It is also coupled to the coil of the buffer stage. The second marker is provided by an external signal generator.

The internal marker has a second use in connection with the alignment of the intercarrier sound channel. For this purpose it is connected to feed into the output with the f.m. signal and it is set to 39.5MHz. The f.m. signal has its total deviation reduced from the usual 12MHz to about 300kHz by the sweep amplitude control, and its mid-frequency is set to 33.5MHz by the bias control of Tr_2 , Fig. 1. The f.m. signal then represents the sound channel and the marker oscillator the vision channel. The two signals pass together through the vision i.f. amplifier and a 6-MHz beat between them is produced in the detector, and fed to the inter-carrier sound i.f. amplifier. The signal generator can still be used to provide a single frequency marker, but it is probably better to have it around 6MHz and inject its output into some point of the sound i.f. amplifier. What can be done in this way obviously depends greatly on the design of this amplifier.

The use of a 50-Hz sine wave from the mains has been mentioned for the sweep. This is done for its convenience. Two supplies are needed, one for the input to Tr_2 in Fig. 1 and the other for the X-deflection of the oscilloscope. The latter must normally have one side earthed. The supply for Tr_2 , however, must have one side at about -70V. However, apart from this, two windings are really desirable since the phase of one may have to be reversed with respect to the other in order to obtain a trace in which movement to the right represents an increase of frequency.

On one half-cycle the spot moves to the right and the frequency increases; on the next half cycle it moves to the left and frequency decreases. Any phase shift in the complete chain from transformer through the wobulator and i.f. amplifier under test to the Y-input of the oscilloscope, and any differential phase shift within the oscilloscope between the X- and Y-channels, will result in two traces of the response curve being produced displaced side by side. A simple phase-shifting circuit in the feed to the X-plates enables the two traces to be brought into coincidence. This has been found adequate, for any errors produce no more than a slight thickening of the trace along its near vertical sides.

An alternative would be to blank alternate half cycles, but some form of phase-shift control would still be needed to give a rough correction of phase and would be difficult to operate since its effect would visually be much the same as that of the d.c. bias control on Tr_2 .

The use of both traces also has its advantages since it can give an indication of some amplifier faults. If non-linear circuits are involved, as they are in the detector, and will be if there is overloading, then the rise and fall times of the output signal may not be the same. When the oscilloscope spot is moving to the right on one half-cycle a rise time is operative on the left-hand side of the response curve and a fall time on the right, whereas on the other half cycle the rise time is operative on the right and the fall time on the left. Therefore any difference in the response to rising and falling outputs will make it impossible to obtain complete coincidence of the two traces.

Corrections

"Sinusoidal Oscillator for High Temperatures" (July 1970). Pin 1 of the 701C op.amp. should, in addition to the connections shown, be joined to the 0V line.

"Integrated Circuit Stereo Pre-amplifier" (July 1970). In Fig. 3 there are three mistakes: the wiper of S_{1b} is in the wrong position relative to S_{1a} ; S_2 should have the lower contact (M) joined to the wiper of S_{1b} ; R_{12b} should be 12k Ω not 120k Ω . On p. 315 in the components list $VR_{3a, b}$ and $VR_{4a, b}$ are 100k Ω + 100k Ω linear pots.

Communications Receiver (June issue). On page 310 the Racal RA1220 frequency stability should have read, one part in 10^7 per day.

On page 303 (New Products) in the June issue, the illustration shown under the heading D.J.L. Reed Relay should have appeared with the note on the Reed Microswitch (WW 329).

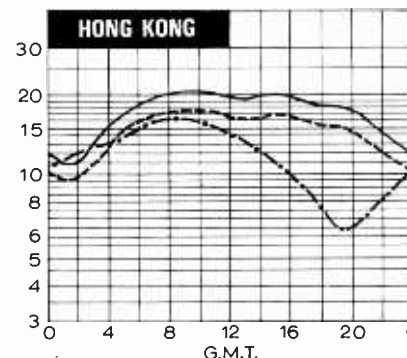
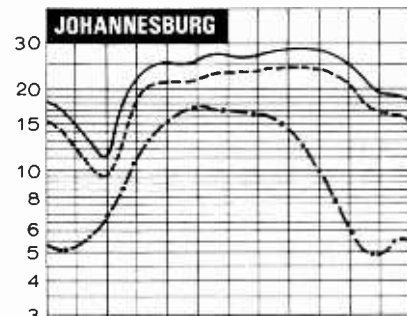
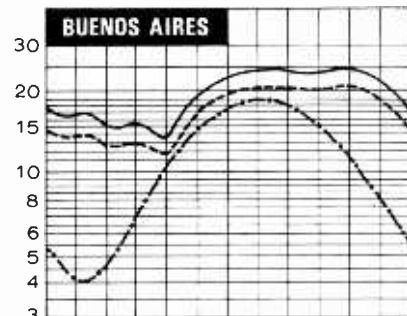
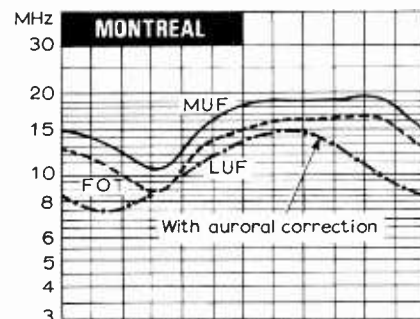
Souriau Lectropon Transistors

Souriau Lectropon Ltd. apologize to readers for the delay in supplying transistors, which has occurred because of problems in obtaining sufficient supplies from the manufacturers. The company say they undertake to deliver all transistors promptly as there are now sufficient stocks on their premises.

H.F. Predictions —August

The Greenwich sunspot number for June is 117, indicating a slight decline in the high level of solar activity since March of this year. This decline is not rapid and frequency usage over the next six months should be the same as for the corresponding months of 1968/69 and 1969/70.

Disturbances which have developed this year are expected to continue at the same level for the next twelve months. With regard to the charts the trans-equatorial routes have highest MUFs during equinox months and the values shown should be the highest for the next ten years.



The Video Disc

Vision programmes on 'gramophone' records

by J. C. G. Gilbert* F.I.E.R.E.

The 24th June 1970 will become another important date in the history of the development of television, for on this day the world's first television recording on a "gramophone" record was demonstrated in Berlin. Although the equipment will not reach the public for another 18 months, technical information was released this year as it coincides with the 80th anniversary of the invention by Emil Berliner of the first flat record. Perhaps one should not forget the early experiments of Baird, in which he recorded the B.B.C. 30-line transmission on a standard 78 r.p.m. record and the sound on a separate record.

Teldec is a research and development organization jointly owned by Decca in the U.K. and AEG-Telefunken in Germany. Since 1965 four German scientists headed by Horst Redlich, in conjunction with Arthur Haddy, the chief engineer of Decca Records, Ltd., have patiently developed a video recording system that will make a considerable impact on the educational, advertising and domestic entertainment fields.

Research teams throughout the world are currently working on methods of recording video information, and some demonstrations and technical information have been given to the public. In the U.S.A. the Columbia Broadcasting System has developed the EVR system (see p.366) the RCA Corporation the Selectavision system, Ampex in the U.S.A. video recording on magnetic tape, and there are other methods using photographic films. The table indicates the performance of each type.

In comparing the various systems note that only video tape and Super-8mm film allow the user to record his own programmes, while EVR, Selectavision and Teldec video disc limit the user to purchasing or hiring already recorded programmes; and of these only the Teldec video disc enables one to quickly locate any particular section of a programme. Also, in some systems it is not possible to show a stationary picture or a slow-motion picture. In the Teldec system each complete television picture (two frames) can be shown separately, and by stopping and starting the mechanism one

can show a sequence of individual pictures.

In any form of storage system, whether it be film, gramophone record or handwriting, it is necessary to arrange for a transient flow of information to be recorded and at a later time for the information to be displayed or reproduced. In sound recording the flow of information is at a rate of approximately 3×10^5 bits per second, and a normal $33\frac{1}{3}$ r.p.m. gramophone record has a data storage capacity of about 5,000 bits/mm² while a magnetic tape has a data storage

capacity of about 1,000 bits/mm². To store electrical picture information it is necessary to accommodate the information at a density about 100 times that required for a sound recording, the information flow rate being of the order of 3×10^7 bits per sec. The first problem therefore is to devise a storage system capable of handling a greater information density, and then to develop a method of reproducing that information.

The Teldec video disc will allow a recording density of upwards of 500,000 bits/mm², or about 100 times the storage capacity of an audio record, and this is equivalent to a signal frequency of 3-4 MHz.

Fig. 1 and the photographs show the principle of the reproducer. The disc is made from thin plastic foil and is rotated at a speed of 1,500 r.p.m. for a 50-Hz mains supply and 1,800 Hz for a 60-Hz supply. The disc is located on a very accurately machined boss and positioned by three pins. It will be seen from the photograph that the disc while stationary follows the contour of the fixed playing desk, and that this is curved and the apex of the curve is just under the reproducing stylus. Concentric with the rotating central boss is an annular slot through which air is forced and then exhausted at the periphery of the disc. Thus when the disc

	Video tape	EVR	Selectavision	8mm film	Teldec video disc
Resolution	250 lines 3MHz	300 lines 4MHz	250 lines 3MHz	250 lines 3MHz	250 lines 3MHz
Signal/noise ratio	> 40dB	> 40dB	> 40dB	> 40dB	> 40dB
Sound recording	Separate track	Separate track	Separate track	Separate track	Combined tracks
Playing time	approx. 60m	2 x 25m 25m colour	approx. 60m	approx. 30m	9in. 5m 12in. 12m
Recording media	Magnetic tape	Special film	Plastic tape	Super-8 film	Plastic foil
Playing time v. copying time	< 50	< 50	< 50	< 50	> 1,000
Material cost for one hour playing	approx. £12	approx. £12 colour £24	approx. £2 5s	approx. £24	less than £1 2s 6d
Pickup device	Magnetic head	f.spot scanning	Laser and vidicon	f.spot scanning	Ceramic p.u.
Reproducer cost (approx.)	£230	£350	£175	£230	£60-£115

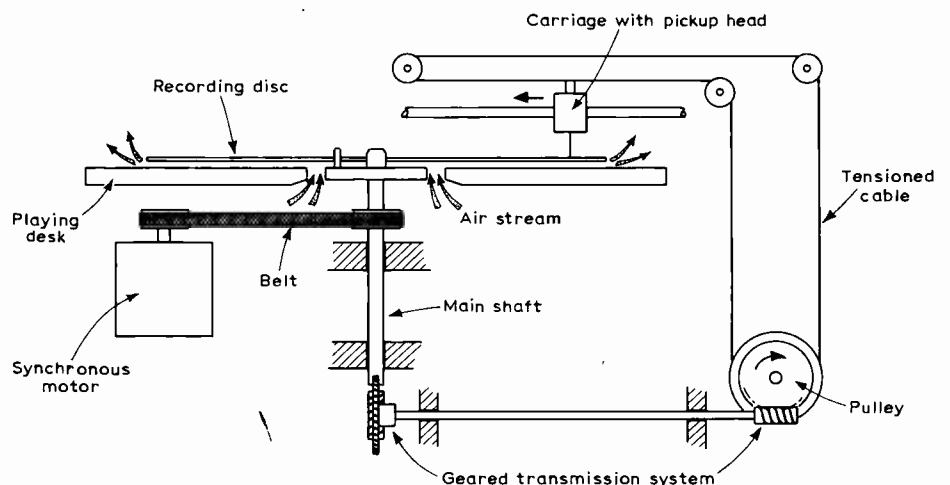


Fig. 1. Principle of the video disc reproducer mechanism.

* Head of Department of Electronic and Communications Engineering, Northern Polytechnic.

rotates it floats on a very thin air cushion and follows the contour of the curved platter.

The boss and shaft are belt-driven from a small synchronous motor which also drives a reduction gearbox. Attached to the output of the gearbox is a pulley which drives an endless tensioned cable. The pickup head is mounted on two parallel bars, and it is smoothly drawn across the disc by the tensioned cable. The video disc is a remarkable development, for in order to have a playing time of 5 minutes on a 9-inch disc, or 12 minutes on a 12-inch disc, the groove spacing is minute, there being between 120-140 grooves per millimetre, and each revolution of the disc represents one complete television picture. The recording method is hill-and-dale, and one photograph shows a comparison between a normal stereo audio recording groove (on the right) and the frequency modulated video disc grooves that occupy an equivalent space (on the left). The accompanying sound is recorded during the blanking interval, using a pulse position modulation system. It is of interest that the groove on a 9-inch disc is about 3km long.

The pickup head that is mounted on the linear tracking bars carries a very fine tube, at the end of which is a microscopic diamond stylus—Fig. 2. Directly connected to the diamond is a piezo electric ceramic transducer which has an

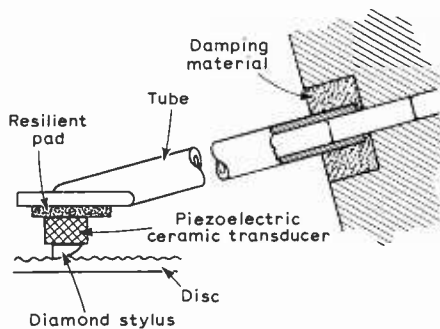


Fig. 2. Details of the pickup, showing stylus and transducer at the end of the fine support tube. The arrangement provides elastic suspension.

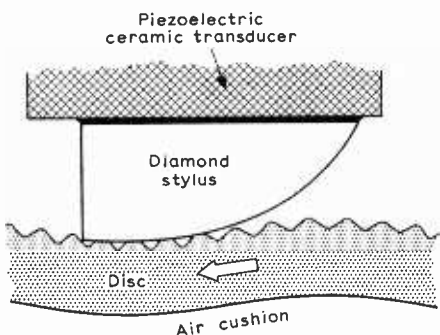
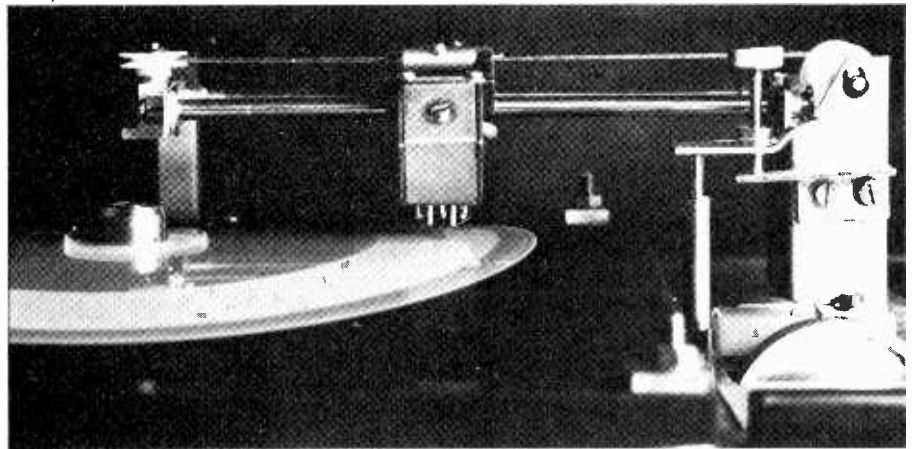


Fig. 3. Cross-sectional side view of the stylus (viewed along a radius of the disc), showing how the disc track is locally deformed where the disc is pushed up to the stylus by the air cushion. The stylus responds to the instantaneous load relief that occurs as the track passes the rear vertical face.

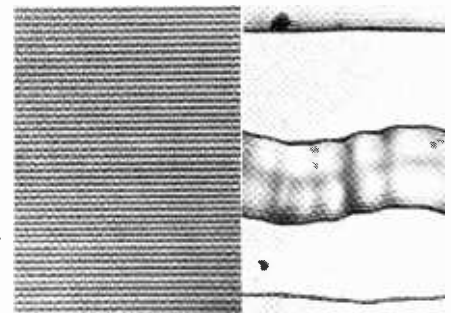


Reproducer mechanism, showing pickup carriage being drawn across disc by the tensioned cable. The convexity of the playing desk, taken up by the flexible disc, can just be seen.

output of about 2mV, and the complete transducer can be seen suspended below the carrying head. The transducer is pressure operated, and, whereas in a normal audio system the record carries the weight of the pickup cartridge, in the Teldec machine the stylus is fixed in position and the video disc is floated up to it on the air cushion. A side view of the diamond stylus, Fig. 3, shows that it is gently radiused in front of the trailing vertical face, and as the disc glides below the stylus, the stylus purposely deforms the hill and dale track which, when it passes the stylus, immediately springs back to its original shape. Thus several bits of information are simultaneously presented to the pressure transducer. It is claimed that each disc can be played at least 1,000 times before the signal-to-noise ratio falls below 40dB.

When one wishes to display a stationary picture a press button on the deck can be operated to disengage the pickup drive cable. As the groove is very shallow the stylus jumps the wall separating the grooves and repeats each complete picture as often as desired. Obviously during such a display there is no speech output as this is integral with each line. The wear of the disc is negligible and even after one has repeated a stationary picture for several hours there is no noticeable visual distortion. While slow motion is not possible in the true sense, it is possible to show complete pictures in slow sequence by operating the press button at regular intervals.

The obvious question is "how well does it perform?" Those fortunate enough to witness this world premiere were astonished at the fidelity of the pictures seen on a multiplicity of television monitors. At present the output from the reproducer is at video frequency, but for the domestic market the unit will embody a modulator so that the signal can be sent over cable to the aerial input of any domestic television receiver. The quality of the black-and-white signal is comparable in definition with the B.B.C./I.T.A. 405-line system although the picture is transmitted on 625 lines. It is confidently expected that colour video discs will be



A single groove of a normal stereo gramophone record (right) compared in size with the closely packed grooves of the video disc (left) which register information by a frequency modulated carrier, hill-and-dale, recording technique. The carrier wavelength on the video disc varies with the video signal amplitude.

available a few months after the release of the black-and-white discs. Demonstrations were given of a number of programmes of an educational and instructional nature, extracts from advertisements, etc. As an example of use, a travel agency might have a selection of discs giving short programmes of "a weekend in Paris", a holiday on the Costa Brava and so on. The possibilities seem endless and AEG-Telefunken even suggest that in the future the daily newspaper might include a disc of the highlights of the previous day's sporting events.

As the video disc is capable of storing information up to 3 MHz while rotating at 1500 r.p.m. one can visualize that a modified system using the same basic principles could be employed for sound recording. At a playing speed of 33½ r.p.m. it should be possible to record up to about 70kHz, and possibly the almost forgotten 16½ r.p.m. speed might come into its own. Using a slow speed, several hours of recording could be achieved on a 9in disc; turntable rumble and anti-skating devices would become a relic of the past. Perhaps the most exciting possibility is the recording of multi-channel stereo programmes—two, three, four or more channels being possible with the Teldec multiplexing system.

Electronic Morse Keyer

Employs m.o.s. integrated circuits to produce dot-dash and space waveforms with precise mark-space ratios

by C. I. B. Trusson *, M.Sc., G3RVM, and M. R. Gleason*, B.Sc.

This article describes the design and construction of an electronic morse code keyer using four m.o.s. logic circuits. The dot and dash waveforms generated by the keyer are defined precisely by means of a two stage counter.

M.O.S. logic circuits

The circuit diagram of a p-channel m.o.s. inverter is shown in Fig. 1. Using the negative logic convention, with logic 0 input level less than the threshold voltage, the inverter m.o.s.t. is 'off' and only leakage current flows into the load m.o.s.t. The logic 1 output level is then a threshold voltage (plus an increment due to source-substrate bias) from the V_{DD} supply. With a logic 1 input greater than the threshold voltage the inverter m.o.s.t. is 'on' and the output is pulled to a logic 0 level near 0V. With a V_{DD} supply of -24V typical logic 0 and logic 1 levels are -2V and -17V. It should be noted that the output resistance in the logic 1 output state is very high and so this level can't be measured with a multimeter.

Where it is required to interface an m.o.s.t. inverter with a bipolar transistor the circuit of Fig. 2 may be used. In the logic 0 output state the inverter m.o.s.t. supplies base current to the n-p-n transistor switching it 'on'. In the logic 1 output state the inverter m.o.s.t. is 'off' and the transistor is 'off' because of the base resistor to V_{DD} .

A NOR gate is simply obtained by connecting a number of inverter m.o.s.t.s in parallel and a NAND gate by connecting them in series. The circuit diagram of a 3-input NOR gate is shown in Fig. 3 and that of a 3-input NAND gate in Fig. 4. Clearly, the NOR gate only gives a logic 1 output when all inputs are 0 and the NAND

gate only gives a logic 0 output when all inputs are 1. The two gate circuits used in the electronic keyer are the Plessey MP104, a dual 3-input NOR gate and the MP102, a dual 3-input NAND gate. With these circuits, unused NOR gate inputs should be connected to 0V and unused NAND gate inputs should be connected to V_{DD} .

The keyer also uses two MP106 counter/register/bistable circuits. The MP106 logic diagram is shown in Fig. 5 and its modes of operation will now be outlined. In its synchronous mode S is set at a 1 and data, D_0 , is transferred to D_1 and its inverse to D_1 on the clock pulse transition CP_1 0→1, assuming CP_2 is at 0. In the steady state, with CP_1 at a 0 or a 1, the outputs D_1 and D_1 cannot be affected by any change in D_0 . In this mode the element operates as a shift register. To obtain a binary counter function the D_1 output is connected back to the D_0 input with S held at 1, causing the D_1, D_1 output states to change every CP 0→1 transition. Asynchronous bistable operation is achieved by setting S to 0. The data on the F input is then transferred to D_1 and its inverse to D_1 irrespective of D_0 and CP .

Design of the electronic keyer

A morse transmission consists of a series of dots, dashes and spaces. Within a morse character (the code for a letter, number or punctuation) a dot consists of a 1:1 mark-space pulse and a dash is a 3:1 mark-space pulse. The waveform of Fig. 6 shows a dot followed by a dash, the code for the letter A. The dot, being the highest frequency component of morse code, is the most difficult for an operator to send and severely limits the maximum speed attainable with a conventional morse key.

The m.o.s. electronic morse keyer allows an operator to send perfect morse characters up to very high speeds by controlling accurately, with a multivibrator, all the periods within a character, i.e. dot, dash and space. In addition, the dot and dash can be made self completing such that the paddle only has to be touched momentarily on the dot or dash side of the key and they are completed automatically, leaving more than the period of a space to move the paddle from side to side.

The dot and dash waveform of the electronic keyer are obtained by gating the outputs from a two-stage MP106 counter

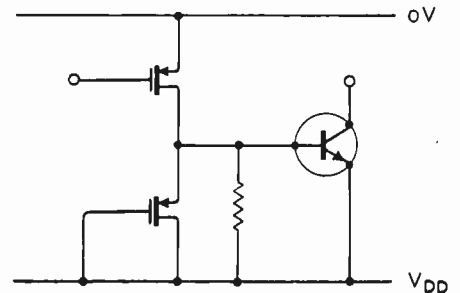


Fig. 2. Connecting a m.o.s. inverter to an n-p-n transistor.

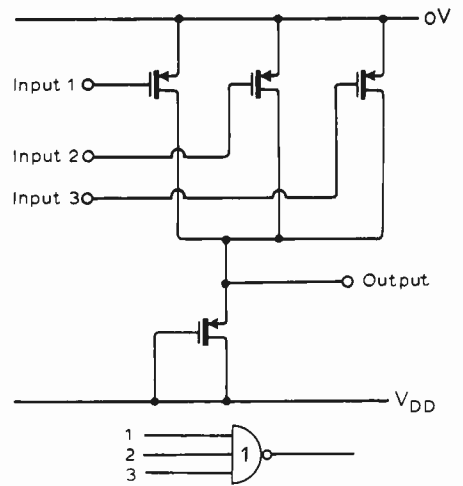


Fig. 3. A three-input NOR gate.

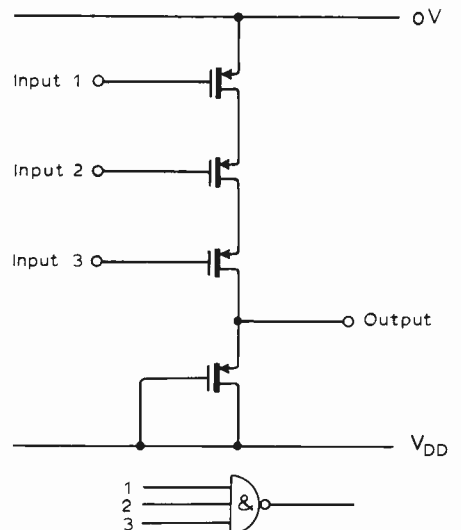


Fig. 4. A three-input NAND gate.

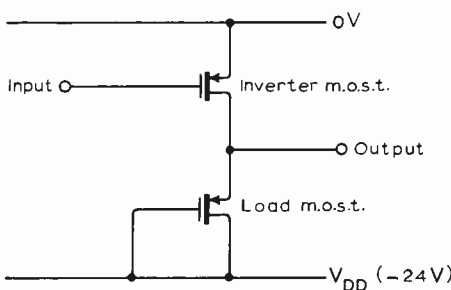


Fig. 1. The circuit of an m.o.s. inverter.

*Plessey Microelectronics

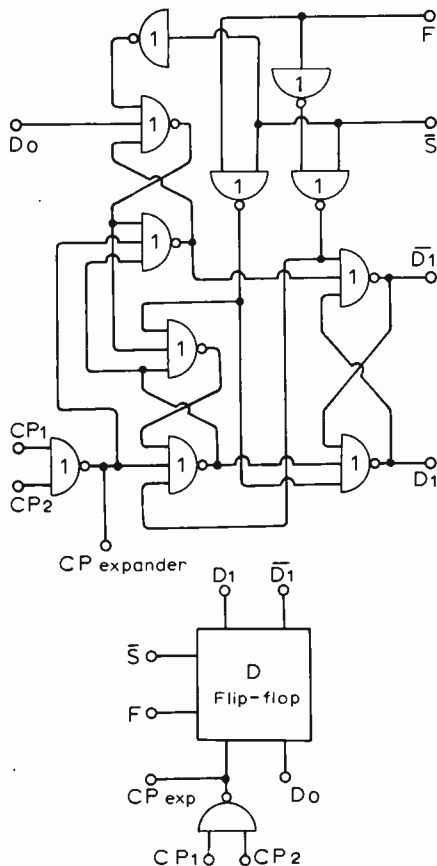


Fig. 5. Counter-register-bistable circuit type MP106.

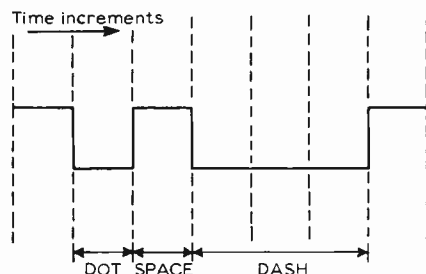


Fig. 6. Morse code waveforms corresponding to dot dash.

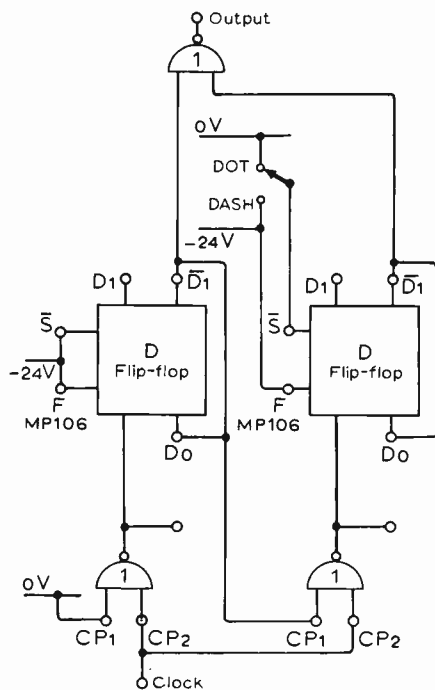


Fig. 7. Dot dash waveform generation.

as shown in Fig. 7. For the dot waveform, the S input of the second counter is set at a 0. This puts the second counter in its asynchronous mode with the data on F, a 1, being transferred to D₁, and its inverse, a 0, being transferred to D₁. The first counter has its S input permanently at a 1, and therefore counts with the 1:1 mark-space ratio dot waveform. A 1 at the output corresponds to a space, a 0, a dot.

The dot waveform is obtained from the output of a counter, rather than directly from a multivibrator so that the mark-space ratio is precisely 1:1 at all speeds. The multivibrator providing the clock to the counter does not need an accurate mark-space ratio and, therefore, only a single gang potentiometer is required to vary its frequency. For the dash waveform, the S input to the second counter is set at a 1. Now both counters are operating in the synchronous mode and the four output states at the two D outputs are 00, 11, 01, 10. the NOR decoding gate decodes 00 to give a 1 output which corresponds to a space. In the remaining three states of the counter the NOR gate output is a 0, giving the required 3:1 mark-space ratio dash.

The method of dot and dash waveform generation described above forms the basis of the electronic keyer. In addition a multivibrator is incorporated which is stopped

between characters so that dots and dashes commence immediately the paddle is operated at the start of a new character. Otherwise, with a free running multivibrator, there is always some uncertainty as to when the first dot or dash of a character is going to start. Logic to control the stopping of the multivibrator with the counter in the space state and to provide self completion of dots and dashes is also included.

The functioning of the keyer will now be described in detail. Its full logic/circuit diagram is shown in Fig. 8. Initially, at switch-on, the emitter coupled multivibrator provides clock pulses to the counters until the output of the decoding gate-1 is in the logic 1 space state and the output of the multivibrator has gone to a 0. Gate-4 gives a 0 output which stops the multivibrator in its present state by clamping the 200Ω load to the -24V supply with a saturated n-p-n transistor. When the paddle is pushed to the dot side the output of gate-3 goes to a 0 causing the output of gate-4 to go to a 1. This releases the multivibrator whose output instantly goes from 0→1 clocking the first counter and producing a dot at the output of gate-1. The paddle may then be moved from the dot side since the multivibrator continues until the space state has been reached and the output of the multivibrator is back at a 0. The

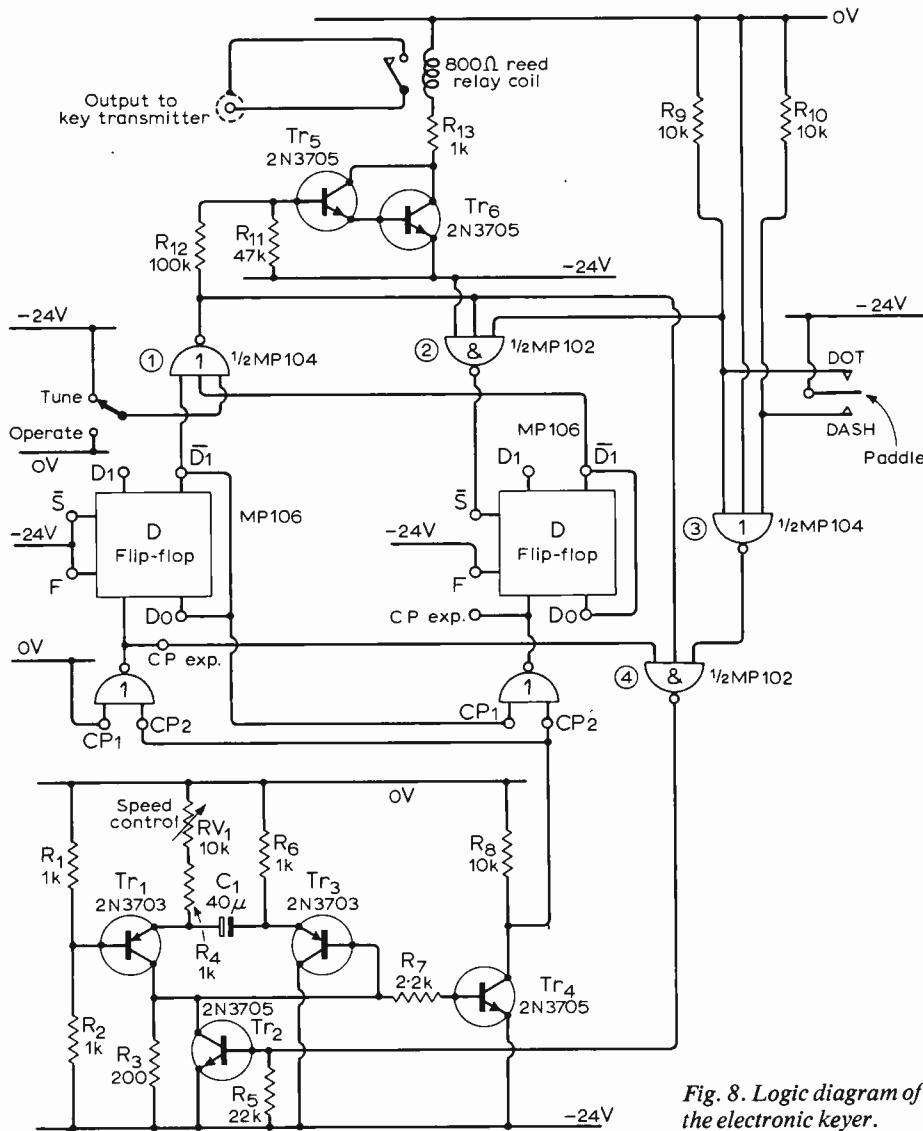


Fig. 8. Logic diagram of the electronic keyer.

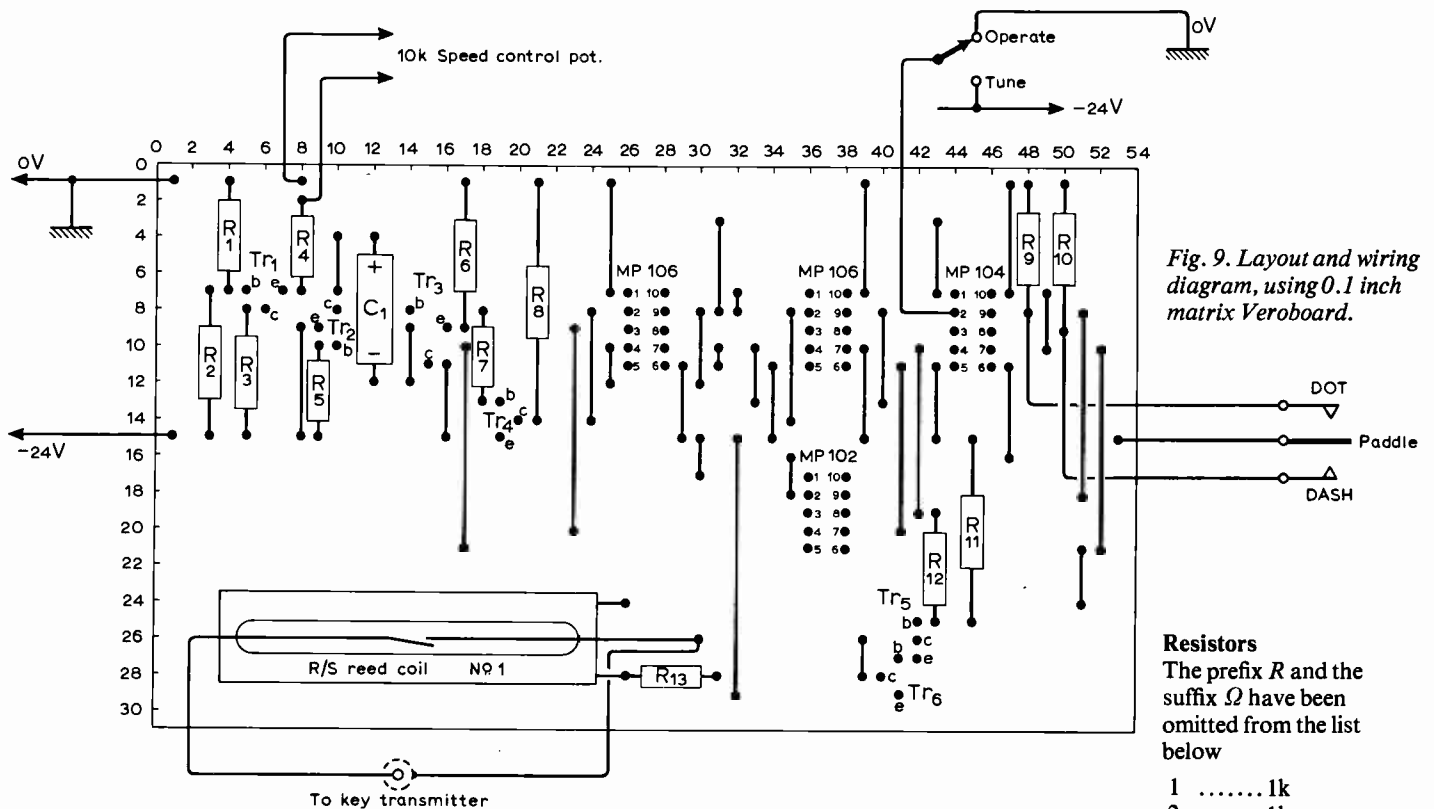


Fig. 9. Layout and wiring diagram, using 0.1 inch matrix Veroboard.

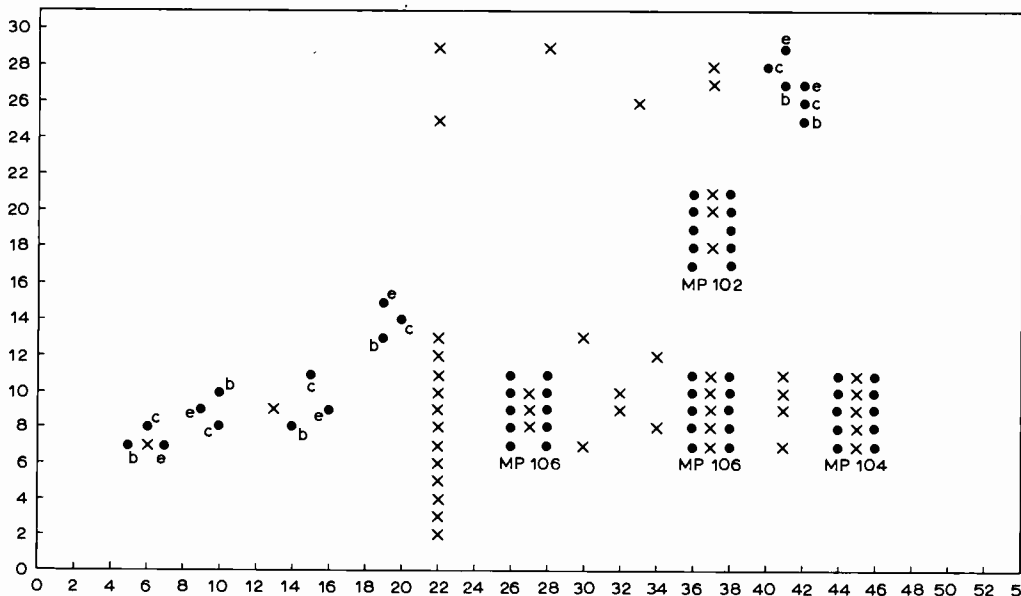
Resistors
The prefix R and the suffix Ω have been omitted from the list below

- 1 1k
- 2 1k
- 3 200
- 4 1k
- 5 22k

- 6 1k
- 7 ... 2.2k
- 8 10k
- 9 10k
- 10 10k

- 11 47k
- 12 ... 100k
- 13 1k
- RV1 .. 10k

Other parts
C1 40μF, 25V
Tr2, 4, 5, 6, 2N3705
Gate-2, -4 MP102
Tr 1, 3 2N3703
Gate-1, -3 MP104
Flip flops MP106



output of gate-4 will then return to a 0 stopping the multivibrator unless the paddle has been transferred to the dash side, in which case the output of gate-4 remains at a 1 and the multivibrator continues. With the paddle on the dash side the output of gate-2 is a 1, setting the second counter in its synchronous mode. The dash waveform is, therefore, produced at the output of gate-1. As for the dot, once the dash has started the paddle may be moved and it is self completing, the S input to the second counter remaining at a 1 until the output of gate-1 returns to a 1, the space state. Strings of dots and dashes within a character are produced by holding the paddle on the relevant side until after the start of the last dot or dash.

Normally the morse key input to a transmitter is intended to be driven by a mechanical key. The output of gate-1,

therefore, is interfaced to a reed relay to drive the transmitter. The 100Ω resistor is included in series with the base of the n-p-n Darlington pair, since a logic voltage swing is required at the output of gate-1 to drive gates-2 and -4. The reliability and contact bounce of a reed relay are both likely to be very much better than that of a mechanical key. However, a preferable solution would be to modify the transmitter to be keyed directly from gate-1.

With an electronic keyer it is not possible to hold the transmitter 'on' continuously for tuning purposes. A 'tune' switch is, therefore, provided which, when operated, sets the output of gate-1 to a 0, holding the reed relay 'on' until the switch is moved back to the 'operate' position. A push button may be more convenient than a toggle switch.

The keyer in use at G3RVM is built on

0.1 in. Veroboard and housed, complete with mains power supply in a 4.5 × 7.25 × 2 inch die-cast box. The Veroboard layout is illustrated in Fig. 9.

The nominal -24V power supply for the keyer does not need to be regulated, the tolerance being -20 to -26V.

The MP100 range m.o.s. logic circuits used in the keyer are available from the Plessey microelectronics distributors: A. C. Farnell Ltd., Kirkstall Road, Leeds 3, or SDS (Portsmouth) Ltd., Hillsea Industrial Estate, Hillsea, Portsmouth, Hampshire.

REFERENCES

- 1. MP.100 series Data Sheet.
- 2. Trusson, Ce. I. B., Foss, R. C. "MOSAIC Blocks for System Breadboarding". (Both of these documents should be obtained from the Plessey distributors.)

News of the Month

Space-probe to Jupiter

Man's first venture (Mariner) beyond the orbit of Mars into the outer solar system will begin with the launch of two spacecraft, Pioneers-F and -G, in 1972 and 1973 on missions which will last about two years each.

These spacecraft will be the first to penetrate the asteroid belt and will spend about a week orbiting Jupiter with the period of closest approach, and maximum scientific interest, covering about 100 hours. Closest approach is planned to be about 100,000 miles.

One goal of the mission is to assess hazards in deep space and to develop technology and operations experience for missions to the outer planets—Jupiter, Saturn, Uranus, Neptune and Pluto—planned for the late 1970s.

Pioneers-F and -G will be identical spacecraft weighing about 550 pounds apiece and carrying 60 pounds of scientific instruments. Each will be capable of performing 13 scientific experiments in space including photographing Jupiter.

The Pioneers will be powered by four radioisotope thermoelectric generators

producing a total of 120W. The spacecraft will be stabilized in space by spinning at five revolutions-per-minute in the plane of the Earth's orbit so that a nine-foot-diameter directional radio aerial is pointed constantly at Earth.

The thirteen scientific experiments will make a broad study of a number of interplanetary phenomena, possible hazards of flying through the asteroid belt, the Sun's influence on interplanetary space and the penetration of galactic cosmic radiation into the solar system.

They will measure hydrogen atoms; electrons; nuclei of hydrogen, helium and other elements; and the interplanetary magnetic field.

They will gather data on the heliosphere, the region of the Sun's influence on the space environment; and they will look for the boundary where the heliosphere ends and space begins.

Both spacecraft will spend six months to a year passing through the asteroid belt which circles the Sun from 180 to 330 million miles out. The experiments will measure the intensity and polarization of sunlight reflected from asteroids and cosmic

dust to allow calculations of overall quantities of cosmic debris.

Near Jupiter, the Pioneers will gather information on a number of mysteries surrounding the planet. In addition, scientists will perform a celestial mechanics experiment and a radio-occultation experiment by analysing the radio signals from the Pioneers just before and just after they pass behind the planet for about one hour as viewed from Earth. Earth-based studies of Jupiter have not yet revealed whether the surface of the giant planet is solid, liquid or gas.

Jupiter periodically emits huge surges of radio noise. It appears to have a magnetic field of its own, similar in shape to Earth but far stronger, and radiation belts an estimated one million times more intense than Earth's.

The planet is believed to be the only one in our solar system which radiates more energy than it absorbs from the Sun, current measurements indicating about twice as much. If these observations are correct, they show that Jupiter has a very dynamic interior and may have processes at work which are similar to a star's such as our Sun.

Much smoke at *Which?*

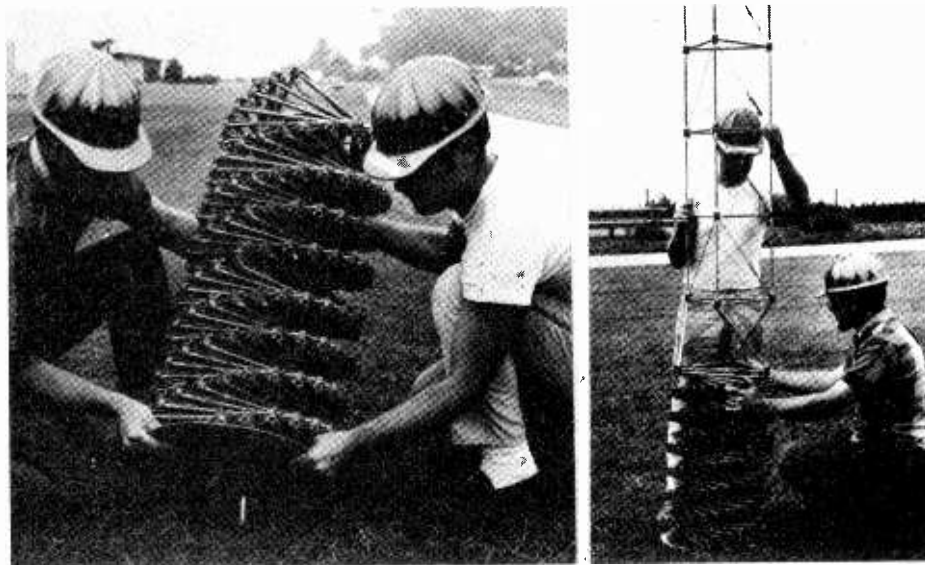
Which?, the journal of the Consumers' Association, recently carried out tests on battery eliminators for portable radios and tape recorders. The subsequent report, rather confusingly headed 'Mains Adaptors', told how the transformers of five of the nine units tested broke down when subjected to the tests laid down by British Standards and were labelled potentially dangerous. All five faulty units came from the far east and were the Aiwa AC-603 and AC-606, Eagle products LA-9P and LA-10S and the Sony AC-90E.

Of the four eliminators which were classed as safe, manufactured by Bang and Olufsen, Grundig, Philips and Radionette, the Philips N6502 was chosen as best value for money.

While on the subject of battery eliminators we would like to point out to readers the existence of even more dangerous examples than those tested by *Which?* The type we have in mind are usually very cheap and do not employ any isolating step-down transformer at all. The required voltage drop being obtained by capacitive or resistive means. These units could be lethal. Be warned!

In these eliminators a direct connection exists between the low battery-voltage output and one side of the mains—as in normal mains radio a.c./d.c. practice. The low voltage equipment to be powered by battery eliminators (transistor radios, tape recorders, etc.) are not designed with mains voltages in mind so it is very possible that external metalwork and uninsulated sockets, etc., may be connected to some part of the internal circuitry—probably the common line.

The pictures show a portable aerial mast which can be erected without the use of tools and without having to worry about loose parts. The masts can be made in aluminium or stainless steel in three diameters from 15 to 25 inches. Packaged they are one-thirtieth of their deployed height which can be up to 100-ft. The Astromast tower, as it is called, is manufactured by the Astro Research Group of California, U.S.A.





A 4-metre transmitter powered by a single Mallory mercury cell is being implanted in the rhino's horn, the single-turn aerial will be accommodated in a groove cut around the horn. After implantation the damage is made good with glass fibre and quick-setting resin. The electronic equipment was designed by the Council of Scientific and Industrial Research, Pretoria, in order that they may keep track of individual animals.

This means that a direct connection exists between this bare external metal and one side of the mains socket, an extremely dangerous situation. Also any external devices connected to the powered equipment, such as tape recorders, extension loudspeakers and earphones, are also likely to become live.

The moral? Do not try to save a few shillings, buy a reputable make at a fair price and satisfy yourself that the circuit arrangements are adequate.

Push-button telephone chips

In the April issue, in this section, the push-button touch-tone method of dialling was discussed. Pushing a button corresponding to a digit resulted in two tones being transmitted to the exchange for decoding. Push-button dialling is quicker and more convenient than the normal dial we use today, and with the touch-tone system it is possible to use the telephone to switch on equipment, from a remote point, merely by tapping out the required code after connection to the premises has been established.

A major disadvantage of the touch-tone system is the need for additional equipment at the telephone exchange to decode the tones.

The present method of dialling in this country is called the Strowger system. If the digit nine is dialled the telephone transmits nine pulses, one after the other, which are counted by the exchange equipment. A push-button telephone, to be compatible with the Strowger system and not demand any alteration in exchange equipment, must also transmit an identical serial pulse train.

It would indeed be difficult and expensive to design a push-button that, by mechanical means, caused nine pulses to be transmitted when it was pressed. But using digital methods such a task can easily be accomplished. The digit nine can be represented by four binary digits.

Pressing the button nine could result in the four bistables in a counter being set in the condition representing nine. A gating system could then allow pulses to the counter to cause it to count backwards: nine, eight, seven . . . until zero is reached, the gating system could then be arranged to cut off the supply of pulses to the counter. Nine pulses would have been fed to the counter and these could also be transmitted to the exchange at a speed compatible with the equipment in use there.

Similar methods to these are now being used in m.o.s. (metal-oxide-silicon) integrated circuits being produced by Marconi-Elliott and by T.M.C. These circuits store all the digits of a telephone number fed to them by push-buttons and transmit them in serial form to the Strowger exchange equipment.

The logic design for the Marconi-Elliott integrated circuit was carried out by the telephone division of G.E.C. and the chip design and layout was done by Marconi-Elliott Microelectronics.

T.M.C. adopted a different approach and designed the whole thing themselves including the structural details of the microcircuitry.

Both systems consist of two chips the difference being in the interconnections, the encapsulations, the logic design and the number of external discrete components required.

The Marconi-Elliott chips are mounted on the push-button unit to form an integral unit, whilst in the T.M.C. unit two circuit cards are employed in addition to the push-button unit.

The use of these m.o.s. dialling systems does not allow coded information from the push-buttons to be used to actuate external devices as is the case with the touch-tone system. It is said by exponents of the m.o.s. system that this does not matter much any way as any amount of data can be sent along the telephone lines by external equipment once connection has been established. An advantage of the m.o.s. system is that often used numbers could be stored in binary form in a small digital store

(an m.o.s. read/write memory chip) so that these numbers can be dialled automatically on pressing a single button.

Just recently T.M.C. have announced an order for £0.5M worth of their m.o.s. equipment that will be used by operators in telephone exchanges.

Aerial for 1-3cm communications

Radio communication in the 3cm to 7mm wavelength region, normally used only for radar, is one possibility to be investigated with an unusual steerable aerial mounted on the roof of Birmingham University's new Electrical Engineering building. This region, 10GHz to 40GHz, would accommodate 5,000 television or 7 million telephone channels, but, of course, the waves are subject to atmospheric absorption and propagation is dependent on the weather. Radio meteorology is, in fact, another field of research for which the aerial will be used. Being sited in the environs of a large city, the aerial is surrounded by sources of man-made interference, but this was a deliberate choice, to permit study of communication in the presence of such interference. Apart from terrestrial communications, the aerial will allow research into the possibility of cities and smaller urban communities having their own satellite terminals. (Next year there will be geo-stationary satellites in orbit working in the 1-3cm region.)

Built by Husband & Co. and Markham & Co. Ltd., the aerial is unusual because it has an offset Cassegrain configuration. The main parabolic reflector, which is 20ft in diameter, can be considered as a piece cut out of the side of the reflector of a larger parabolic aerial. Hence the small hyperbolic sub-reflector is not within the beam of the main bowl. This means, for one thing, that the small reflector does not

The aerial on the roof of Birmingham University.



obstruct and scatter radiation passing into or out of the main bowl and, secondly, that it does not reflect local interference energy into the receiver.

The cabin can be rotated about the vertical axis to obtain azimuthal motion, while the main bowl support arm and small reflector can be turned about the slant axis, thereby rotating the aerial beam around a cone centred on the slant axis. In this way the beam, which has a width of 12 minutes of arc at 1cm wavelength, can be aimed at any point above the horizon. An advantage of this design is that it reduces the length of waveguide required, and hence losses, from the aerial feed horn to the transmitter or receiver.

Digital position control is used, and for tracking communication satellites there will be an on-line digital computer with a "hill-climbing" optimising control programme.

At present no receiving or transmitting equipment is installed. The first experiments will use radiometers to map noise energy from natural and man-made sources.

The technology of music

Music is steadily becoming more closely linked with electronic engineering. Whenever a concert or other performance is broadcast or recorded a considerable burden of responsibility falls upon the sound engineer. Realizing this, the University of Surrey, is to start a "Tonmeister" course leading to B.Mus. (Tonmeister). For this course the music department will run in conjunction with the Department of Physics. The declared

aim is to produce graduates who are fully competent in both the technical and artistic aspects of music reproduction. A Tonmeister must therefore be a musical, artistic personality having a well-trained musical ear as well as considerable technical knowledge, and he must be competent in handling microphones, mixers, recorders and other apparatus for sound reproduction. This course at the University of Surrey (Guildford) is due to begin in October of this year.

Experimental pacemaker

An experimental pacemaker which is powered by electrical energy generated by blood pressure now offers the hope that the thousands of people with pacemakers implanted in their bodies may avoid the need for periodic surgical battery changes. The new pacemaker was devised at Bell Laboratories and the New York Hospital-Cornell Medical Center. Much work remains to be done before the experimental pacemaker can be tested on humans. However, its feasibility has been demonstrated.

A pacemaker is an electronic "clock" about 2.5 inches in diameter which is usually implanted surgically beneath the skin below the shoulder. It produces about 70 electrical impulses a minute which travel down a long electrode wire inserted through a vein (such as the jugular vein) into the heart. These electrical impulses stimulate the heart.

The experimental pacemaker uses piezoelectric discs to convert variations in blood pressure into electricity. A small plastic tube is inserted through a vein into the right ventricle of the heart, following much the same path as the electrode in a conventional pacemaker. At the end of this tube inside the heart is a small 'balloon' filled with water. When the heart contracts and there is a change in blood pressure, the water is squeezed up the tube, producing a mechanical strain in the piezoelectric discs. The piezoelectric material converts the mechanical strain produced by the blood pressure into electricity, which is stored in a capacitor and used to run the pacemaker. Electrical impulses produced by the pacemaker travel down a pair of wires which are wrapped around the plastic tube.

Industrial information service

Information on the products, services and business structure of nearly 30,000 major U.K. companies is now offered by the Industrial Information Services conducted by Kompass Publishers Ltd., of R.A.C. House, Lansdowne Road, Croydon, RC9 2HE. The source of this information is the computer memory bank used in the compilation of the 2-volume U.K. Kompass Register. Any permutation from various categories of data stored in the



An historic moment of 50 years ago; Dame Nellie Melba making the first advertised broadcast in this country from an improved studio of the Marconi Works at Chelmsford. This event took place on the 15th June 1920 when Wireless World was about nine years old.

computer can be extracted and printed to customers' requirements, to provide a precise basis for marketing strategies or, in list or gummed label form, for direct mail operations. Cost of the service varies according to the amount of information required by the client.

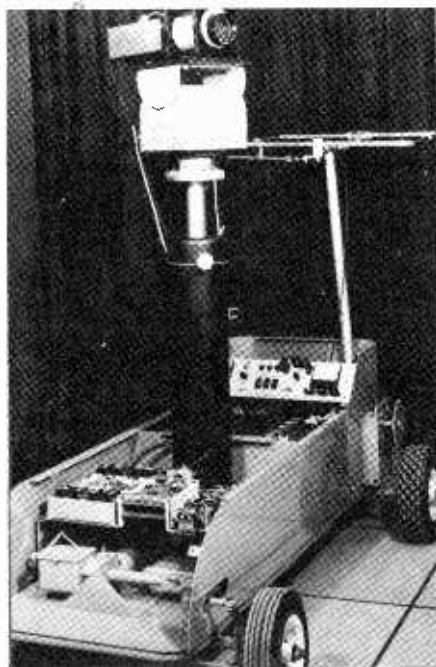
Weather system for the Army

Under a £3M Ministry of Defence contract GEC-Elliott Space and Weapons Division and Plessey are to manufacture an automated meteorological system for use by Army artillery sections. GEC-Elliott will be the prime contractor and will be responsible for the research and development required by the overall system and will supply all the data processing equipment. Plessey, as principal sub-contractors, will be the R&D authority and supplier of the tracking radar and radiosonde sub-systems.

The complete equipment is called AMETS (Automated METeological System). It consists of an instrumentation vehicle containing the data processing equipment and a small trailer for the radar. Other vehicles would normally be employed as well to function as a command post, to carry stores and to carry out reconnaissance.

In operation a hydrogen filled balloon carrying a radar reflector and radiosonde, which transmits temperature measurements, is released. The computer, an Elliott 920B, receives temperature measurements from the radiosonde, details of the balloon's position and rate of movement from the radar, a measurement of surface atmospheric pressure from the

A television remote controlled vehicle developed by the Communications Division of America's National Aeronautics and Space Administration. The vehicle simulates a lunar rover.



instrumentation vehicle and average humidity figures from its own memory. These figures are fed into the memory prior to the operation and depend on the area in which the equipment is located.

From all this information the computer calculates and prints out the required meteorological message two minutes after the radiosonde balloon reaches the required height. Earlier methods needed far more equipment to be carried by the balloon and the subsequent calculations took about an hour.

I.E.E.T.E. have a good year

The Institution of Electrical and Electronics Technician Engineers report of the council and accounts for the year ended 31st March 1970 shows that the Institution made further progress and that membership had advanced to nearly 12,000. With the setting up of the Northern Ireland Region in May, 1969, the Institution now has ten regional centres.

Radar network for Africa

An air traffic control and meteorological radar network, valued at more than £1M, has been ordered from Plessey Radar Limited by the Directorate of Civil Aviation for the East African Community. The network will cover most of East Africa and is part of the modernization programme currently being carried out to re-equip the airports and air traffic control system of Kenya, Tanzania and Uganda.

The hub of the new air traffic control system will be a central area control radar station equipped with an AR-5 long-range radar and an automatic secondary surveillance radar system. These radars will be used for surveillance and control between the three major airports of East Africa: Entebbe (Uganda), Nairobi (Kenya) and Dar-es-Salaam (Tanzania).

Under the contract Plessey will also supply three AR-1 medium-range terminal area radars for Entebbe, Dar-es-Salaam and the new Kilimanjaro international airport.

A new Ampex video tape duplicating centre at Boeblingen, West Germany. A master tape is played on a VR-1200 and duplicated on eight VR-7003 videotape recorders. Present capacity of the centre is 1000hrs/month.



Audio Fair

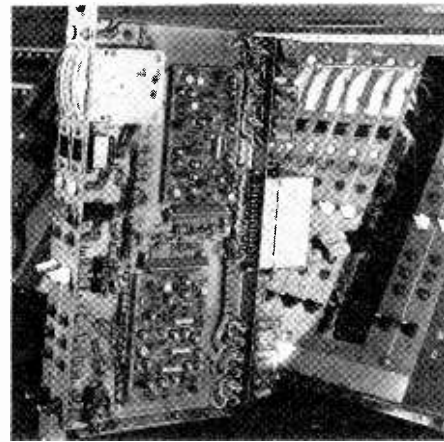
An innovation at this year's London Audio & Music Fair, which is again being held in Olympia (October 19-24), is the presentation of lecture-demonstrations and concerts in one of the halls four times each day. Full details are not yet available but *Wireless World* has undertaken to put on a series of lecture-demonstrations on the general theme of "what is fidelity in sound reproduction?" These will be given by well-known designers who have contributed to the journal. We hope, as far as possible, to use equipment described in *Wireless World* for the demonstrations. Further details of the lectures and the procedure for obtaining tickets will be announced as soon as they become available.

We understand from the organizers that over 75% of the available space in the exhibition has already been booked by 80 manufacturers and dealers. "Sound-proof" demonstration booths will again be constructed adjacent to the exhibition stands.

Computer talk

Bell Laboratories engineers in America have programmed a computer to convert printed English text into synthetic speech. Recent experiments take advantage of an improved understanding of speech patterns—the way people really use their language and tailor it to match their intended meaning. Bell researchers gave the computer mathematical approximations of the shapes and motions the human vocal tract assumes when uttering common sounds and sound sequences. They programmed the computer with a basic dictionary of word categories and definitions in digital form. Then they approximated, for computer storage, the complex rules of timing, pitch and stress which people use naturally in everyday conversation.

In the experiments passages are typed and sent to the computer from a



Under a £73,000 contract International Aeradio has designed and built system control equipment for the control centre of Britain's military satellite system, Skynet, at Oakhanger, Hampshire. The photograph shows a module which forms part of the channel switching console.

keyboard. The computer analyses the sentence, assigns stress and timing to each word, and finds a phonetic description of each word from a dictionary stored in the computer's memory. Mathematical descriptions of vocal-tract motions are computed. These descriptions are used to generate electrical speech signals which may be heard over a loudspeaker or a telephone. The typed sentence also can be stored in the computer for later use.

An oscilloscope connected to the computer produces a line drawing of the model vocal tract, and displays the change in position of the throat, jaw, tongue, and lips as different sounds are produced. The oscilloscope display, though unnecessary for text-to-speech conversation, aids researchers in monitoring the performance of the system.

An exercise in circuit maximization

Do you use a sledgehammer to crack a walnut? A circuit recently released by Motorola appears to do just this. The circuit is intended to eliminate component damage in a flashing-lamp warning indicator due to current surges caused by the low cold resistance of lamps. It also prevents any damage due to short-circuits within the lamps.

The engineer who designed the circuit must have had his eyes on the sales figures for he used five transistors, two diodes, one zener diode, four two-input gates, twelve resistors and three capacitors. This did not include the two transistors, two capacitors and four resistors needed for a multivibrator to drive the circuit.

It may be that a single resistor could have been used to keep the lamps warm to offset the low cold resistance problem and a simple ring-of-two constant current circuit may have been enough to cope with lamp short-circuit problems. Never mind, perhaps the report was issued on April 1st.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Symmetry in class B

I have carefully read Mr. King's letter in the July issue (p.330), and I am sorry to have to say that I think his argument has gone astray.

The signal voltage V_s shown in Fig. 2 of my September 1969 letter (on earthed circuit) is not the same as Mr. King's V_s . As I thought I had made clear, V_s in my Fig. 2 is intended to represent the e.m.f. of the floating signal-voltage source, of internal resistance R_1^* , connected between points P and Q in my Fig. 1. A further point is that though Mr. King describes his Fig. 1 circuit as a simplified version of my circuit, it omits the vital and fundamental detail of a connection via a large capacitor from point B to a tapping on the top resistor shown in his diagram.

Mr. King feels that I have lost sight of the wood for the trees, and suggests also that it is impossible to produce shunt

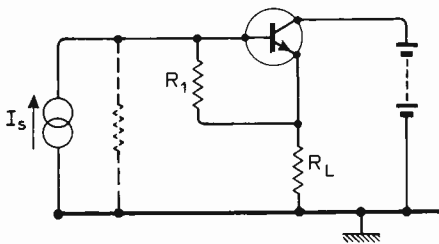


Fig. A.

feedback with one resistor earthed at one end. Consider, however, the accompanying Fig. A, ignoring for the moment the resistor shown in broken line. This circuit looks like an emitter follower, at first sight, but can hardly be properly regarded as such, since there is no negative feedback. The current source, I_s , feeding its current into R_1 , produces a floating voltage source, of internal resistance R_1 , connected directly between base and emitter, and the circuit functions as a simple common-emitter amplifier. Now consider the effect of connecting the broken-line resistor across the current source. As the value of the resistor is lowered, conditions tend more and more towards those of an ideal voltage-driven emitter follower, and feedback is thus increasingly introduced.

The same circuit as in Fig. A, redrawn with the transistor emitter earthed, is

* R_1 in Fig. 1, that is, not Fig. 2.

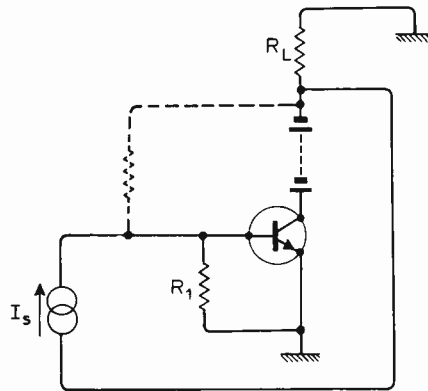


Fig. B.

shown in Fig. B, and it is now seen that the broken-line resistor can, indeed, be very properly regarded as a shunt feedback resistor.

Though circuit B is exactly equivalent to A, the circuits remain nearly enough equivalent, for many purposes, if the lower end of the current source, in circuit B, is earthed rather than taken to R_L as shown. I_s is so small, at least in the present context of audio output stages using transistor pairs, that it makes very little difference whether I_s itself is added to the much larger load current in R_L or not.

While attention has thus been focused on my letter of last September, I would like to take the opportunity to correct a genuine mistake, pointed out to me by Mr. I. J. Kampel, of Bournemouth. In the caption to my Fig. 5(b), curve 3 is said to apply to "Mr. Shaw's scheme". Unfortunately I had not noticed that, with the switch S in my Fig. 2 closed, putting a power diode in series with R_3 does not exactly convert the circuit to Mr. Shaw's arrangement. To get the latter, one should add a 100-ohm resistor (using my value) between the lower driver emitter and the junction of R_2 and R_3 (i.e. earth), the lower end of R_1 also going to this latter point. With these matters attended to, the input current characteristic becomes more like curve 2, and is thus a good match to the curve for the upper, Darlington, pair. I must apologize to Mr. Shaw for any implication that his circuit has significantly inferior

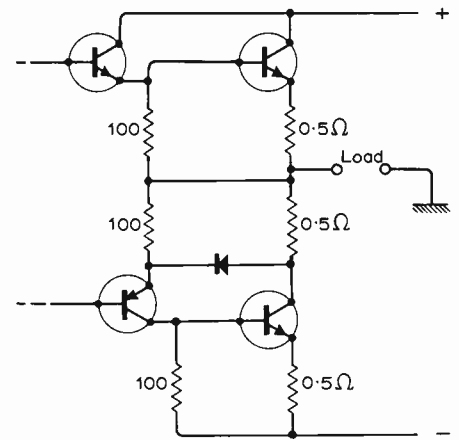


Fig. C.

linearity to that given by my low-power-diode scheme.

The connection of the 100-ohm resistors to the junction of the 0.5-ohm resistors, as Mr. Shaw does, is preferable, from the point of view of avoiding thermal runaway, to connecting them to the other ends of the 0.5-ohm resistors, as in my circuit—though this consideration is of much reduced importance now that silicon power transistors have largely replaced germanium ones. Improved thermal stability can, however, also be obtained with the low-power-diode-type of circuit, by arranging it as in Fig. C. Note that, in either type of circuit, to preserve the utmost symmetry of behaviour, a third 0.5-ohm resistor should be included at the bottom, as shown. Whether this small improvement is really worthwhile in practice, is, however, rather doubtful.

P. J. BAXANDALL,
Malvern,
Worcs.

Sonex '70 report criticized

It is always rather saddening to read opinionated drivel in a much-respected technical journal. Even more so, when it is factually inaccurate.

The author* of the smugly anonymous "report" on Sonex '70 in your June issue was either jaundiced by an outside chip on his shoulder or otherwise coerced by commercial influences. I know of no other account of a technical exhibition which is opened with a discussion of the journey to the venue.

There follows a blistering attack on a handful of exhibitors and the remarks concerning the KEF demonstration imply a certain disregard of musical values. Now, it may interest you to know that the formula for that demonstration was evolved from a careful study of public preferences, following comments in the correspondence columns of a popular hi-fi magazine. As a result, KEF abandoned their previous demonstration format which used only two types of loudspeaker, and played a predominantly classical programme. Instead a very varied selection of shorter items was switched through all available speaker

*It is a widely accepted convention in journalism that unsigned material is a statement by the journal. Ed.

systems. The preparation of this demonstration took about 200 man-hours, and if your reviewer did not like the result, we are naturally sorry and he is, of course, entitled to say so. But he is not entitled to assume or imply thoughtlessness on our part.

The statements regarding acoustic isolation are seriously in error, because the transmission loss between adjacent rooms was more than 20 dB better than the hardboard cubicles used in Olympia in 1969. When annoyance was caused, it was usually attributable to abnormally loud playback and open casement windows which reflected the sound along the outside of the building. The ship-builder surely cannot be blamed for a sinking if the skipper insists on sailing with the seacocks open.

In the closing stages of his article, your reviewer calls for standardized reproducing equipment. This is a wonderfully Utopian concept in which we look forward to a British standard amplifier prescribed by a newly formed Ministry of Home Entertainment. In practical terms, however, I very much doubt that such a development is either probable or even desirable.

RAYMOND E. COOKE,
Managing Director,
KEF Electronics Ltd.

Class AB amplifier

Mr. Linsley Hood is quite correct when he states that the operation of transistor output stages in class AB can cause increased distortion, because of the change in the slope of the transfer characteristic around the crossover point. However, I fear that he is wrong in supposing that a low source impedance overcomes the problem.

Fig. 1 shows a test circuit which I constructed to measure the transfer characteristic of the output stage under various bias conditions and the results are shown in Fig. 2 for 200mA, 20mA and 0mA. Note the prominent change in slope at 200mA bias. In the test circuit the transistors are operated in the common emitter mode to enable the changes in the slope of the transfer characteristic to be seen more easily, but this does not alter the validity of the results since the effect of putting the load into the emitter circuit is only to provide local negative feedback. Under the same conditions a push-pull emitter follower using an output stage with the transfer characteristic of Fig. 2(b) will produce less distortion than a similar output stage with the transfer characteristic of Fig. 2(c).

To check this I constructed Mr. Linsley Hood's amplifier and measured the distortion at 200mA and 20mA bias current with a Marconi TF2330 wave analyser and TF2100/1M1 low-distortion oscillator. The results are shown in Fig. 3 and show clearly the improvement in distortion at intermediate output levels produced by the lower bias current. However, in spite of the excellent results obtained I would not advise constructors of this amplifier to use

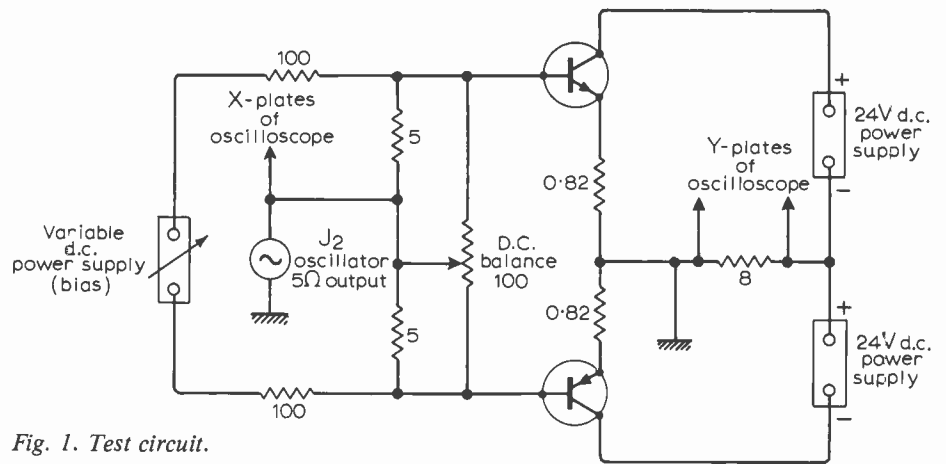


Fig. 1. Test circuit.

a bias current as low as 20mA as it tends to be rather unstable. A bias of 50mA would be about the optimum and at this level there would still be a "hump" in the distortion curve but it would be smaller than at 200mA bias and removed to a lower power level. I would also consider the use of a temperature compensating diode or transistor in the bias network strongly advisable, to minimize thermal variations.

Mr. Linsley Hood is also incorrect when he states that the emitter follower driver Tr_3 presents the output transistors with a low source impedance. This would be true if it were not for the bootstrap capacitor which raises the effective value of the $6.8k\Omega$ load resistor in Tr_2 collector to around $50k\Omega$. Thus the source impedance seen by the output transistors is about $1k\Omega$, i.e. about twice their input impedance with an 8Ω emitter load.

A further point concerns the current gain of the output transistors. The specified gain spread for the MJ481/MJ491 devices used is 30-200 at 1A. As only 40mA is available from the driver stage the peak collector current with minimum gain devices is only 1.2A. This corresponds to an output power of about 8 watts into 15Ω and 5 watts into 8Ω . To achieve the output power claimed by the author the output transistors need to have a minimum current gain of around 80 at 1A. Perhaps the author could suggest alternative component values for those unfortunate enough to get low-gain transistors.

One last point. The author obviously attaches great importance to "square-wave transfer distortion" but he has not yet told us how he defines it. It is well known that any network, whether it be active or passive, that does not have a linear phase/frequency characteristic will produce transient distortion of a square wave. Does the author consider that, for example,

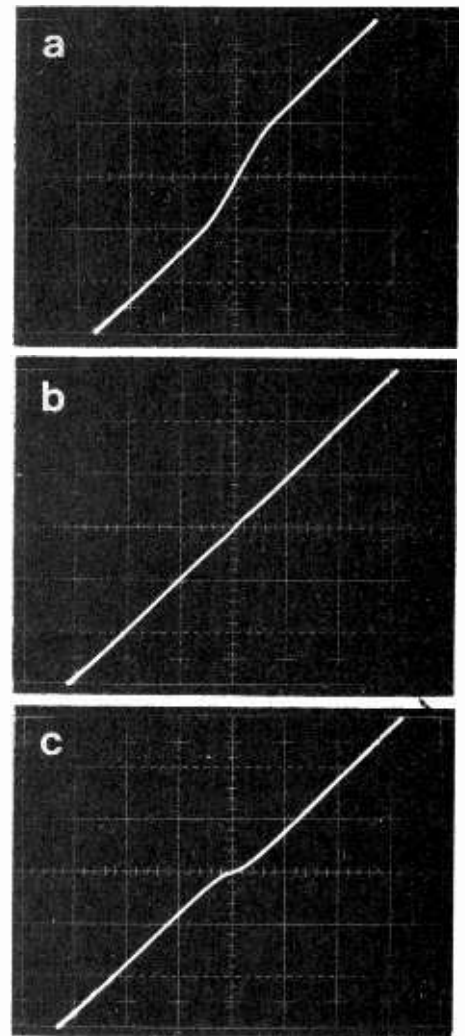


Fig. 2. Transfer characteristics at 200mA bias (a), 20mA (b), and 0mA (c). Vertical scale 500mA/division, horizontal scale 500 mV/division.

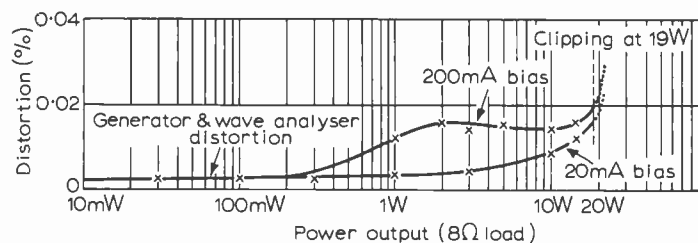


Fig. 3. Distortion Versus output power for bias currents of 200 and 20mA (load 8Ω , frequency 1kHz).

an *L-C* filter with a sharp cut-off at 50kHz would produce audible distortion? The ringing produced by such a filter would be very similar to that produced by an audio amplifier with a load of 15Ω and $2\mu\text{F}$.
D. S. GIBBS,
Bury,
Lancs.

The author replies:

Mr. Gibbs' letter raises a number of interesting points, with some of which I concur. However, I regret that he has misunderstood the argument in some cases.

To take his points separately.

1. *Optimum quiescent current:* The fact that there is an optimum value of quiescent current in a class B output stage for minimum harmonic distortion is well known and is not in dispute. This optimum current depends, among other things, on the current gain of the output transistors (or the product of the current gains if a Darlington pair or a similar output stage configuration is used) and, to a first approximation, the higher the effective current gain of the individual halves of the output stage the lower the optimum value of quiescent current. From the figures Mr. Gibbs quotes it would seem that the transistors he chose for this experiment had a high value of current gain.

However, this is not the point. I believe that the bulk of normal listening is done with output power levels which are of the order of only 50-250mW, only the very occasional transients demanding power levels in the 1-2 watt region. I also believe that it is advantageous for the amplifier to operate in true class A bias conditions for normal listening power levels, in that this avoids most of the ill-effects which can arise in class B, for example due to mismatched output transistor characteristics. These ill-effects produce the bulk of the high order harmonic and intermodulation distortions which appear to be objectionable to the ear.

Therefore, the question is simply which output stage configuration will operate best overall, with a forward bias of say, 200mA (this being chosen to allow class A operation up to 600mW), 1.2 watts with 8-15 ohm loads. The simple complementary emitter follower combination appears to be the best one for this purpose.

The measurement of very low order harmonic distortion levels is difficult, and is influenced by such things as h.t. supply impedances, lead connections, etc. and I am grateful therefore to find that Mr. Gibbs' measurements confirm my own findings that such a design, with such an output stage and forward bias does not give rise to harmonic distortion levels in excess of 0.02%. My own subsequent measurements with a harmonic analyser show that the distortion produced in the 'hump' region is mainly 3rd harmonic, whereas the higher magnitude of distortion produced by a more conventional complementary Darlington pair biased to 200mA, in a similar circuit, also contains more of these audibly objectionable higher order harmonics (see my Fig. A). Whether one has 0.015% or 0.005% t.h.d. is probably only of academic interest to the user.

2. *Base-emitter impedance:* For good high-frequency and transient performance it is desirable, I believe, that the impedance between base and emitter of the output transistors should be low. In the case of the class AB amplifier circuit, this condition is met by the 100Ω potentiometer, $400\mu\text{F}$ combination connected between the bases of the two output stage transistors, since when one of these is cut-off the other is conducting and provides the necessary base-to-emitter return path. The use of a relatively high driver impedance is actually advantageous in minimizing harmonic distortion due to the transistor base impedance non-linearity.

3. *Output power:* The question of the range of current gains to be found with the MJ 481-491 series transistors has been raised before in different contexts in these columns. My own experience with quite a large number of these is that the lowest current gain encountered, at 1A, is of the order of 75, and most, in fact, lie in the 100-150 bracket. However, this is not really an important limitation under dynamic conditions, because the effect of the bootstrap connection to the emitter load of Tr_3 allows adequate drive current even with low-gain transistors.

4. *Audible effects of transient overshoots on reactive loads:* My experimental findings are that there is an occasional audible difference between an amplifier whose

stability under reactive load conditions is such that no overshoots are produced with a transient input and one which 'rings'. I do not think that this has anything to do with the nature of the h.f. response curve although it is evident that a 'ring' can be produced by a steep-cut low-pass filter. In the case of an audio amplifier driving a loudspeaker load, my own hypothesis is that some loudspeaker systems, under some dynamic conditions, can provide a negative reactive impedance, and this, however transitory, can exaggerate incipient reactive load instabilities present in the amplifier, and introduce spurious (and audible) waveform distortions.

I will take this opportunity of adding a personal note. In the original draft of my article, I walked into a philosophical booby-trap on the output power calculations, through overlooking the fact that current can flow both ways through the load. On subsequent consideration I became aware of this error, and the calculations shown in the Appendix 1 are correct. That part of the article relating to this—the last half of the third paragraph on page 322—is however, in error. The values 1.2W and 640 mW should be substituted for the 300 and 160 mW figures shown and the remaining 35 words of that paragraph deleted. I apologize to readers for this contradiction appearing in the text.

J. LINSLEY HOOD.

Aerial noise

I wish to disagree with a statement made by your contributor P. G. Baker in the article "Aperiodic Loop Aerial" appearing in your May issue. He states, "The aerial output noise comes primarily from atmospheric and galactic sources hence the thermal noise introduced by the aerial radiation resistance is insignificant by comparison, provided the resistance is assumed to be at ambient temperature."

I suggest this conception is entirely erroneous. The noise temperature which can be allotted to a radiation resistance is that of the media to which it is coupled, the atmosphere and galaxy at the frequencies under discussion. Radiation resistance is not a physical resistance but a hypothetical one, generating no ohmic noise, but having a noise temperature due to its surrounding environment, which is usually considerably above earth ambient.

The only noise an aerial system can generate of itself, is that attributable to ohmic and dielectric losses in the aerial and feeder. As this noise contribution is of a considerably lower order than that resulting from external sources in the range up to approximately 30MHz, it can usually be ignored for design purposes. Furthermore as external noise is of a higher order than receiver noise at these frequencies it will remain the limiting factor in signal resolution, even for aerials with relatively inefficient space coupling.
H. F. LEWIS,
Ealing,
London W.5.

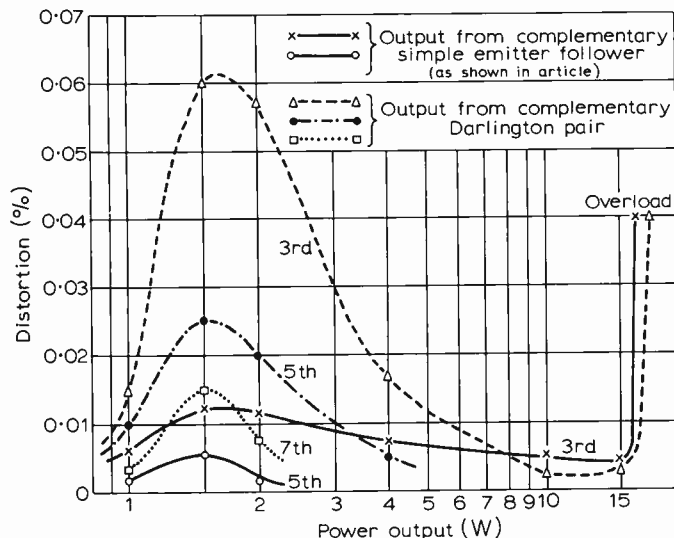


Fig. A. Measurements of Class AB amplifier with 200mA quiescent current and 15 ohm load. Second harmonic distortion below 0.01% was similar in both circuits.

100MHz Frequency Divider

Extend the range of your digital frequency meter to 100MHz with this circuit which employs a tunnel diode and emitter-coupled logic

by *D. R. Bowman, M.I.E.R.E.*

A large number of digital frequency meters with a limited frequency range are in use in laboratories throughout the world and it is to extend the range of these instruments that the 100 MHz frequency divider described here has been developed.

The circuit consists of a wideband r.f. amplifier with gain extending from about 5 to 120 MHz followed by a very fast pulse squaring circuit which in turn feeds the logic divider stages as shown in Fig. 1.

At an early stage in the development it was decided to use integrated circuits wherever feasible. After a search of the literature it was decided to try the Motorola range of e.c.l.-2 (emitter coupled logic) for the frequency divider stages. To achieve the maximum toggle frequency from the JK flip flops the drive waveform must have rise and fall times each of equal to or less than 2 nsec. To achieve this performance it is necessary to use a tunnel diode in a waveform squaring circuit. The original intention was to divide the input frequency by ten (dotted Fig. 1) but this circuit was found to have a maximum frequency of operation of about 70 MHz. This frequency limiting is due to the low input impedance of the divide-by-five circuitry loading the first flip flop. The divide-by-ten instrument is somewhat cheaper than the 100 MHz divide-by-100 design and may be constructed as an alternative. The maximum frequency of operation is obtained, and the maximum impedance is presented by the JK flip flops when they are connected as binary dividers. The 100 MHz, divide-by-100, design overcomes its frequency limiting problem by operating the first two stages as divide-by-two, followed by two divide-by-five sections.

Wideband amplifier

The tunnel diode pulse shaper requires a signal with an amplitude greater than 0.5 V to switch correctly. It was decided to design for a 10 mV sensitivity which dictates 40 dB of voltage gain for the amplifier. The use of voltage gain in this description can be justified as both the amplifier's input and output is terminated in 50 Ω. The idea of using emitter coupled pairs with ferrite wideband coupling transformers originated from some earlier work carried out by the author*. The previous work demonstrated

the feasibility of u.h.f. amplifiers with very wide bandwidths. The requirement for the amplifier is a voltage gain of 40 dB with a bandwidth of 7 to 100 MHz.

Mullard manufacture a range of ferrite cores and it was decided to use type FX2249. These cores are small and exhibit very low losses up to at least 100 MHz. BFY90 transistors are used in the amplifier as they had been found to give repeatable results in this type of circuit. The minimum f_T value to be expected from BFY90 is in excess of 1,000 MHz. The emitter coupled circuit (Fig. 2) displays a very sharp limiting characteristic which gives the unit a very wide dynamic range.

The amplifier input is protected from damage that might be caused from large voltage swings by a silicon diode connected across the first emitter base junction. The

effect of this in conjunction with the base emitter diode of the first transistor is to limit the input signal to ± 0.5 V. To maintain interstage stability it is essential to isolate each stage of amplification by using Filtercons to decouple the individual supply leads. Erie Filtercons consist of a pi low-pass filter constructed by using two concentric ceramic capacitors separated by a ferrite bead threaded on the supply carrying wire. As the attenuation of these components is low at frequencies below 10 MHz it is necessary to bypass each one with a 0.1 μ F disc ceramic capacitor. It is found that the emitter follower stages of each transistor pair, due to the high f_T , can under certain drive conditions generate spurious parasitic oscillations. This difficulty has been eliminated by reducing the Q factor of the collector stray inductance circuit. Connect-

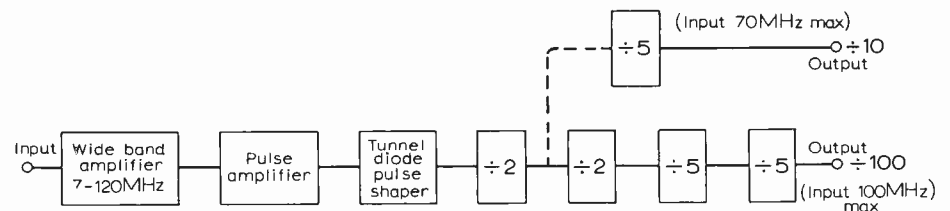


Fig. 1. Block diagram of the divider. The section shown dotted will divide by a factor of ten and may be used instead of the full divide-by-100 circuitry, however the maximum operating frequency will be reduced to 70 MHz.

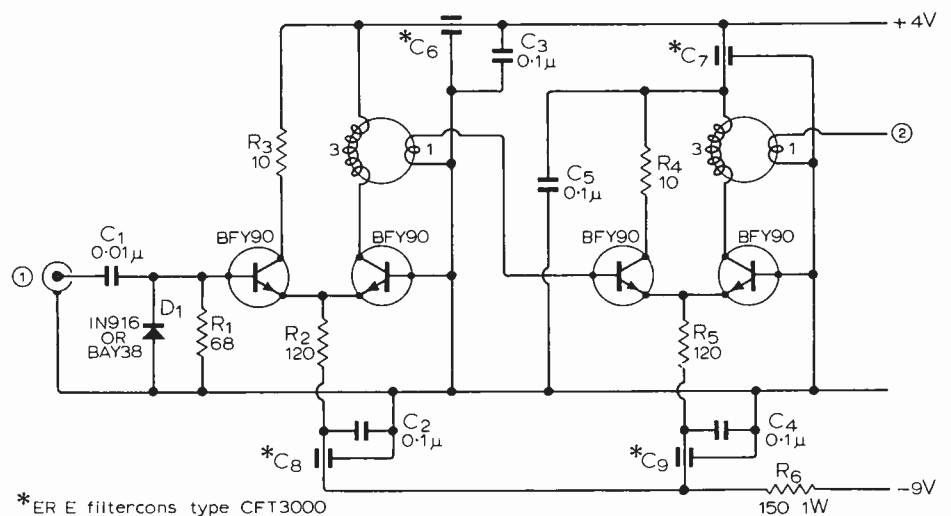


Fig. 2. Wideband amplifier circuit. The transformers are wound with 24 s.w.g. enamelled wire, primary three turns, secondary one turn.

*University College, London.

ing small 10 Ω resistors in series with the collector lead achieves this.

A second source of instability can occur in the stray inductance associated with the emitter circuit if the tail resistor has too high a resistance value.

The design of the ferrite transformers must take into account the performance at both ends of the frequency range. The l.f. performance depends upon the inductive reactance, stray effects only becoming important at the high frequency cut off of the transformer. These stray effects are mainly due to leakage inductance and lumped capacitance, both of which must be minimized to achieve the required h.f. performance. Leakage inductance is kept to a minimum by winding the primary and secondary of the transformer in very close proximity. The wire length per turn should also be as small as possible. The core used has two holes through which the primary and secondary should both be threaded. As each hole is common to both primary and secondary of the transformer, little increase in performance is gained by bifilar winding and, as this would be rather tricky, the author suggests that no attempt is made to twist the two windings together. The results achieved using a turns ratio of 3:1 are shown in Fig. 3. It is seen that the frequency response of the terminated transformer is substantially constant over the range of 0.5 to 60 MHz rising to a peak at 125 MHz. This peak tends to compensate for the amplifier's reducing gain with frequency rise.

The amplifier's performance using two of these wideband transformers to interspace the two emitter coupled amplifier stages is shown in Fig. 4. The gain is constant within ±3 dB over the range of 7 to 90 MHz. The graph shown in Fig. 5 indicates the instrument's performance and it can be seen that the signal required to drive the unit is never greater than 10 mV.

Pulse shaper

Following the amplifier is a common base connected stage (Fig. 6) whose purpose is to drive the tunnel diode pulse shaper

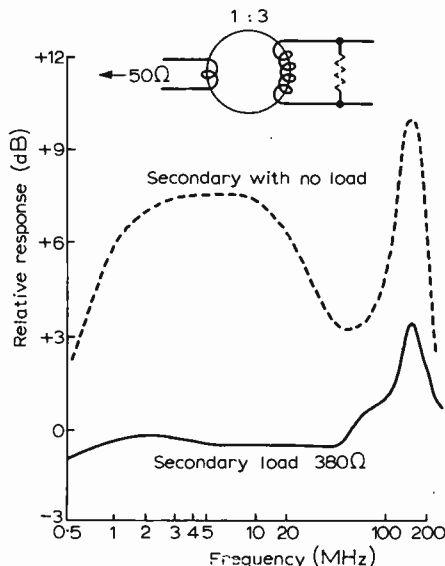


Fig. 3. Performance of the transformer wound on an FX2249 ferrite core.

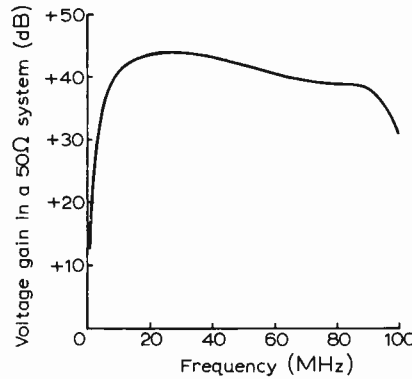


Fig. 4. Wideband amplifier gain plotted against frequency.

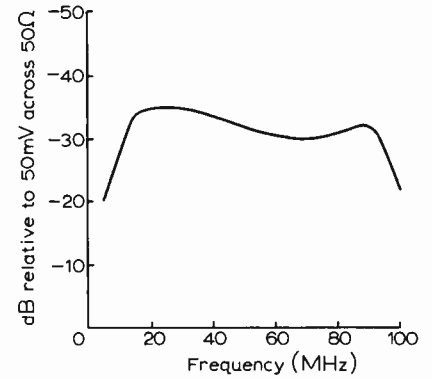


Fig. 5. Minimum input signal plotted against frequency.

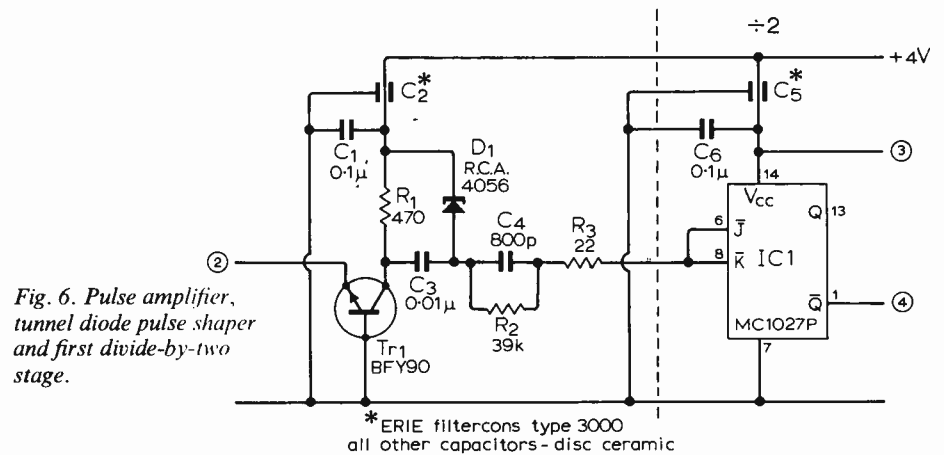


Fig. 6. Pulse amplifier, tunnel diode pulse shaper and first divide-by-two stage.

circuit. Tunnel diodes make very fast switches and can be expected to operate with rise times of anywhere from 100 to 2000 picoseconds. This time is mainly determined by the shunt capacitance of the diode together with the magnitude of the trigger pulse current. A pulse which raises the current through the tunnel diode to greater than the peak current will switch the device from its "on" to "off" state. If alternatively the pulse reduces the standing current to less than the valley current the diode will switch back to its "on" state. This process is clarified by studying the characteristic illustrated in Fig. 7. Diode switching time is defined as the period required for the voltage across the diode to rise from 10% to 90% of its maximum value.

This time t_r is derived as follows:

$$t_r = \frac{(V_{pp} - V_p)C}{(I_p - I_v)} \text{ sec}$$

where:

C = the terminal valley-point capacitance.
 V_{pp} = the positive voltage greater than V_v at which the static current I_f is equal to the peak-point forward current I_p .

V_p = peak-point voltage where $dI_f/dV = 0$ for the first time.

I_p = the peak-point current occurring with V_p above.

I_v = valley-point current. The value of forward current I_f flowing at the second lowest positive voltage V at which $dI_f/dV = 0$.

Therefore the rise time for the diode used

(R.C.A. type 40566) is as follows:

$$t_r = \frac{(0.56 - 0.09) 15 \cdot 10^{-12}}{(5 - 0.6) \cdot 10^{-3}} \text{ sec}$$

$$= \frac{0.47 \cdot 15 \cdot 10^{-9}}{4.4} \approx 1.5 \cdot 10^{-9} \text{ sec}$$

$$t_r = 1.5 \text{ ns}$$

This time is well within the 2 ns required to drive the first logic stage.

Divider stages

Both the MC1013 and MC1027 integrated circuits employed are from the Motorola high speed e.c.l.-2 family. The MC1027 JK flip flop is guaranteed to toggle at frequencies up to 120 MHz although the author did experience some difficulty with this device above 100 MHz. The MC1013 toggled satisfactorily up to at least 85 MHz. These integrated circuits are intended for use with a negative 5.2 V supply and in the interest of maximum speed all unused input leads should be shorted to this line. A far simpler approach used by the author is to mount the dual-in-line devices on to copper laminated fibreglass board and by connecting the negative supply to earth all unused inputs can be simply soldered down to the earth plane. This does of course mean that V_{cc} pin 14 must be used as the positive 5.2 V input terminal. This results in the logic input levels being referred to the +5.2 V line, but this difficulty is easily overcome by referring the tunnel diode pulse squaring network to the positive rail. It has been found that the integrated circuits

will operate quite satisfactorily with supply voltages anywhere between 3 and 6 V. The maximum toggle speed of 105 MHz is achieved by the author's unit with a +3.9 V supply.

The MC1027 and MC1013 devices are basically binary dividers and a form of feedback has to be employed to divide by five. The circuit of the counter is shown in Fig. 8. The output is taken from Q on IC₇ giving a mark-space of 2 : 3 which will drive all digital frequency counters without any difficulty. A truth table for one divide-by-two and one divide-by-five stage is given in table one. As the fanout of these logic blocks is adequate to drive a 2-ft long coaxial cable leading to the associated counter the author

has not included a post divider amplifier. The output pulse has an amplitude of at least 0.3 V peak-to-peak.

Performance

The top three traces shown in Fig. 9 are oscilloscope pictures depicting the tunnel diode switching waveforms appearing at the input to the first logic divide-by-two stage. The first trace has a frequency of 100 MHz (10 nsec per cycle). The switching time is very short, of the order of 2 nsec. The second and third traces show similar waveforms of 55 and 10 MHz respectively. These waveforms were displayed using a Tektronix sampling oscilloscope with an effective

bandwidth of 1 GHz. The lower three traces show the output waveforms associated with the previous logic drive traces. These were displayed on a Tektronix 545B oscilloscope. The unequal mark-to-space ratio of the output signal is evident in these last three photographs, but has no detrimental effect on the following counter.

The frequency divider has been used to extend the operating frequency range to 100 MHz of both a Racal SA535 and a Venner TSA6636/2 digital counter. The minimum frequency at which the unit will reliably divide is about 4 MHz. Over the design range of 10 to 100 MHz the sensitivity is never worse than 10 mV across a 50 Ω input termination. As the total component

Table 1

state	IC 1	IC 2	IC 3	IC 4
0	0	0	0	0
1	1	1	0	0
2	0	1	0	0
3	1	0	1	0
4	0	0	1	0
5	1	1	1	0
6	0	1	1	0
7	1	0	0	1
8	0	0	0	1
9	1	0	0	0

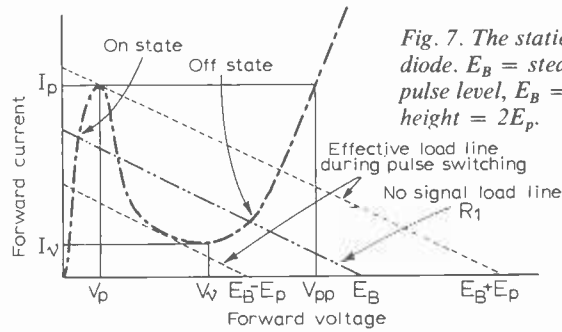


Fig. 7. The static forward characteristic of a tunnel diode. E_B = steady-state load line, $E_B + E_p$ = positive pulse level, $E_B - E_p$ = negative pulse level. Output pulse height = $2E_p$.

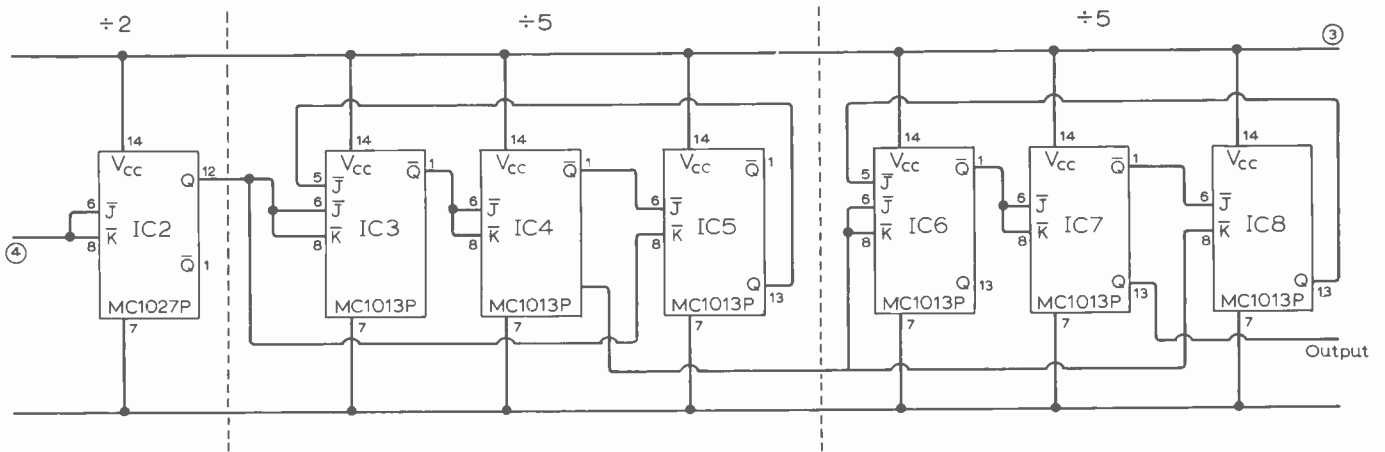
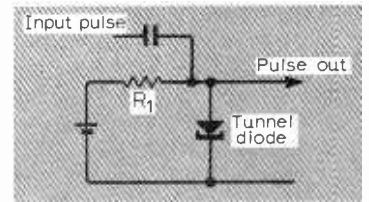


Fig. 8. The logic circuit diagram. The first divide-by-two stage is on the pulse shaper circuit.

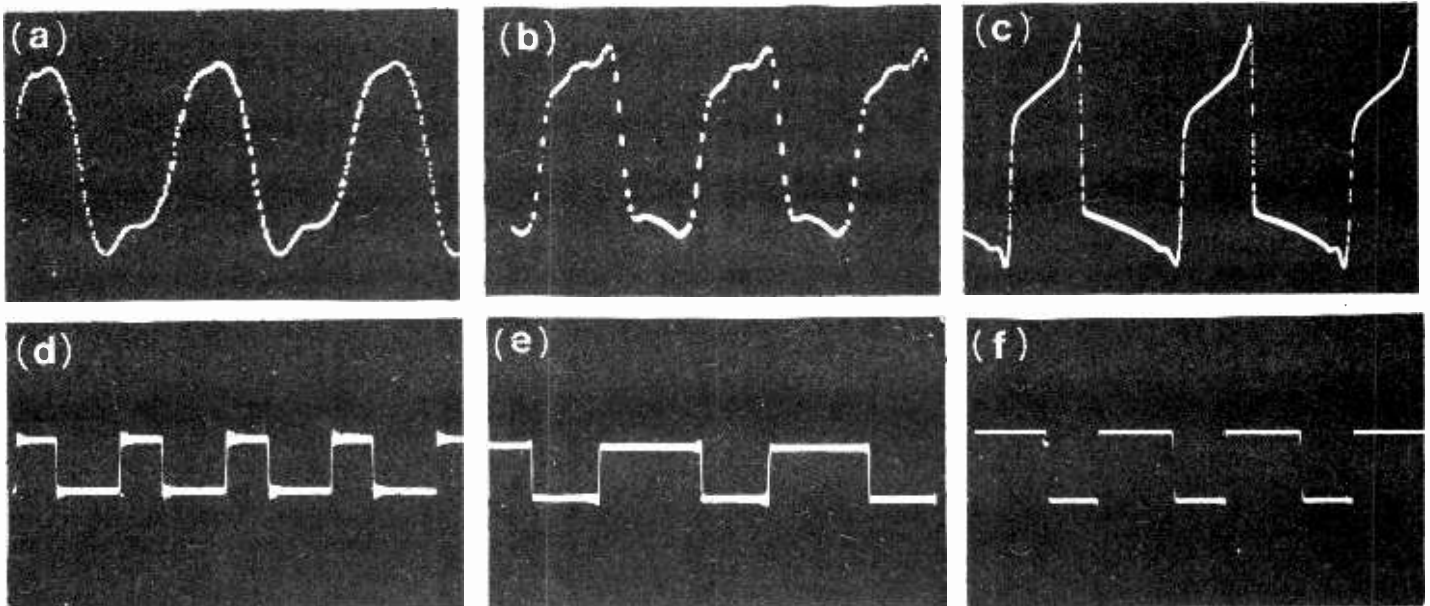


Fig. 9. Waveforms within the unit. The top waveforms are inputs to the divider and the lower traces are outputs.

cost of the instrument does not exceed £20 a considerable saving should be achieved as an equivalent performance commercial instrument is likely to cost upwards of £120.

Power supply

The power supply described here is a "universal" one based on a standard printed circuit board.* A version is described which will power the frequency divider, but the circuit can be used to supply any voltage from 3 to 30 V at up to 100 or 200 mA. If an "outboard" power transistor is employed the output current is increased to 3 A.

The basic circuit (Fig. 10a) consists of a differential transistor pair with one input tied to the stabilized supply output voltage with the other referred to a zener regulated reference voltage. The current flowing in the collector circuit of the zener diode stabilized transistor Tr_2 is used to drive the series connected stabilizing device Tr_1 . On no load I_3 flows almost entirely through Tr_3 , but as the load current increases I_3 is divided between Tr_2 and Tr_3 . As the load is further increased I_2 becomes progressively larger until $I_2 = I_3$. At this point Tr_3 refuses to supply any further current as its base voltage is tied by the zener diode Z and more current would mean an increase in the potential across R_2 , thus further switching off Tr_2 . At this point V_{out} begins to drop and the zener diode loses control further reducing the output voltage until the supply finally switches off. The fold-back characteristic is shown by both Figs 11 and 12. The circuit's voltage stabilizing action can be explained as follows. Assume a small reduction in load voltage which will, though

reduced in amplitude, be transferred to the base of Tr_3 . This will produce a small reduction in the emitter current of Tr_3 , and as R_2 is common to both Tr_2 and Tr_3 , the emitter current of the former will increase. This increment in I_2 will produce a current β times as great in I_1 , thus restoring the load voltage.

Performance

The prototype provided the following performance figures which are by no means the best that can be achieved: 0 to 100 mA regulation >1%; ripple voltage <1 mV r.m.s.; output impedance <1 Ω . 0 to 1 A version, regulation >1%; ripple voltage <3 mV r.m.s.; output impedance <0.2 Ω . The circuit of the power supply for the frequency divider is shown in Fig. 13 and the layout is given in Fig. 14. It will be noticed that the common resistor R_2 has been replaced by a potentiometer and a fixed resistor in series. Although not absolutely necessary it does allow the cut out current to be set accurately. The BD123 power transistor can be expected to exhibit a current gain of at least two even at 30 MHz. To avoid any suspicion of h.f. instability a limiting capacitor should be connected across the base to collector of Tr_4 . It will be found that the voltage control potentiometers R_8 and R_{15} have an extended range which can be used to obtain best overall divider performance.

Design procedure for a power supply giving other voltages

If the power supply is to be used for other than the frequency divider then decide on the output voltage required and calculate the stabilizer input voltage (from trans-

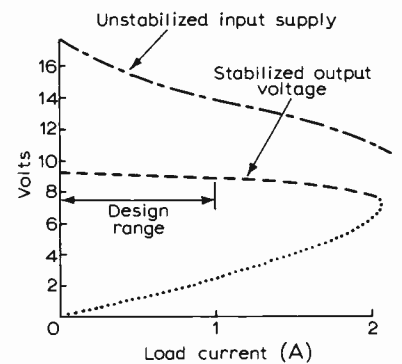


Fig. 12. Input output characteristics of 1 A output version.

former and full-wave rectifier) at no load and full load. Layout as in Fig. 15.

Example one

Full load current $I_1 = 100$ mA; cut-out current = 400 mA.

Let $V_{out} = 9$ V

Then choose $Z \approx 2/3 V_{out} = 6$ V

Assume $Tr_1 \beta = 50$ (BFY50)

and $Tr_2, Tr_3 \beta = 100$ (2N3702)

Full load $I_2 = I_1/Tr_1\beta$
 $= (100 \times 10^{-3})/50 = 2.10 \times 10^{-3}$ A

Maximum Tr_2 base current
 $= I_2/Tr_2\beta$
 $= (2 \times 10^{-3})/100 = 0.02.10 \times 10^{-3}$ A

The minimum zener current for good stabilization is about 1 mA:

Let zener current $I_6 = 2$ mA

$$R_1 = (V_{out} - V_z)/I_6$$

$$= (9 - 6)/2.10 \times 10^{-3} = 1.5 \text{ k}\Omega$$

Decide upon required cut out current:

$$I_{max} = 400 \text{ mA}$$

$$R_2 = Tr_1\beta(V_z - 0.5)/I_{max}$$

$$= 50(6 - 0.5)/0.4 = 690 \Omega$$

$$I_3 = (V_z - 0.5)/R_2$$

$$= (6 - 0.5)/690 = 8.10 \times 10^{-3} \text{ A}$$

$$I_4 = I_3/Tr_3\beta$$

$$= 8.10 \times 10^{-3}/100 = 80.10 \times 10^{-6} \text{ A}$$

If Tr_3 base voltage is to remain substantially constant then I_5 must be at least twenty times I_4 ; let $I_5 = 2$ mA

Total divider

$$RV_1 + R_3 = V_{out}/I_5$$

$$= 9/2.10 \times 10^{-3} = 4.5 \text{ k}\Omega$$

$$RV_1 = 2.5 \text{ k}\Omega \quad R_3 = 2.2 \text{ k}\Omega$$

Under certain conditions this circuit will not switch on. To correct this deficiency R_4 is connected across Tr_1 . The value of R_4 is dependent upon the load at the instant that the supply is switched on. If the value chosen is such that with Tr_1 switched off the load is great enough to keep V_{out} below about 1 V then the power supply will remain in a paralysed state. With V_{out} less than 1 V Tr_2 and Tr_3 will be cut off thereby starving Tr_1 of base current and the only

*Available from A. C. Mansell, 46 Headley Rd, Woodley, Reading, Berks. Price 10s 6d.

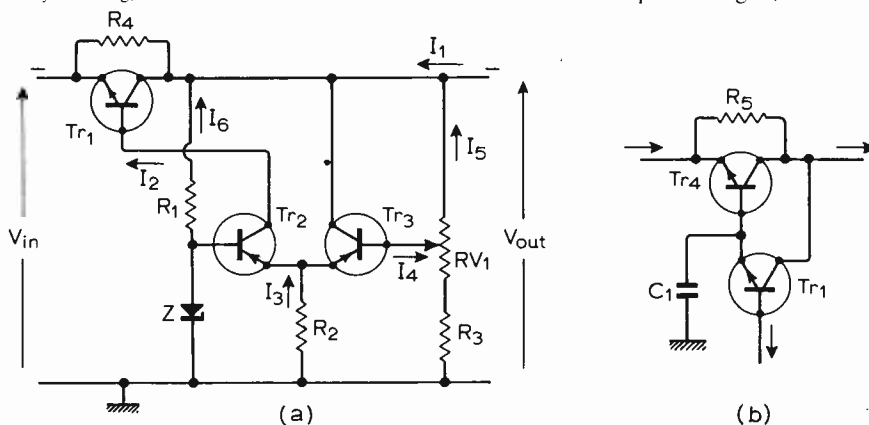


Fig. 10. (a) power supply basic circuit, (b) modification to increase current output.

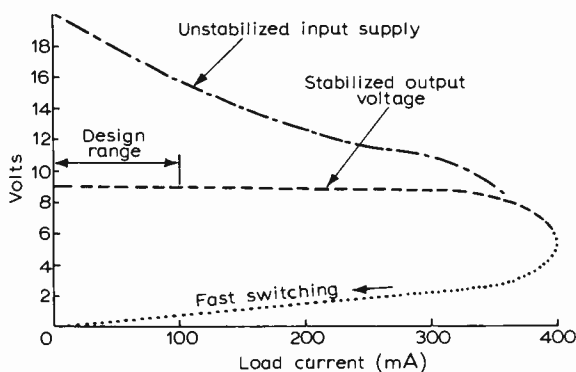


Fig. 11. Input and output characteristics of the power unit. 100 mA, 9 V version.

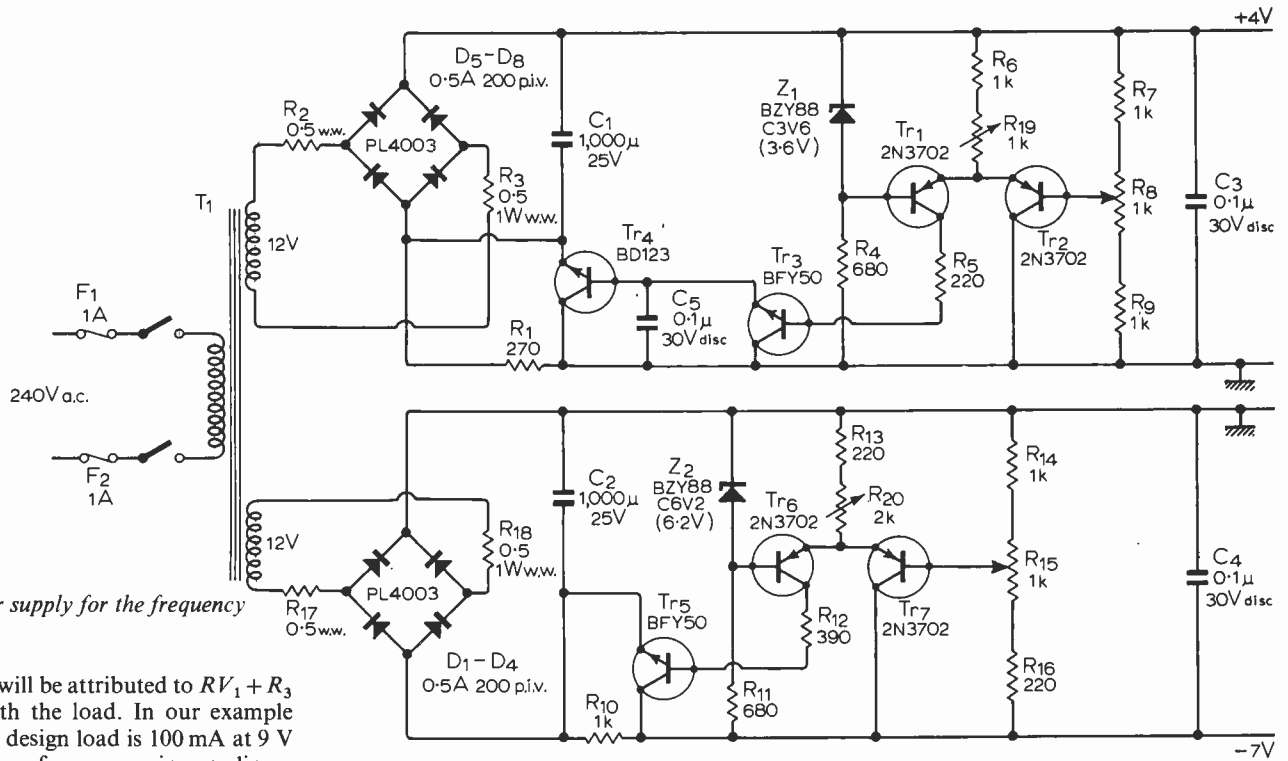


Fig. 13. Power supply for the frequency divider.

current drain will be attributed to $RV_1 + R_3$ in parallel with the load. In our example the maximum design load is 100 mA at 9 V i.e. 90 Ω. Therefore assuming a linear related load at 1 V output:

$$\begin{aligned} \text{Load current} &= 1V(RV_1 + R_3) + (1V \cdot I_1) / V_{out} \\ &= 1/2 \cdot 10^{-3} + (1 \times 0.1) / 9 = 12 \cdot 10^{-3} \text{ A} \end{aligned}$$

Refer to Fig. 11. For a load current of 12 mA the input unstabilized potential is 19 V

$$\begin{aligned} R_4 &= (V_{in} - 1) / \text{Total load current} \\ &= (19 - 1) / 12 \cdot 10^{-3} = 1.5 \text{ k}\Omega \end{aligned}$$

Example two

Full load current $I_1 = 1 \text{ A}$. Cut-out current = 2 A.

Tr_4 transistor type BD123, $\beta = 20$

$$\begin{aligned} R_2 &= [(V_z - 0.5)Tr_1\beta \times Tr_4\beta] / I_{max} \\ &= [(6 - 0.5)50 \times 20] / 2 = 2.75 \text{ k}\Omega \end{aligned}$$

There is no need to alter the component values derived in the first example with the exception of removing R_4 and installing R_5 as shown in Fig. 10(b)

Full load current = 1 A

At $V_{out} = 1 \text{ V}$

$$\begin{aligned} \text{Load current} &= 1V / (RV_1 + R_3) + (1V \cdot I_1) / V_{out} \\ &= 1/2 \cdot 10^{-3} + (1 + 1) / 9 = 0.1115 \text{ A} \end{aligned}$$

Refer to Fig. 12. Unstabilized input voltage is 17 V at a load current of 0.1 A.

$$\begin{aligned} R_5 &= (17 - 1) / \text{Total load current} \\ &= 16 / 0.11 = 150 \Omega \end{aligned}$$

make $R_5 = 129 \Omega$

Note: Tr_4 must be adequately heat sinked.

REFERENCE

Bowman, D. R., "600 MHz intermediate frequency amplifiers", *Electronic Engineering*, August 1970.

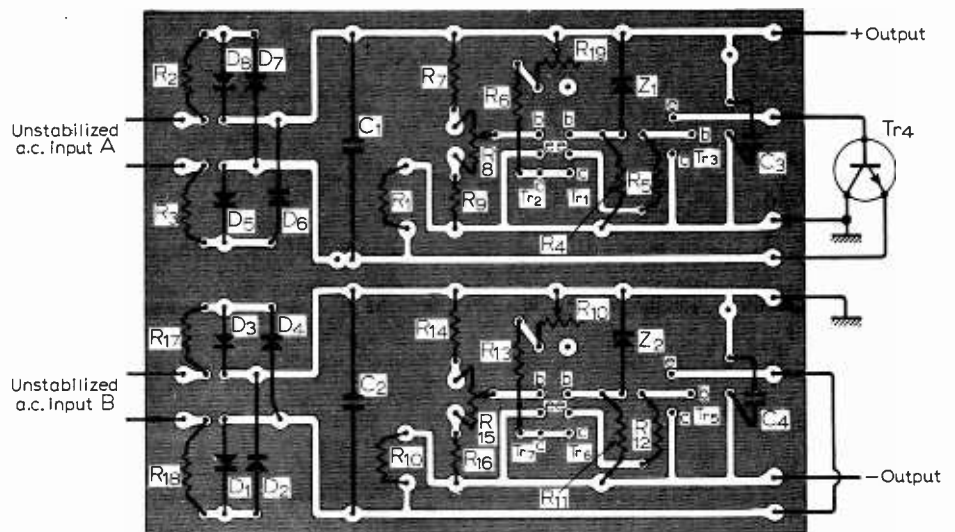


Fig. 14. Layout of power supply on standard board, frequency divider unit version.

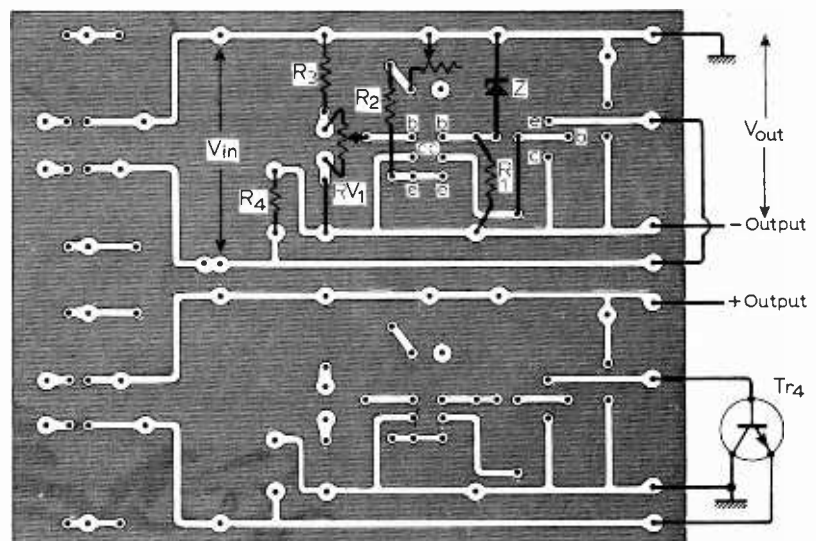


Fig. 15. Layout of power supply for other purposes.

Transient Trinity

Walkabout with Fourier, Laplace and Cauchy

by Thomas Roddam

One of the oddest features of the world of electronics engineers is the reluctance of many of them to do any mathematics. In large companies this does not show up very much, because the jobs are carved up into neat segments and the basic analysis is done by men who never even look at a soldering iron. In small companies it is a very different story, and one hears tales of some very rum goings-on indeed. The great advantage of the theoretical approach is that it is so much easier and quicker. The problem is that more and more of the literature is devoted to the reporting of new and highly sophisticated techniques. Now you need to run as fast as you can and you still will not stay where you are. And if you weren't anywhere in particular to begin with you do not know which way to run.

In this group of articles I have tried to look at some of the basic ideas and to follow where they led me. By asking what a capacitor and an inductor actually do I found why we use sine waves and why the damped sine wave is the real basic signal in our world. This led on to the idea of roots, the set of labels which characterize every circuit. There remains one topic which must be explored. In an article on transient response I took what may be called a fundamentalist approach. Now it seems appropriate to see how the formal treatment of transient behaviour has evolved.

Fourier analysis is the basis for something we do every day. We test circuits with sine waves and we assume that the results are meaningful when applied to practical signals. Practical signals are rarely long-sustained sine waves. The reasoning behind our behaviour is based on the Fourier series and on the principle of superposition. We start off by writing the series

$$\begin{aligned} & \frac{a_0}{2} + (a_1 \cos x + b_1 \sin x) \\ & + (a_2 \cos 2x + b_2 \sin 2x) + \dots \\ & (a_n \cos nx + b_n \sin nx) + \dots \end{aligned}$$

It is assumed that the series converges uniformly when $0 \leq x \leq 2\pi$. This amounts to saying that there are certain ground rules which must be obeyed, or the pure mathematicians will get you. What happens in a Cup Final, apart from a riot, if the ball bounces off a low-flying helicopter into the net? I haven't thought too much about this, but I do not think one can *construct*, with

real components, a non-convergent series signal. Strays will always save you. However, that's the rule, and if the function obeys it, it will converge uniformly for all values of x . It will also satisfy the equation:

$$f(x) = f(x + 2\pi).$$

From this it follows that

$$\begin{aligned} f(x + 2\pi) &= f(x + 4\pi) \\ f(x + 4\pi) &= f(x + 6\pi) \end{aligned}$$

and so on. It is, in fact, a periodic function with a period of 2π . When we write $x = \omega t$, it is periodic in ωt , and the period is $t = 2\pi/\omega$, or $1/f$.

In plain English, always dangerous in dealing with mathematical situations, a wave form which is periodic can be represented by a set of sine and cosine waves. The superposition principle says that if we have a linear system we can treat each of these separately and then add them up at the end. In a decent sound reproducing system you can take the signals from a number of instruments, apply them all to the input together, and you should still be able to tell the difference between a flute and a fiddle at the end. If the system is not linear each signal affects the progress of the others.

The mathematician shows us how to find the coefficients. We can write down $f(x) = a_0/2 + (a_1 \cos x + b_1 \sin x)$ etc., and multiply both sides by, say, $\cos nx$. This gives a rather long expression, containing terms of the forms

$$\cos nx \sin mx, \cos nx \cos mx.$$

Now either $m = n$ or $m \neq n$. If $m \neq n$ we can show that

$$\int_0^{2\pi} \cos nx \sin mx \, dx = 0$$

$$\text{If } m = n, \int_0^{2\pi} \cos^2 nx \, dx = 1/\pi.$$

Applying this to the series we get, rather simply

$$\int_0^{2\pi} f(x) \cos nx \, dx = \pi a_n$$

and a similar term with $\sin nx$ if we multiply through by $\sin nx$:

$$\int_0^{2\pi} f(x) \sin nx \, dx = \pi b_n.$$

Very often we can carry out the calcula-

tions using just a slide rule. One simple example is if we want to know how much third harmonic there is in a square wave. The function $f(x)$ is 1 for $0 - \pi$ and -1 for $\pi - 2\pi$. The integral for the third harmonic is seen at once to be one-third of that for the fundamental.

What we said above was that we start with a series, and go on to call it $f(x)$. When we start with $f(x)$ we can write down a Fourier series. The rule is that $f(x)$ and df/dx must be, as they say, piecewise continuous. This does not mean it cannot have any jumps in either $f(x)$ or df/dx . It really means it must not be all jumps. Anyone who has seen the news reports coming in by teleprinter knows the difference between the odd letter that went wrong and the whole paragraph of total confusion. At any jump it is assumed that as $f(x)$ jumps from f_1 to f_2 it touches down to make

$$f(x_0) = (f_1 + f_2)/2.$$

The elegant form of Fourier is obtained by writing

$$\cos nx + j \sin nx = \exp(jnx).$$

Then

$$f(x) = \sum_{n=-\infty}^{\infty} C_n \exp(jnx)$$

$$\text{with } C_n = \frac{1}{2\pi} \int_0^{2\pi} f(x) \exp(-jnx) \, dx$$

Here n goes from $-\infty$ through 0 to $+\infty$.

Suppose we have a non-periodic waveform of the kind shown by the heavy line in Fig. 1. We are, however, only interested in what happens during a limited time, evenly spaced round the mid-morning coffee-break at $t = 0$. We begin to observe the function at $t = -\pi/\Omega$, and stop at $t = \pi/\Omega$. With a bland smile we say it could just be repeating the bit we have observed, for all we care. It could, in fact, be the wave-form $\delta(t)$. I am not going to write down the mathematics, which contains double integrals and is the sort of thing which discourages the reader. The thing is that by manipulating the solution one can arrive at a pair of equations:

$$f(t) = \int_{-\infty}^{\infty} F(j\omega) \exp(j\omega t) \, d\omega$$

$$F(j\omega) = \frac{1}{2\pi} \int_{-\infty}^{\infty} f(t) \exp(-j\omega t) \, dt$$

This nicely balanced pair is called a pair of Fourier transforms, and it relates the whole time history of the waveform to an infinite range of frequency, both negative and positive frequencies, of course. We can get rid of the negative frequencies, which appear in order to fill in the phase angles, by writing

$$f_1(t) = \frac{1}{2}[f(t)+f(-t)]$$

$$f_2(t) = \frac{1}{2}[f(t)-f(-t)]$$

and then

$$F(j\omega) = \frac{1}{2\pi} \int_0^\infty f_1(t) \cos \omega t dt$$

$$- \frac{j}{2\pi} \int_0^\infty f_2(t) \sin \omega t dt.$$

There is a mate in which we find f_1 and f_2 with an integration of ω from 0 to ∞ .

This continuous pattern is the Fourier Integral. To use it we assume that for the system with which we are concerned we know the frequency response in the form of the ratio of detected current to applied voltage for sinusoidal inputs at all frequencies: the frequency response, in fact. We write

$$I(j\omega) = Y(j\omega) E(j\omega)$$

Now we take some applied signal $f(t)$. We can find $E(j\omega)$ by means of the equation

$$E(j\omega) = \frac{1}{2\pi} \int_{-\infty}^\infty f(t) \exp(-j\omega t) dt.$$

Multiply by $Y(j\omega)$ to get the solution $I(j\omega)$. Now write

$$I(t) = \int_{-\infty}^\infty I(j\omega) \exp(j\omega t) dt$$

and we know the time response to the input, expressed also as a time function.

It's a lot of work, it does not take account of initial conditions, and for a unit step there are convergence troubles. Heaviside did not worry about convergence, and although he usually got the right answer his contemporary mathematicians were so indignant about his informality that they refused to consider just why this was so. On the other hand he was not too fussy about the order in which he differentiated and integrated, which landed him in trouble with his initial conditions.

When we introduced the idea of complex frequency it became clear that the pure sine wave is really an oddity. Over the whole complex frequency plane there is just that one line on which there is neither damping nor growth. In a passive system there must be some loss: the frequencies must die away. Mathematical solutions are always easier if we can keep away from special situations:

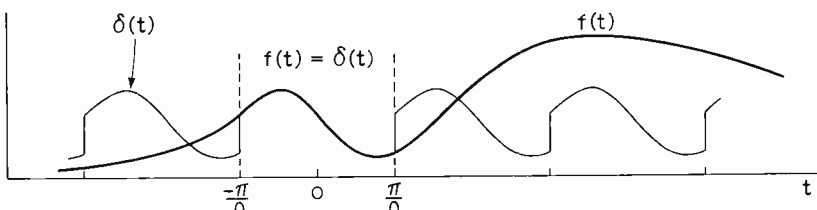


Fig. 1. Non-periodic waveform (heavy line) of which part under observation, $-\pi/\Omega$ to π/Ω , could belong to a periodic waveform.

reserve these for dealings on the Stock Exchange. The more elegant approach is the more realistic. First of all, we are in charge. Until we decide to switch on at $t = 0$, the excitation $e(t) = 0$. Secondly we write

$$s = \alpha + j\omega$$

We determine a function

$$E(s) = \int_0^\infty e(t) \exp(-st) dt.$$

This is almost the same as we had before, but now we have put $\alpha + j\omega$ where he had $j\omega$, and we drop the integration from $-\infty$ to 0 because $e(t)$ is zero before $t = 0$. Also the $1/2\pi$ is omitted. This is written as

$$E(s) = \mathcal{L}[e(t)]$$

and is called the Laplace transform of $e(t)$. The use of the complex frequency makes it possible to control the convergence of the integral. Obviously one can work the other way round, and in quite a few reference books you will find tables of Laplace transforms. I have picked out a few only:

$f(t)$	$\mathcal{L}[f(t)]$
$e^{-\alpha t}$	$\frac{1}{s+\alpha}$
$t e^{-\alpha t}$	$\frac{1}{(s+\alpha)^2}$
$\frac{1}{a-b} (e^{-bt} - e^{-at})$	$\frac{1}{(s+a)(s+b)}$
$\frac{1}{b} e^{-\alpha t} \sin bt$	$\frac{1}{(s+\alpha)^2 + b^2}$
$\sin \omega t$	$\frac{\omega}{s^2 + \omega^2}$
$\cos \omega t$	$\frac{s}{s^2 + \omega^2}$
Unit step ($e^{-\alpha t}$ as $\alpha \rightarrow 0$)	$\frac{1}{s}$

Without going into too much detail, suppose that we apply a signal $e(t)$ to an LCR circuit. We can write, and initial charge is neglected,

$$E(s) = I(s) \left(sL + R + \frac{1}{sC} \right)$$

and $E(s) = \mathcal{L}[e(t)]$

If $e(t)$ is, say, 1 volt of d.c. switched in at $t = 0$

$$E(s) = 1/s \quad \text{and so}$$

$$I(s) = \frac{1}{s} \frac{s}{s^2 + (R/L)s + 1/LC} \cdot \frac{1}{LC}$$

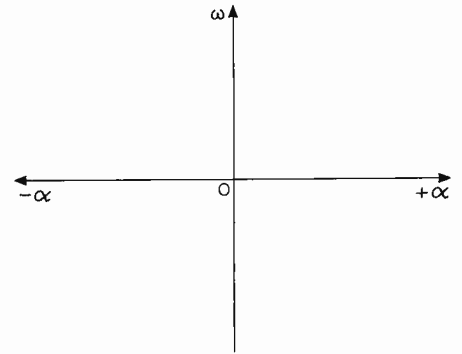


Fig. 2. Only on the ω axis is there a pure sinusoid.

$$= \frac{1}{LC} \cdot \frac{1}{s^2 + (R/L)s + 1/LC}$$

If we extract the roots of

$$s^2 + (R/L)s + 1/LC = 0$$

we find that we have either

$$\frac{1}{(s+a)(s+b)} \quad \text{or} \quad \frac{1}{(s+a)^2 + b^2}$$

Now we transform back to get

$$i(t) = \text{either } \kappa(\exp(-bt) - \exp(-at))$$

$$\text{or } \kappa \exp(-at) \sin bt$$

Not much gained over a formal full analysis, you may think. But if there are a lot of roots it becomes rather easier this way. You find the roots and then break the whole thing up into separate functions which are transformable. This is simpler in practice because it is a routine and can be performed without thinking about decisions. There are many situations in which the advantages show up even more strongly. If you are studying the transient behaviour of filters you will have designed your filter in terms of its roots: you know the roots, not the frequency response, function-wise, that is. Of course your tables relate one to the other. But you are half-way towards this approach as soon as you decide between Tchebycheff and Butterworth. Active systems which are being handled by the root locus method are also easily studied to see how transient response changes as the roots are moved about.

Another important feature of the Laplace transform must be considered. We have seen that it enables us to dodge backwards and forwards between responses on the time axis and responses in the complex frequency plane. The mathematics is quite rigorous and has nothing to do with what we call the symbols. The reason for using rigorous mathematics is simply that it is easier, as you do not need to check up. Non-rigorous mathematics is like working out $2 \times 2 = 3.99$ on the slide-rule: you need to keep thinking. We can give the symbols different names, provided the basic equations are suitable. One such pair of names can be found in the design of aerial systems. I am not going into any detail, but a uniformly illuminated slot transforms, just as an ideal low-pass filter does, into a $(\sin x/x)$ response. Instead of the ringing of the time response we have the side-lobes of the space response. Just

as we can shape the frequency response to reduce ring, so we shape the illumination to reduce side-lobes. The advantages are tremendous. Measurements on a practical aerial must be carried out in the open on a wet and windy day. This is an observed fact, lacking theoretical justification. Mathematics is an indoor sport. It is also a set of general-purpose tools.

The search for flexibility goes one stage further. At first it looks as though it took one step back. The Laplace transformation equation can be written as

$$F(s) = \int_0^{\infty} f(t) \exp(-st) dt$$

and the rule is that $f(t) = 0$ if $t < 0$. It will not matter, therefore, if we change the integration limits and take

$$F(s) = \int_{-\infty}^{\infty} f(t) \exp(-st) dt$$

Next we fix α at α_1 into expression $s = \alpha + j\omega$, and we call this version of F

$$F'(s) = \int_{-\infty}^{\infty} [f(t) \exp(-\alpha_1 t)] \exp(-j\omega t) dt$$

Compare this with the Fourier form

$$F(j\omega) = \frac{1}{2\pi} \int_{-\infty}^{\infty} f(t) \exp(-j\omega t) dt$$

The $1/2\pi$ factor is simply the result of the pure mathematician's taking over. The inverse equation gives us

$$f(t) \exp(-\alpha_1 t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F'(j\omega) \exp(j\omega t) d\omega$$

We are allowed to move the $\exp(-\alpha_1 t)$ term, because we are integrating with $d\omega$, and so

$$f(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F'(j\omega) \exp(\alpha_1 + j\omega)t d\omega$$

Finally we change variables, putting back $s = \alpha_1 + j\omega$, and thus

$$ds = j d\omega \quad d\omega = (1/j) ds$$

We emerge with

$$f(t) = \frac{1}{2\pi j} \int_{\alpha_1 - j\infty}^{\alpha_1 + j\infty} F(s) \exp(st) ds$$

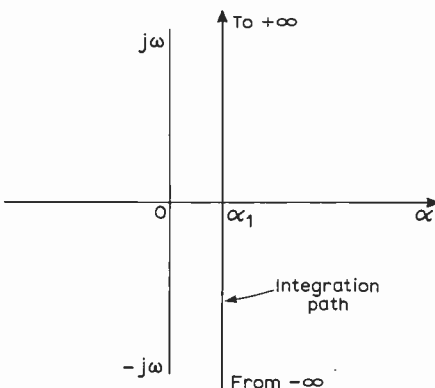


Fig. 3. The integration path for

$$f(t) = \frac{1}{2\pi j} \int_{\alpha_1 - j\infty}^{\alpha_1 + j\infty} F(s) \exp(st) ds$$

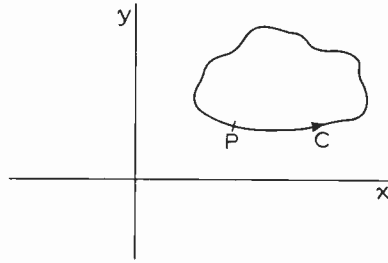


Fig. 4. At every point $f(z) = f(x + jy)$ is analytic and single-valued. Then $\oint f(z) dz = 0$ as you go round from P back to P.

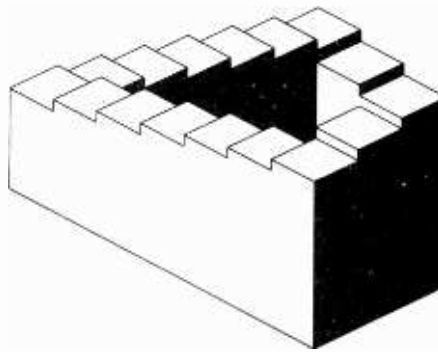


Fig. 5. Three-dimensional view of a function which, even if you smooth out the steps, is not analytic.

A good many readers will have regarded all this as a pretty complicated ritual. The object of going through the formality is to have this last expression to talk about, and to help to identify the fuller treatment you can find in the textbooks. In the expression above we integrate along the line shown in Fig. 3. For each value of s we work out $F(s) \exp(st)$, multiply by ds and sum. We choose α_1 to have a value which makes this a meaningful procedure. But are we any better off.

At this point we introduce one of those odd bits of mathematics which crop up all over. This is Cauchy's Theorem. This says that if you integrate round a contour, and if, in formal language, the function is analytic and single-valued everywhere inside and on the contour,

$$\oint_C f(z) dz = 0$$

Another bare diagram, Fig. 4. If you walk to work and back by a different route, without falling through an open man-hole, you finish up at the same height above sea-level. If you cycle it does not feel like this, and if you find a function like Fig. 5 you know it can't be analytic, even if steps are replaced by a ramp.

Cauchy's theorem, simple as it looks, is tremendously important in the theory of the complex variable—in our case the theory of complex frequencies. In consequence it must be proved with the utmost vigour and the proof is not too easy. We shall not bother with it here. What we want is this result that if you walk round a perimeter and there is nothing odd going on inside it you get back to where you started.

We were integrating along the line $s = \alpha_1$. If we close the ends by a semi-circle joining ω_1 to $-\omega_1$ and integrate round the

whole loop, Cauchy's theorem tells us that if there are no poles inside the area the integral will be zero. We choose α_1 to make sure that this is true. This integration round the right-hand semi-circle is used for the response when $t \leq 0$. When the radius of the semi-circle is allowed to approach infinity, the integral along the semi-circle is also zero. This last statement is also true for integration along the semi-circle to the left, which we shall follow for $t \geq 0$. Now, however, the integral round the contour is no longer zero. Inside the contour there are poles, as we see in Fig. 7. Again the integral is zero round the semi-circle, when it is big enough, but the integral we really want is still left.

First of all, what can we do to make use of the properties of the contour integral? In Fig. 8 we see a pole, P , and a bigish circular contour round it. At AB we snip the contour and go off from B down to C , round the small circle to D , and then back to A . The pole is no longer inside this new contour and so the integral round it must be zero. BC and DA are very close together, and the integrals along these bits cancel out. The integral round the full big circle must therefore equal the integral round the small circle. We can do this with each pole, and we finish up by having small circles round the poles and zero for the rest of the contour integral.

We need to know a specific contour integral,

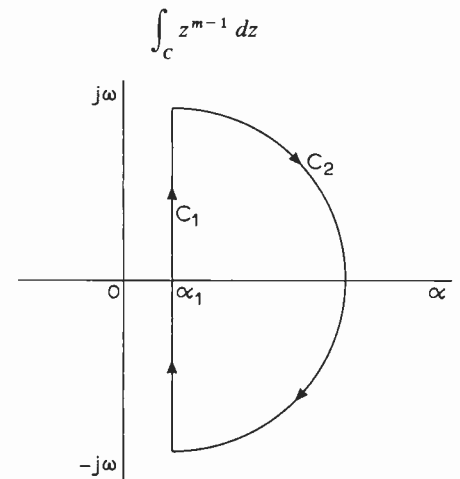


Fig. 6. Closing the path C_1 with a semi-circle C_2 .

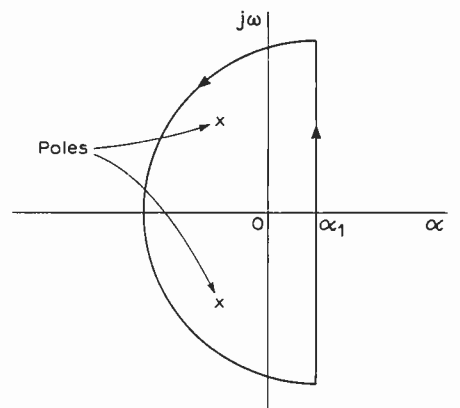


Fig. 7. Inside this contour are poles. Here be singularities.

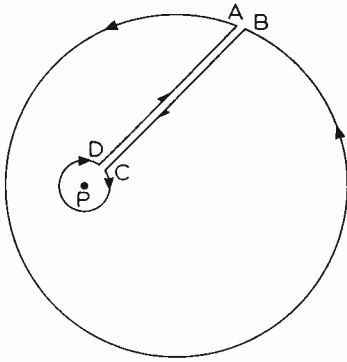


Fig. 8. Isolating a pole.

For $m \neq 0$ this is zero, but if $m = 0$,

$$\int_C \frac{dz}{z} = 2\pi j$$

and equally $\int_C \frac{dz}{z-a} = 2\pi j$

We have embarked on what is called the calculus of residues. Suppose that we have a double pole at $s = -a$. This means that $F(s)$ contains a term $A/(s+a)^2$. The function we are integrating is then $\exp(st)/(s+a)^2$, and we turn this into a series for values of $s \approx a$:

$$\frac{\exp(st)}{(s+a)^2} = \frac{a_{-2}(t)}{(s+a)^2} + \frac{a_{-1}(t)}{s+a} + a_0(t) + \text{terms in } (s+a)^n$$

The residue of the function at $s = -a$ is $a_{-1}(t)$. This means that

$$\int_C A \exp(st)/(s+a)^2 \cdot ds = a_{-1}(t) \times 2\pi j.$$

To make life easier, we have an expression for the residue:

$$a_{-1}(t) = \frac{1}{n-1} \cdot \frac{d^{n-1}}{ds^{n-1}} \cdot \exp(st)$$

with $s = -a$.

For $n = 2$ $a_{-1}(t) = t \exp(-at)$.

$$f(t) = At \exp(-at)$$

The prospect of being hanged in a fortnight concentrates a man's mind wonderfully. This article is not a "how to fix your own operational calculus", but a "what's it all about". We begin with a network, a system, and we want to know how it behaves with real signals. The sine wave is a nice simple signal and so we try to build up our real signal with pure sine waves. On paper it is quite satisfactory. We call it Fourier analysis, and go gaily ahead until some awkward details appear. All the mathematics is based in eternity. We switched on yesterday and may not switch off tomorrow. If we get an infinite circuit, a pole on the $j\omega$ axis, we can't be too sure what to do.

The mathematics is manipulated to make it more clearly defined, and to allow us to start up today, at $t = 0$. The frequencies we use are still on a line, but we can move it sideways to dodge trouble. We hardly know we have done this, because we can choose any line to the right of a critical one, and our choice disappears anyway in the table of Laplace transforms.

To widen our scope we consider what happens with every possible complex frequency, varying both α and ω . Cauchy's theorem leads us on to the conclusion that now we need only look at the poles themselves. The broadest possible input signal concentrates attention on the minimum number of points. All we need is a table of residues:

	$\exp st/s$	$\exp st/s^2$	$\exp st/(s+a)$	$\exp st/(s+a)^2$
Residue	1	t	$\exp(-at)$	$t \exp(-at)$

and we can work out the transient response. The hard work comes in getting to grips with the procedure, once and for all. It is true to say that solving problems this way is cheaper by the dozen.

Cauchy's theorem can be extended to deal with contours which go round a given point several times, and which include poles and zeros. This is the theoretical basis for

Nyquist's criterion in feedback amplifier theory, especially when dealing with conditional stability. This leads on to the rules for dealing with negative resistance circuits. Like sodium glutamate, Cauchy's theorem seems to be in everything nowadays.

Some engineers seem to consider mathematics as too detached from real work. It is quite profitable, even for the so-called

practical man, to get some idea of these theoretical techniques. Even if you are going to look at the responses on an oscilloscope, a knowledge of the underlying theory will save an awful lot of wasted effort by suggesting which way to vary components to get the cut-and-try answer. Who knows, in the end you may realize that it's easier to do the job properly from the beginning.

Announcements

The Electrical Research Association's Circuit Design Department has initiated a return-of-post information service on techniques and components. A consultancy service is also available to clients who wish to discuss specific design and application problems. All enquiries should be addressed to Colin Ray, Design Information Engineer, E.R.A., Cleeve Road, Leatherhead, Surrey.

Centralab Ltd, of Co. Antrim, Northern Ireland, jointly owned by Joseph Lucas (Industries) Ltd and Globe Union Inc. of Milwaukee, U.S.A., has acquired the whole of the issued capital of **Stability Radio Components Ltd** and its subsidiary Stability Capacitors, of Basildon, Essex, at a price of approximately £727,000.

Pye have relinquished the **Ferranti trade mark** for radio and television products, and the right to use the name has been returned to Ferranti Ltd, of Manchester.

Tele-Nova Ltd, a company in the Shipton Automation Group, have signed a further agreement with Hasler Ltd, in Berne, Switzerland, for the sale in the U.K. and Eire of **Hasler** radio staff location systems.

The Telephone Manufacturing Co. Ltd has been appointed sole marketing agent in the U.K. for the range of switch and light units manufactured by the **Dialight Corporation**, of America.

An agreement has been signed between **Cossor Electronics Ltd**, of Harlow, Essex, and the **Raytheon Service Company**, of Massachusetts, to market the full range of **Cossor oscilloscopes** in the United States.

Guest International Ltd announce that Best and Raynor have ceased to act as their distributors. Full stocks are still being held by the company's other distributors: **GDS (Sales) Ltd.**, G.S.P.K. Ltd., and E.C.S. (Windsor) Ltd.

Daystrom Ltd, of Gloucester, manufacturers of the **Heathkit** range of products, have changed the name of the company to **Heath (Gloucester) Ltd**.

The former range of **Dansette** and **Perdio** record reproducers, radiograms and audio equipment is now being manufactured and marketed under the trade name of "Tonesta". **Electro-Impex**, of 4 Carlisle Avenue, London E.C.3, have been appointed by **Tonesta Ltd** as the sole selling agents for the U.K. and all overseas markets.

The **Electrotech Instrument Division** of **Coutant Electronics Ltd** has been acquired by **Instant Starter Engineering Co. Ltd**. The division has been formed into a new limited company, **Exel Electronics Ltd**, and becomes a wholly owned subsidiary of I.S.E.

EMI is to acquire all the shares of **Recording Designs Ltd**, of Camberley, Surrey, who specialize in magnetic tape data storage equipment for military and commercial use.

Sprague factory in Scotland: **Sprague Electric Company**, of Massachusetts, U.S.A., is to build a factory in Galashiels, initially to produce aluminium electrolytic capacitors. The company hopes to have the factory ready for occupancy by the autumn.

Tektronix UK Ltd has opened regional offices and a repair and recalibration centre at **Beaverton House**, 181A Mauldeth Road, Manchester 19. (Tel: 061-224 0446.)

The U.K. sales office of **EMI-Varian Ltd** has moved from **Walton-on-Thames** to the head office and factory site at **Blyth Road**, Hayes, Middx. (Tel: 01-573 5555.)

Mullard Ltd are to build a second factory for the production of television picture tubes at **Belmont**, near Durham.

Time Delays

2. Delay tubes, storage devices, quartz thread, ceramic piezoelectric delay lines. . . .

by H. D. Harwood, B.Sc.

Last month's article on ways of producing time delays was devoted to all-pass electric circuits and ultrasonic methods. This month we start by looking at delay tubes.

Acoustic delay tubes

This is the oldest form of time delay but it still finds occasional use because of the large values possible. The velocity of sound in a tube is similar to that in free air, namely 340 metres per second at 20°C. In narrow tubes a certain amount of dispersion takes place but attenuation at high frequencies usually limits the use of such a tube before dispersion becomes serious. The amplitude at a distance x is given by:

$$A = A_0 e^{-\alpha x}$$

where A_0 is the amplitude at the beginning of the tube,

$$\alpha = \frac{\gamma'}{Rc} \frac{\omega}{2P}$$

R is the radius of the tube in cm,
 c is the velocity of sound in cm/s,
 $\omega = 2\pi f$,
 f = frequency in hertz
 P = density in gm/cm³
 $\gamma' = 1 + 1.58(\gamma^{\frac{1}{2}} - \gamma^{-\frac{1}{2}})$,
 and γ = the ratio of specific heats.

The maximum level is dictated by non-linearity effect in the air in the tube; distortion in a uniform tube is proportional to the length. The maximum length is determined by attenuation at high frequencies which leads to poor signal-to-noise ratio in the receiving microphone. As can be seen from the formula given above, attenuation is inversely proportional to the tube diameter but this cannot be increased beyond the point at which radial modes of resonance occur in the pipe with a consequent change in the characteristic impedance and production of serious echoes. The maximum diameter can be used is thus found in practice to be about 25 mm.

The termination of the tube is formed by means of graduated lengths of wool forming, in effect, a tapered absorber. Reflections are mainly troublesome in the middle frequency band as absorption at the bass is very good and air attenuation at high frequencies rapidly reduces any reflected wave. It is possible to improve the signal/

noise ratio at high frequencies by inserting the receiving microphone in the end of the tube and constructing the termination at right angles to it. At low and medium frequencies the sound turns the corner and is absorbed by the termination, whilst at high frequencies the inductance of the bend is too great and the sound is reflected from the microphone giving a rise in pressure of 6 dB. The reflected sound is heavily attenuated by the tube and does not cause any trouble from echoes.

In practice, the tube is usually coiled into a helix to conserve space. Delays of up to 100 ms are feasible over the audio band.

Applications are for artificial reverberation¹⁸ and for delaying the onset of added reverberation to give the impression of a larger echo room.

Storage devices

Storage devices differ from the preceding delay lines in that no inherent velocity of propagation is involved, the storage being a static effect. Various storage media have been proposed including homogeneous surfaces such as phosphors, magnetic tape, and electrostatic storage surfaces. However, the amount of energy associated with information stored by such means tends to be low with a result that the signal to noise ratio of the delayed signal is marginal by the best broadcasting standards. They share the advantage however that quite long delay times may be achieved, adequate for television field storage purposes. Discrete storage elements such as capacitors or inductors are able to store much larger quantities of energy and hence provide a better signal-to-noise ratio, but require individual switching and hence rather involved circuitry to handle the very large number of programme samples which would have to be stored for the delay period in any programme application. Furthermore, owing to the large number of picture elements it is not practicable to store a picture field and only a line store is convenient at present. A store of each type will now be described.

Storage on cathode ray tube phosphors: The storage of information on the phosphor of a cathode-ray tube dates back to the first computer stores. The total amount of information which could be stored by this

means, however, was small and the method is no longer used for this purpose.

It is however still useful for converting television pictures from one field rate to another. In this type of standards converter¹⁹ the usual procedure is to display the picture on tube and photograph it using a television camera. Ideally in order to avoid a variation of picture brightness due to the difference in the number of fields per second the display tube should maintain constant brightness until one frame has been photographed and is replaced by the next. Unfortunately tubes of this type are unable to satisfy other requirements of standards conversion and phosphors with a finite decay time must be employed. A phosphor having an afterglow of about 9 ms gives the best compromise between the blurring of moving objects and gain due to the decay of picture brightness.

Magnetic recording devices: When a signal is recorded on a magnetic tape the record is permanent and can therefore be reproduced afterwards without any change of signal-to-noise ratio, reduction in bandwidth or echo due to the magnitude of the delay: long delays can therefore be obtained without any difficulty. The shortest absolute delays on a single track are determined by the minimum spacing between the recording and reproducing heads and by the tape speed. Shorter (relative) delays can be obtained by using two tracks and arranging the head spacing so that the difference between them corresponds to the desired delay. For very short delays however tape is not a very suitable medium as it is not sufficiently homogeneous; variations in thickness and elasticity causing variations in tape stretch and hence delay. The effects of wow and flutter also become important. For example, with a delay of 200 μ s at a tape speed of 38.1 cm/s (15 in/s) the difference between the spacing of the reproduce heads, for an in-line record head, would be 0.075 mm (0.003 in) and this would have to be maintained to a high degree of precision. This is very difficult and for accurate short delays it is necessary to use a drum with magnetic coating instead of a tape. In this case the heads are used out of contact with the recording medium, and a frequency modulation system is employed to overcome the consequent loss in signal-to-noise ratio and the effects of wow and flutter.

In autocorrelation it is necessary to be able to vary a time delay continuously over a wide range and magnetic recording lends itself admirably to this purpose. As used in B.B.C. Research Department²⁰, for example, in measuring the sound insulation between two rooms, a smooth variation in delay between 100 ms and 250 μ s is required and this is obtained with a two track tape system.

Further applications are in ambio-phony²¹ for delaying added reverberation to give the impression of a larger echo room and in an artificial reverberation machine¹⁸.

Line store using capacitors: In the capacitor line store the storage takes place in a group of capacitors which is approximately equal in number to that of the picture elements capable of existing in a line of the television picture. A different capacitor is connected to the incoming video signal during each picture element by a system of electronic switches and each capacitor is thus charged to a potential proportional to the amplitude of the input signal at the time of its connection. At the end of one line period all the capacitors have thus been charged and this information may be subsequently read out at any required time.

When used in a line store converter, the number of storage elements is theoretically twice the number of line harmonics which lie within the video bandwidth as phase and magnitude must each be taken into account.

After allowing for the fact that the position of the line occupied by blanking needs no storage, for practical filter design, the number used is 576. A similar number of input and output switches are therefore required.

The requirements for the switches are quite stringent, timing errors and those due to a potential difference between switches can both cause visible defects in the picture and should be below 5 ns for the former and -49 dB in the latter case. In addition, cross-talk due to resistance coupling must be held below -45 dB and that due to capacitive coupling below -16 dB.

The time constant of capacitor plus switch should exceed 10 ms if leakage is not to be a serious factor at 3 MHz. It is evident from these considerations that the design of appropriate switching is a major problem.

The size of a capacitor store of this type is about that of an enclosed bay and with the associated switching the cost is necessarily high and is about £10,000.

The main use for a store of this kind is in standard converters from 625 to 405-line and vice versa. A suggestion has also been made²² that it could be used to synchronize two pictures when the timing error is less than one line and also to remove timing errors from the output of a video tape recorder.

Although reflections are not present in this type of delay, other sources of defects have been indicated. In practice these are

made so small as to be invisible in converting a 625-line picture to 405-line but are just visible when conversion the other way round is effected.

Other possible developments

Quartz thread: This is an extension of the wire delay line already discussed. One of the limiting factors of wire delay lines is that, as the attenuation is proportional to f^4 , the high frequency range is limited. It has been suggested by R. E. Davies and G. D. Monteath and others that the wire should be replaced by a quartz thread. With this material the losses are proportional to f^2 as there are no crystal boundaries to reflect the torsional waves. A line would have to be only about 0.5 mm in diameter to pass 10 MHz without the appearance of high order modes of transmission and it would be difficult to use piezoelectric transducers or normal magnetostriction drives. There is the possibility of using a short length of nickel wire as a Wideman form of transducer or of using coils of the Scarratt and Naylor type. If difficulty is found in making the coils as short as indicated by the formula given last month, i.e. up to half a wavelength long, it should be possible to use them in the range one wavelength to one and a half wavelengths. It appears that delays of up to 20 ms over a bandwidth of 10 MHz could be produced by this method.

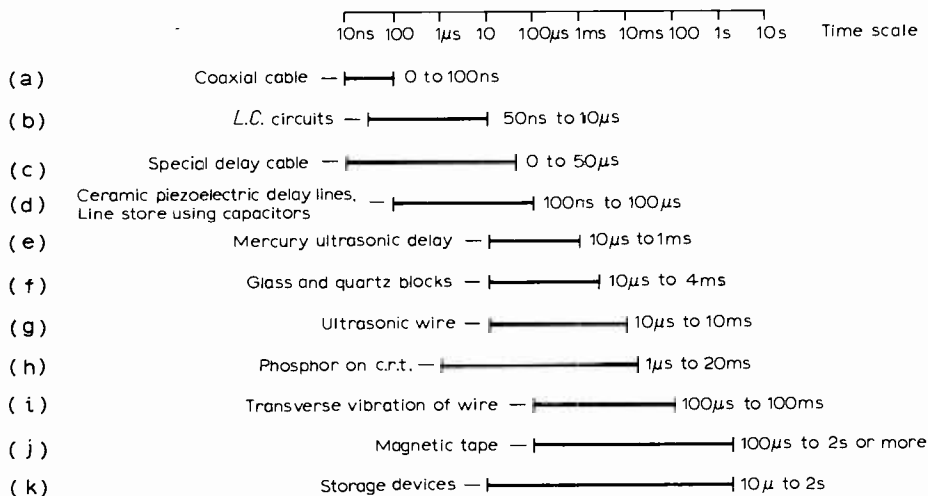
Transverse mode in wires: The velocity of a transverse mode along a thin flexible wire or string is proportional to $\sqrt{T/m}$ where T is the tension and m the mass for unit length. It will be seen that the velocity is independent of frequency, and this mode of propagation is therefore suitable for a delay line. These is also the advantage that the delay can be easily adjusted by changing the tension.

One of the simplest methods of driving the wire is to place it between the poles of a magnet and to pass a current along the wire. Other methods include moving coil, moving iron and piezoelectric transducers. The wire must be terminated in a mechanically resistive medium at the far end and means for applying a tension provided. Electrostatic transducers can be employed for extracting the signal at any position along the line and delays of up to 100 ms should be feasible for a line 1.5 m long.

Some protection would be required against building vibrations but this should not prove unduly difficult.

Low velocity materials: There are a few materials in which the velocity of sound is lower than it is in air and it is of interest to see whether these differences are great enough to be worthwhile exploiting in delay tubes.

Liquid helium III: This liquid has the lowest velocity of any liquid known, the value being less than one tenth of that of water. At the triple point the velocity is about 130 ms and therefore the length of a delay tube could be reduced to about a third of one using air as the conducting medium. The diameter would have to be reduced in



Summary of time delays and performance. (a) Coaxial cable—0 to 100 ns—cheap, low echo level, bulky for longer delays. (b) LC circuits—50 ns to 10 μ s—medium price, low echo level, compact, can easily be made to exact delay, variable length available. (c) Special delay cable—0 to 50 μ s—cheap, echoes can be troublesome, matching amplifiers needed. (d) Ceramic piezoelectric delay lines—100 ns to 100 μ s—cheap fixed delays. (e) Line store using capacitors—100 ns to 100 μ s—very expensive, delay fixed. (f) Mercury ultrasonic delay—10 μ s to 1 ms—expensive but easy method of obtaining variable delay over wide bandwidth, associated equipment needed, echoes fairly low. (g) Glass and quartz blocks—10 μ s to 4 ms—expensive but only means of obtaining long delays over wide bandwidth. Associated equipment needed, echoes low, generally fixed delay. (h) Ultrasonic wire—10 μ s to 10 ms—medium price, medium bandwidth, high echo level, adjustable. Greater delays and bandwidths may be possible using quartz thread. (i) Phosphor on c.r.t.—1 μ s to 20 ms—expensive as associated equipment required, no definite cut-off so blurring of moving images occurs. (j) Transverse vibration of wire—100 μ s to 100 ms—cheap but would require development. Adjustable. (k) Magnetic tape—100 μ s to 2 s or more—medium price for a f., expensive for TV. Adjustable delay. (l) Storage devices—10 μ s to 2 s—theoretically infinite delay, expensive, no echoes; extensive associated equipment needed.

the same ratio to avoid cross modes and would thus be about 0.3 in. A tube of this length and diameter could be coiled into quite a small volume but the necessary cryogenic apparatus would be very expensive.

Uranium hexafluoride: This is a substance which is produced in large quantities by the U.K.A.E.A. in the course of their activities and appears to have the largest atomic weight of any gas. The liquid boils at room temperature and the vapour is stable except that hydrogen fluoride is formed in the presence of water vapour; the radioactivity is quite low. The velocity of sound in the vapour is about 0.3 of that of air; the scaling factor with this medium would therefore be similar to that mentioned in the last section for liquid helium but the absence of cryogenic equipment would make the application much simpler. The high density would make the radiation impedance correspondingly large with a consequent increase in efficiency of the sound generators.

Variable LC delay lines: Reference was made last month to the Amtec LC delay line in which the capacitors consist of back-biased diodes whose capacitance can be varied by changing the bias. The available range of $\pm 20\%$ in the delay cannot be utilized in practice owing to the changes in the impedance of the line with the bias applied and the consequent mismatch of the termination. For example, for a $6 \mu\text{s}$ line the echoes from a matched line were about 40 dB below the main signal but when the delay was changed to $5 \mu\text{s}$ the echoes were about 10 dB worse; the frequency response was also appreciably degraded. These effects can be overcome by employing two variable resistors, such as the drain-to-source impedance of a field effect transistor, as the source and load impedances of the line. A portion of the bias supplied to the line diodes is applied to the gates in such a way as to keep the termination correct over the whole range of adjustment. Other variable resistors such as light sensitive devices or thermistors could also be used for this purpose, the choice depending on the speed of response required. The variation in gain brought about by the change in termination can be taken up in a variable gain amplifier stage controlled by the same voltage.

Ceramic piezoelectric delay lines: It is possible to make the mechanical equivalent of the electrical lumped-constant low-pass filter type of delay line. In one form²³, using a rotational mode, it consists of a series of spaced coaxial discs joined axially by a corresponding number of rods as shown in Fig. 8. The discs are the mechanical equivalent of the inductances and the rods of the capacitors in the electrical circuit and the velocity of propagation and the image im-

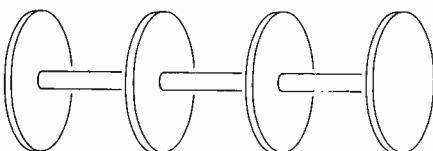


Fig. 8. Mechanical torsional delay line.

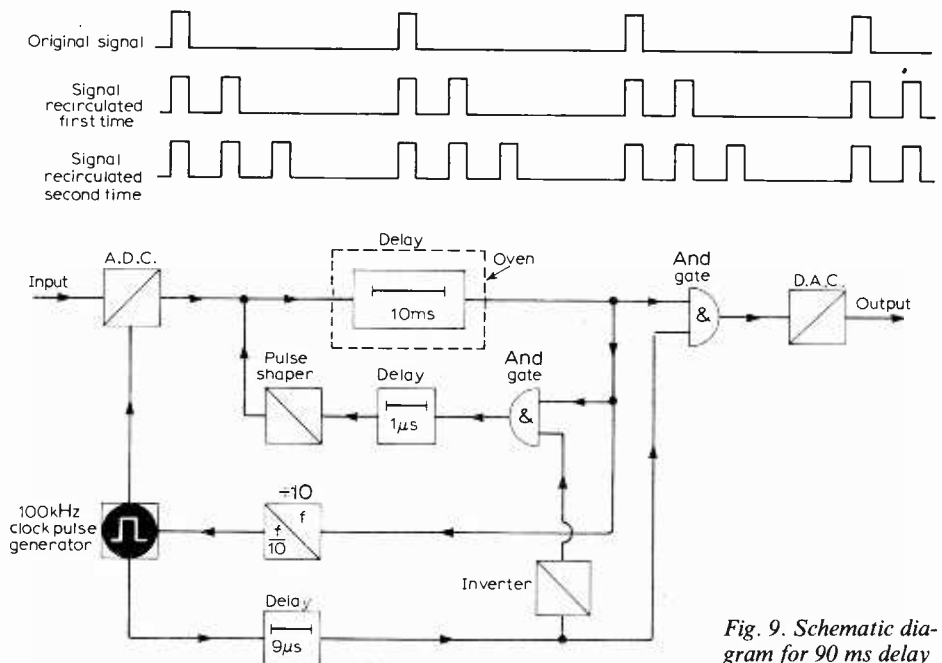


Fig. 9. Schematic diagram for 90 ms delay line by recirculation

pedance are given by corresponding expressions. Recently, however, the elements of such a line have been made of ceramic piezoelectric materials so that the device contains its own input and output transducers. At least one firm is experimenting with such a line for use in PAL colour television receivers but no details are available yet as to the performance achieved.

Magnetic memory stores: The use of these for delays can be regarded as an alternative to the capacitor store method. Unlike the capacitor store, however, the magnetic type is fully magnetised in one direction or the other and thus has the advantage of holding the recorded information indefinitely. On the other hand to use the magnetic type of store it is necessary first of all to digitize the signal and this appreciably increases the complexity of the auxiliary apparatus. Increased delay can be obtained by simply adding to the size of the store and this can be done without any of the difficulties such as attenuation, change in frequency response, signal-to-noise ratio or echo levels associated with other types of delay.

There are several types of magnetic store in production and developments in this field are so rapid that any survey is liable to be out of date by the time it is published. One type extensively used in computers consists of a series of minute ferrite rings about 450 microns in diameter with conductors threaded through a centre hole. Stores of this type can be made large enough to store a whole television field but in practice the read/write cycle time of 500 ns is too great for this application. On the other hand, a store of 36,000-bits would enable 100 ms of audio frequency programme to be handled and this would be adequate for some applications. Such a store would cost about £250.

A faster design has been brought out employing two cores per bit. This has a cycle time of about 300 ns but because of the added complication costs appreciably more than its simpler counterpart.

A second type of store was introduced by the Sperry Rand Corp.²⁴ It consists of a number of wires plated with an anisotropic magnetic medium with the hard direction of magnetization along the wire. On either side at right angles to the direction of the wires is a strip of conductor. The passage of current along the conductor causes the magnetic field in the wire to change direction. The strips are about 0.1 mm wide and are spaced about 1.5 mm between centres so the packing is about 80-bits to the square cm. The store, with a cycle time of about 150 ns, is fast enough for some television purposes. Very large stores, 16,000,000 bits, of this type are being developed; the cost per bit is expected to be less than ferrite by 1972.

Active stores: Metal oxide silicon transistors, (m.o.s.t.) and metal nitride silicon transistors (m.n.s.t.) have an insulated input electrode and this gives them an exceedingly high input resistance. The input capacitance is several picofarads and any charge deposited on this will therefore be held for a considerable time. The presence or absence of this charge can be determined by an examination of the current flowing in the output electrode and thus a nondestructive readout is possible. These stores are being developed by most of the semiconductor firms. The cost is expected to come down to about 1d or 2d per bit.

Another variety is the bipolar flip flop type. This is faster than the static capacitor type and clock rates of 50 MHz are feasible.

Active networks: One type of active delay system which seems to offer some promise is the resistance-capacitance all pass network. Sections of these networks are separated by operational amplifiers with a very high input impedance, a very low output impedance and unity voltage gain. A line of this type has been built by Standard Telephone Laboratories for the Admiralty to give a 700 μs delay over a bandwidth up to 6 kHz and occupies a space of only 200 cm³. The line consists of 14 stages and uses thin

film circuits, the components being made to a 1% tolerance. The system will deliver a signal level of 22 V into 2 Ω and has a noise level over the operational bandwidth of 15 μV r.m.s.; the attenuation over the whole line is only 0.4 dB. The price at the moment is high but it is expected that it will come down to £1 per section for the thin film circuits, with extra for the operational amplifiers. It is calculated that this line occupies only one tenth of the volume of a line made of conventional components.

Multiplication of delay times by recirculation: Although long delay times can sometimes be achieved by the simple process of adding delays in series a more elegant method, which can be used where the bandwidth of the line is sufficient, is that of recirculation.

In this process the signal is converted into pulses with a small mark to space ratio and applied to the line. The pulses are received

at the end of the delay line, further delayed by a fraction of cycle as shown in Fig. 9 and retransmitted down the line again. The number of times this process can be repeated obviously depends on the pulse repetition rate of the original signal and the maximum pulse repetition rate the line will transmit.

In one example an audio frequency signal was digitized and converted into pulses at a rate of 100 k pulses per second. Using an ultrasonic delay line of 10 ms having a maximum pulse repetition rate of 1 MHz the pulses were recirculated eight times giving a total delay of 90 ms. The form of circuit used is illustrated in Fig. 9.

Conclusions: A description has been given of the various types of time delay used in the B.B.C. and of others which are potentially useful. Owing to the wide variety of requirements there is no one method which can be recommended above the others.

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B.B.C. Band-two Broadcasting Stations

	Frequencies (MHz)			Maximum ERP (Each Prog)					
	Radio 2	Radio 3	Radio 4						
Ashkirk	89.1	91.3	93.5	18 kW*	Orkney	89.3	91.5	93.7	20 kW*
Ballachulish	88.1	90.3	92.5	15 W*	Oxford (Midland (South and West))	89.5	91.7 ^S	93.9	22 kW*
Ballycastle	89.0	91.2	93.4	40 W*	Penifiler	89.5	91.7	95.85	22 kW*
Barnstaple	88.5	90.7	92.9	150 W*	Perth	89.3	91.5	93.9	6 W*
Bath	88.8	91.0	93.2	35 W*	Peterborough	90.1	92.3	94.5	15 W*
Belmont	88.8	90.9	93.1	8 kW*	Pitlochry	89.2	91.4	93.6	20 kW*
Betws-y-Coed	88.2	90.4	92.6	10 W*	Pontop Pike	88.5	90.7	92.9	60 kW
Blaenplwyf	88.7	90.9	93.1	60 kW	Redruth	89.7	91.9	94.1	9 kW*
Brecon	88.9	91.1	93.3	10 W*	Rosemarkie	89.6	91.8	94.0	12 kW*
Bressay	88.3	90.5	92.7	10 kW*	Rowridge	88.5	90.7	92.9	60 kW
Brighton	90.1	92.3 ^S	94.5	150 W*	Sandale (Scottish (North))	88.1	90.3	92.5	120 kW
Brougher Mountain	88.9	91.1	93.3	2.5 kW	Scarborough	89.9	92.1 ^S	94.7	120 kW
Cambridge	88.9	91.1	93.3	20 W*	Sheffield	89.9	92.1 ^S	94.3	25 W*
Campbeltown	88.2	90.4	92.6	35 W*	Skriaig	88.5	90.7	94.3	60 W
Carmarthen	88.5	90.7	92.9	10 W*	Sutton Coldfield	88.3	90.5 ^S	92.9	10 kW*
Churchdown Hill	89.0	91.2	93.4	25 W*	†Swaledale	89.6	91.8	92.7	120 kW
Divis	90.1	92.3	94.5	60 kW	Swingate	90.0	92.4 ^S	94.0	35 W*
Dolgellau	90.1	92.3	94.5	15 W*	Tacolneston	89.7	91.9	94.4	7 kW*
Douglas	88.4	90.6	92.8	6 kW*	Thrumster	90.1	92.3	94.1	120 kW
Ffestiniog	88.1	90.3	92.5	50 W*	Toward	88.5	90.7	94.5	10 kW*
Forfar	88.3	90.5	92.7	10 kW*	Ventnor	89.4	91.6	92.9	250 W*
Fort William	89.3	91.5	93.7	1.5 kW	Weardale	89.7	91.9	93.8	20 W*
Grantown	89.8	92.0	94.2	350 W*	Wensleydale	88.3	90.5	94.1	100 W*
Haverfordwest	89.3	91.5	93.7	10 kW*	Wenvoe (Welsh (South and West))	88.3	90.5	92.7	25 W*
Hereford	89.7	91.9	94.1	25 W*	Whitby	89.95	96.8	94.3	120 kW
Holme Moss	89.3	91.5 ^S	93.7	120 kW	†Windermere	89.6	91.8	94.0	120 kW
Isles of Scilly	88.8	91.0	93.2	20 W*	Wrotham	88.6	90.8	93.0	40 W*
Kendal	88.7	90.9 ^S	93.1	25 W*	Local radio stations	89.1	91.3 ^S	93.5	20 W*
Kilkeel	88.8	91.0	93.2	25 W*	†Birmingham		95.6	93.5	120 kW
Kingussie	89.1	91.3	93.5	35 W*	†Blackburn		96.4		5.5 kW*
Kinlochleven	89.7	91.9	94.1	2 W	Brighton		88.1		1.5 kW*
Kirk o'Shotts	89.9	92.1	94.3	120 kW	†Bristol		95.4		75 W*
Larne	89.1	91.3	93.5	15 W*	†Derby		96.5		5 kW*
Les Platons	91.1	94.75	97.1	1.5 kW*	Durham		96.8		5.5 kW*
Llanddona	89.6	91.8	94.0	12 kW*	†Humberside		95.3		2.6 kW*
Llandrindod Wells	89.1	91.3	93.5	1.5 kW	Leeds		94.6		4.5 kW*
Llangollen	88.85	91.05	93.25	10 kW*	Leicester		95.05		140 W
Llanidloes	88.1	90.3	92.5	5 W	†London		95.3		140 W
Lochgilphead	88.3	90.5	92.7	10-W*	†Manchester		95.1		16.5 kW*
Londonderry	88.3	90.55	92.7	13 kW*	†Medway		97.0		4 kW*
Machynlleth	89.4	91.6	93.8	60 W*	Merseyside		95.85		5.5 kW*
Maddybenny More	88.7	90.9	93.1	30 W*	†Newcastle		95.4		2.5 kW*
Meldrum	88.7	90.9	93.1	60 kW	Nottingham		94.8		3.5 kW
Melvaig	89.1	91.3	93.5	22 kW*	†Oxford		95.0		140 W
Morecambe Bay	90.0	92.2 ^S	94.4	4 kW*	Sheffield		88.6		4.5 kW
Newry	88.6	90.8	93.0	30 W*	Sheffield (Rotherham)		95.05		30 W
Northampton	88.9	91.1 ^S	93.3	60 W*	†Solent		96.1		9 W*
North Hessary Tor	88.1	90.3	92.5	60 kW	Stoke-on-Trent		94.9		5 kW
Oban	88.9	91.1	93.3	1.5 kW	†Teesside		96.6		2.5 kW*
Okehampton	88.7	90.9	93.1	15 W*					5 kW*

*Directional aerial

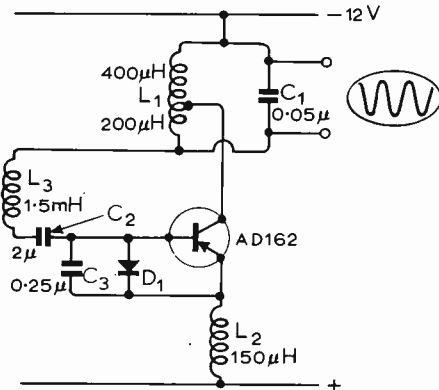
^SIncludes stereophonic broadcasts

†Not yet in service

Circuit Ideas

Sine-wave power oscillator

This form of oscillator can give a considerable increase in power output compared with conventional oscillator circuits when using low-power transistors. A typical example is that of an OC72 type transistor giving a sine wave output at 50kHz with a power output of 1W. The circuit uses three separate inductors, there being no inductive coupling between them. The collector inductor L_1 is tuned by C_1 . The emitter inductor L_2 forms part of the tuned circuit when the transistor is conducting and is in saturation. The third inductor L_3 provides a drive current that is in phase with the collector current. C_2 is a d.c. blocking capacitor. C_3 in conjunction with D_1 provides bias. D_1 also prevents a large voltage appearing across the base/emitter junction during cut off as well as providing a path between L_1 and L_2 via



13-W 20-kHz power oscillator.

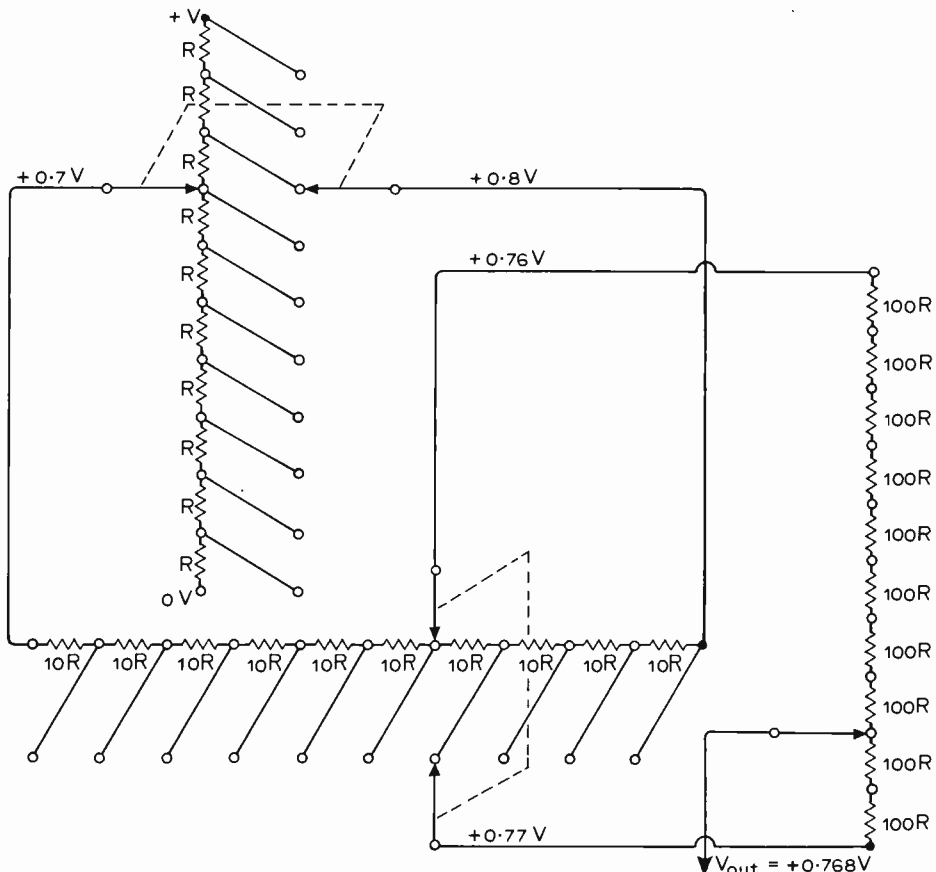
the collector/base diode as the output voltage is falling from positive to zero and cut off. The successful operation of the circuit is due to the fact that it is possible to control the collector current by the base current whilst the transistor is in saturation and that large currents can flow without exceeding the dissipation limit of the transistor. A typical saturation voltage is about 0.5V, and using an OC72 transistor it is possible to obtain a current of 125mA; and using an AD162, 2A. From the circuit it will be seen that L_1 and L_2 are in series to d.c. but in parallel to a.c., as the a.c. voltage appearing at the collector and emitter are nearly the same voltage when the transistor is in

saturation. The other ends of L_1 and L_2 are at the same potential a.c.-wise, both being earthy. The transistor is not tied to either positive or negative and can swing virtually unlimited above and below earth provided the transistor limits are not exceeded during cut off. Short circuiting the output stops oscillation and the current drops to zero until the short is removed.

H. L. ARMER
Mastertape (Magnetic) Co. Ltd.,
Slough,
Bucks.

1000 : 1 attenuator

Three thumb-wheel switches can be connected as a 1000 : 1 attenuator with 1000 positions. The combination employs two 10-way 2-pole switches and one 10-way single pole switch. In the circuit



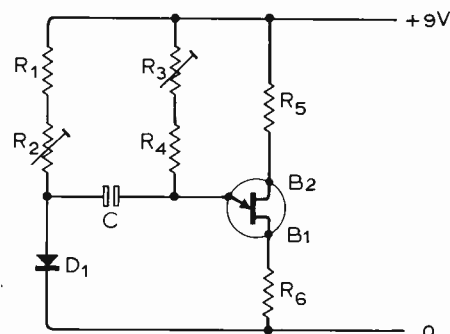
Thumb-wheel switch attenuator.

diagram the output has been set to 0.768 of the applied input voltage.

L. UNSWORTH
Southport, Lancs.

Unijunction square-pulse generator

The unijunction square-pulse generator circuit submitted by Mr. Paul (Circuit Ideas, March 1970) is rather unpredictable in its operation. In the circuit below, the timing capacitor charges via R_3 , R_4 and the forward biased D_1 from the supply. When the capacitor reaches the trigger voltage the unijunction goes into conduction. When this occurs, the positive end of C becomes



Unijunction pulse circuit.

referred to the negative of the supply and therefore D_1 becomes reversed biased. The capacitor C can then only discharge via R_1 , R_2 , the emitter-base junction and R_6 .

P. J. GRANGER
Sevenoaks, Kent.

The Unijunction Transistor

2. Using the unijunction

by O. Greiter

Last month I discussed the properties of the double base diode, the unijunction transistor, with particular reference to its use in a very simple relaxation oscillator circuit. There are two reasons for treating this device in this way. First of all, this is how unijunctions are generally used—in one or other variation of the trigger and reset mode: secondly it brings out the character defects of the device—its dependence on temperature and supply voltage. Readers who have been around for twenty years will remember how we all began with common base class-A amplifiers when transistors came our way, and how we struggled to bias the first germanium junction transistors so that we could get the same answer two days running.

The discussion was limited, because it did not consider how we could extract the signal. There is our pulse, or our sawtooth, on the oscilloscope, but we want it to do some work—to be, as we say, at a prescribed power level. Taking out a pulse can be easy. If you are using the unijunction to control a thyristor (which is a very common way of designing controlled rectifier circuits) you simply set up the arrangement of Fig. 1(a). If you need to keep the two circuits isolated you can use a pulse transformer, as shown in Fig. 1(b). The value needed for R_1 depends on the characteristics of the thyristor on the voltage available for V_{BB} , and on the capacitance. For G.E. thyristors the information is easily available in both their *Transistor Manual* and their *SCR Manual*.

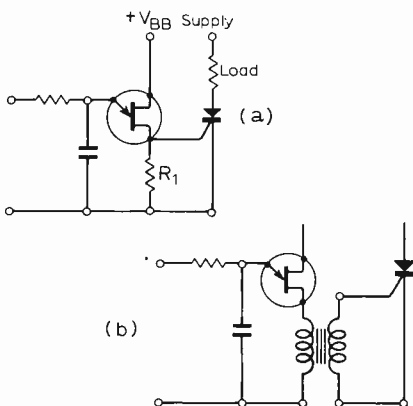


Fig. 1. (a) Unijunction triggering a thyristor with a common negative supply. (b) A pulse transformer may be used to separate the two circuits.

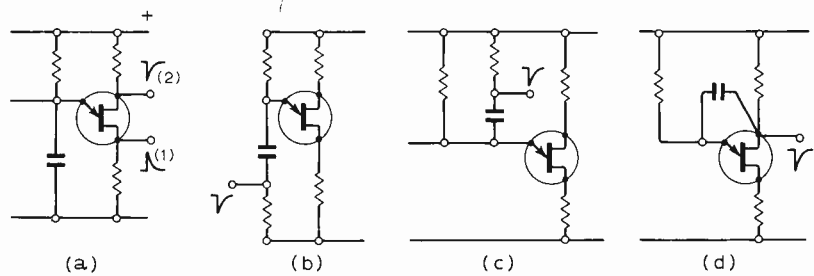


Fig. 2. Pulses are available in any of these five ways.

Curves show that when the capacitance is less than $0.1 \mu\text{F}$ for the smaller thyristors and $1 \mu\text{F}$ for the bigger ones, the necessary voltage gets squeezed between the limits of what the unijunction will stand and the minimum needed to get the extreme limit thyristor to turn on when it is really cold.

Pulse points

Since we have started to consider pulse circuits, we may as well continue along the same line, but without the restriction of applying the pulses to a thyristor. Fig. 2 shows a number of possible outlet points, and indicates the corresponding pulse polarities. In (a, 1), (b), (c) and (d) the source impedance is relatively low, because it is essentially the capacitor discharge current which is presented at the output. In (a, 2) we have only the increase in base-two current, but the actual voltage may be higher. This is a relatively high impedance.

Whichever circuit is used there may be the need to buffer the unijunction system from what we may call the working load. The various low impedance circuits will offer us a pulse of about 2 V across 20Ω in circuits using $0.1 \mu\text{F}$, rising to 4 V in circuits using $1.0 \mu\text{F}$. We can feed this into a buffer transistor to get a very large output. The more powerful transistors in the TO-3 size, for example, can be driven to saturation at 100 mA with a drive of only 5 mA, which implies that we can put 200Ω in series between the trigger point and the transistor base. By keeping the amplifier input impedance well above the source impedance we reduce the chance that the transistor will affect the stability of the oscillator circuit. It is also possible to use this impedance section, if that is the right expression, to do some pulse shaping. Inevitably this implies

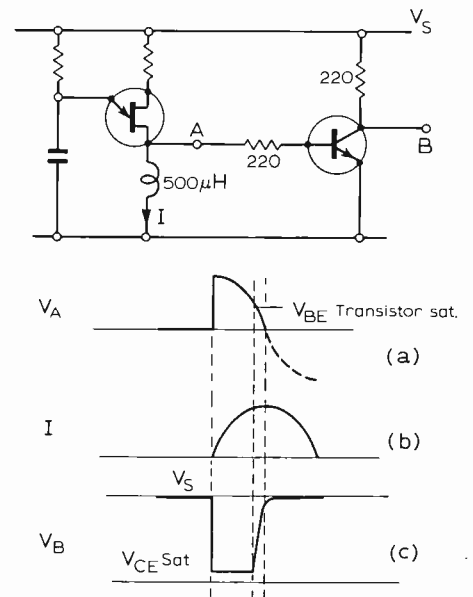


Fig. 3. The leading edge of the pulse at B (c) depends mainly on the speed with which the unijunction switches into the conducting state, and on the speed of the transistor. The trailing edge is determined by the transition of the LC "ring" across the base characteristic of the transistor. For a supply voltage of 10 V we should have $V_{Amax} \approx 5 \text{ V}$ and $V_{BE} \approx 0.25 \text{ V}$. This would make the ratio of on-time to fall time about $90^\circ/3^\circ \approx 30$.

pulse lengthening. To get pulses shorter than the natural unijunction transistor fall-time it is necessary to differentiate or to use an edge-sensitive triggered circuit. One interesting form which gives a pulse with fast rise and fall times is shown in Fig. 3. In this circuit R_1 is replaced by an inductor,

and for a particular example the rise and fall times were 0.3 μs with a pulse length of 11–12 μs. Replacing the inductor by a 47 Ω resistor gave a pulse rising in 0.3 μs but then falling in 3 μs. The pulse length is roughly one-quarter cycle of the natural frequency of the LC network, so that if we write

$$\begin{aligned} \omega^2 LC &= 1 \\ 4\pi^2 f^2 LC &= 1 \\ t &= \frac{1}{4}f \\ \frac{4\pi^2}{16t^2} LC &= 1 \end{aligned}$$

and $L = 0.4t^2/C$.

The rapid fall time is the result of the clipping action in the transistor. You cannot use an emitter follower.

A low frequency circuit in a hot environment is very awkward when, for some reason, short pulses are needed. To get the low frequency we use, we really must use, a fairly large value of capacitance. At high temperatures the fall time with a 1 μF capacitor is 30 μs, so that we must be prepared for a current pulse lasting 50 μs or more. There are situations in which this is not tolerable. One such situation is when the pulse is to drive units which are also used at higher frequencies and which are thus designed for short pulses. To avoid re-designing these parts of the system, and losing all the advantages of standardization, we must convert the long pulse into a short one.

The regenerative unijunction amplifier shown in Fig 4 will do this quite simply.

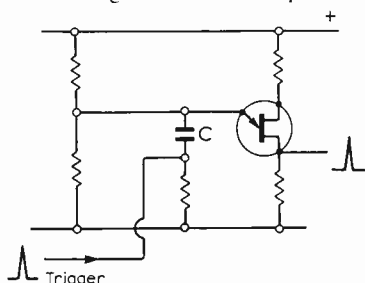


Fig. 4. Unijunction used as pulse repeater.

The capacitance here is small, so that the fall time is correspondingly low. The emitter is held by the voltage divider at just below the voltage ηV_{BB} which will trigger the circuit.

Pulling a sawtooth

Although one might reasonably describe the output of a multivibrator as a pulse train it seems to me to be carrying classification too far. I propose, therefore, to leave the long-pulse unijunction circuits and turn to the immediate extraction topic, although now it will be a matter of extracting the sawtooth. Two very simple ways of doing this are shown in Fig. 5. The direct connection here is almost invariably safe because V_E drops only to around the valley points which is high enough to keep the n-p-n transistor in conduction and the p-n-p transistor clear of saturation. The input impedance of the emitter follower is the first disturbing factor to consider. It has a value

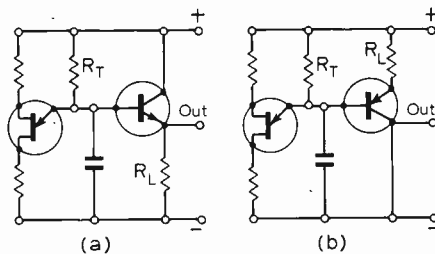


Fig. 5. The use of an emitter follower as sawtooth buffer amplifier.

of about h_{FE}R_L, and R_L must not be too large, because we want to do something with the sawtooth. In the circuit of Fig. 5(a) the term βR_L is part of a voltage divider with R_T, and if

$$\frac{\beta R_L}{R_T} < \frac{\eta}{1-\eta}$$

the emitter voltage will never reach the trigger point. Long before this condition is reached, however, the effect on the operating frequency and on the waveform will have been devastating. I find it easiest to make the rough calculations in the following way. Let us take a 20 V supply, and R_T = 30 kΩ. V_E will have an average value of about 5 V, so that the average current in R_T is 500 μA. Suppose the transistor has an h_{FE} of 100. For R_L = 1000 Ω the base current will be 50 μA: for R_L = 10 kΩ the base current will be 5 μA. It does not really matter all that much whether this current is added to the charging current through R_T, as it is with the p-n-p transistor, or subtracted, as it is with the n-p-n transistor. It is still a rather large proportion if we are concerned with good frequency stability. However, we must not overlook the unijunction emitter current in the region below the peak point. This is of the same order of magnitude, but of the opposite sign, and has about the same temperature coefficient. There is some possibility of matching these two currents, but I think that it will be much easier to use a really high value of R_L, the lowest possible value of R_T, and a second stage of amplification.

It is difficult to think of situations in which very high frequency stability is needed for a sawtooth which is not particularly linear. And if one has more than half an exponential rise it really is not the sort of linearity we are usually needing. A number of circuits have been devised to give better linearity: some of them I rather dislike. Four circuits are given in Fig. 6. The constant current circuit in Fig. 6(a) does not

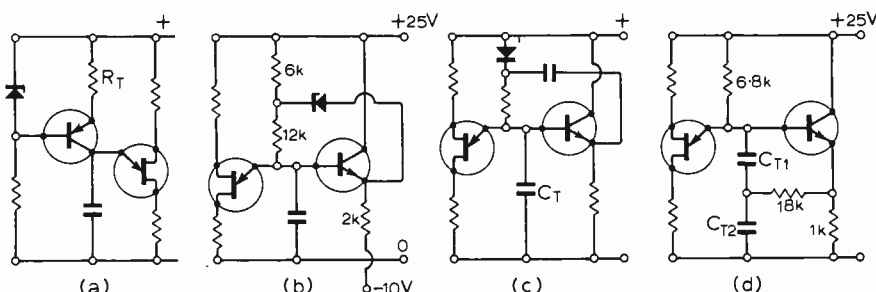


Fig. 6. Linearization circuits for sawtooth generator: (a) constant current; (b) zener bootstrap; (c) capacitor bootstrap; (d) integrator feedback.

provide a buffer output, but uses the transistor simply to charge the capacitance with a current of

$$(V_Z - V_{BE})/R_T$$

The frequency is not given by the expression roughly approximated as 1/R_TC_T, but is readily calculated from the linear charging characteristic. Notice that it now depends sharply on the supply voltage, because the charging current is constant while the trigger point, V_p, is still ηV_{BB}.

The two bootstrap circuits give a buffered output and use the output sawtooth to lift the charging voltage, keeping the voltage across the timing resistance nearly constant. With the zener diode we introduce a voltage which does not depend on the supply, V_{BB}, and the result is that variations in supply cause inverse variations in frequency. This does not happen with the capacitor bootstrap. The final circuit, Fig. 6(d), uses an integrating RC network fed from the emitter follower to add a concave-upwards voltage across C_{T2} to the normally concave-downwards voltage at the emitter of the unijunction.

The problem with these three circuits is that the need for a good big output at the emitter means a low value of emitter load resistance, and thus a rather heavy drain at the base. The relatively low cost of the circuits is a factor which must not be overlooked. The oscillator can easily be synchronized to a more stable source. Operational amplifiers can be used to give a really linear sawtooth. These are cheap bread-and-butter circuits which show the swings and roundabouts trade-off which is normally encountered with this class of circuit.

Triggering with the unijunction

Pulse generators (and we have seen that the unijunction transistor is an excellent choice for the active element in a pulse generator) are widely needed to trigger binary counter stages. The use as a regeneration amplifier is fairly obvious, and this is an area of interest in slow counting problems. Binaries are also used as square wave generators. The advantages of using an independent trigger and a resistance coupled pair rather than a multivibrator are the ease with which the frequency can be varied and the exact equality of the two halves of the waveform. Unless the highest stability is needed the triggering arrangements can be very simple. Fig. 7 shows the two versions, for n-p-n and p-n-p transistors. It is important in the design of this

type of circuit to ensure that the transistors are not oversaturated—so that the trigger pulse can lift the emitters to cut-off—and to ensure that there is enough drive—that is a big enough timing capacitor. It is not very difficult to get this system to work at around the 50 mA level.

If the timing resistance is returned to one of the transistor collectors rather than to one positive line, either of the circuits in Fig. 7 can be used as a single-shot timer. The initiating pulse is fed to the other transistor and must be such that it drives the end of the timing resistor positive. This rather involved wording covers both the p-n-p and n-p-n systems. After a time of about $C_T R_T$ (about meaning the η -dependent factor) the unijunction will trigger

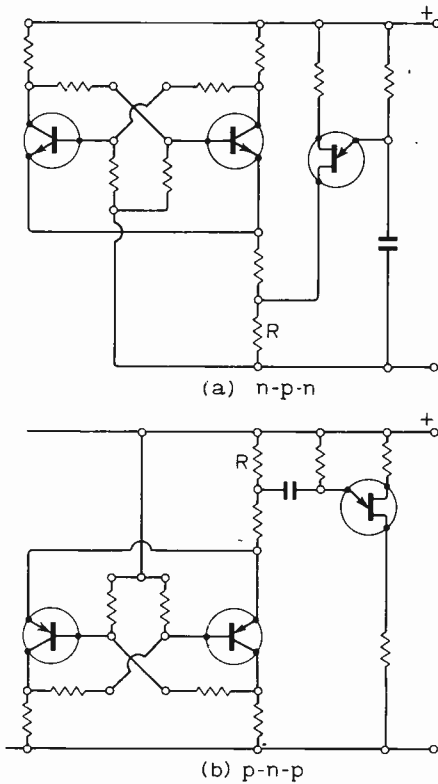


Fig. 7. Triggering a simple bistable pair from a unijunction transistor. Small "memory" capacitors are needed across the two collector-base feedback resistors. The emitter current pulse in R must knock the "on" transistor off.

and the system will return to its original state. If precautions are taken to fix the low level of the unijunction emitter this arrangement has virtually no memory and the shot time does not change significantly with the duty cycle.

Frequency division, low-level current detection, and long-term timing

The simplicity of the unijunction relaxation oscillator circuit, the fairly high stability of its frequency and the fact that it is a non-linear system combine to make it a very attractive frequency divider. If we consider one basic relaxation oscillator, in its simplest form of Fig. 2(a), we know that the emitter voltage rises exponentially towards the supply voltage until it reaches a value

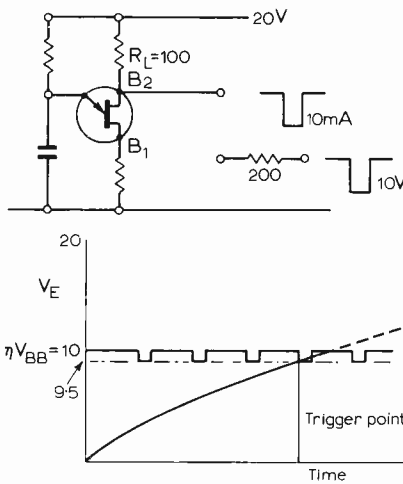


Fig. 8. Triggering a divider.

of ηV_{BB} . In order to have some numbers to talk about, let us take $V_{BB} = 20$ V and $\eta = 0.5$. Then, forgetting the need for a fraction of a volt to get the peak current through, the emitter will trigger at 10 V. Let us take the value of the resistance from base 2 to the positive supply as 100 Ω . We inject into this resistance an extra 10 mA, so that V_{BB} looks like 19 V. If the emitter has reached 9.5 V it will trigger. The pattern is shown in Fig. 8. Once the circuit triggers it is completely re-set and the whole process repeats itself.

Although it is not too difficult to make the calculation an exact one, an approximate approach gives a reasonably reliable answer and shows the solvent features more easily. If the run-up were linear, it would be at the rate of $\eta V_{BB} f$ volts per second, where f is the natural frequency of the divider. For a division ratio of n , the critical moment is $1/nf$ seconds before the natural trigger point, when the emitter voltage will be $\eta V_{BB}/n$ below triggering. The pulse applied to B2 must be less than V_{BB}/n if it is not to trigger the oscillator. If the pulse is a bit bigger than this, the triggering will take place after $n-1$ pulses instead of after n . If the pulse is more than twice this size

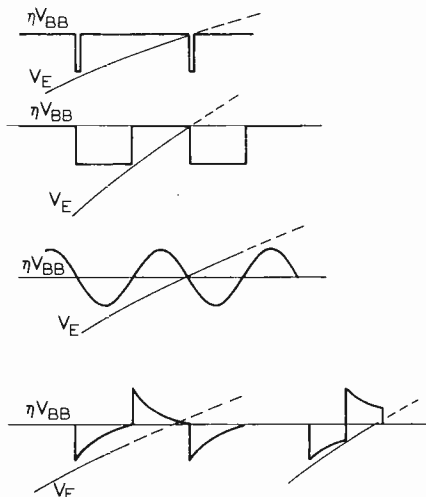


Fig. 9. Triggering details for pulse, square-wave, and sine-wave locking. If the square wave is roughly differentiated we can even (as shown on the right) get an improvement over pulse behaviour.

we shall divide by $n-2$, or even worse.

This is an order of magnitude calculation for dividing with a trigger pulse. If we are triggering from a square wave we must avoid the trailing edge of the triggering signal. With a sine wave the ideal, which is not shown in Fig. 9, is that the slope of the sine wave should equal the slope of the emitter voltage. For a sine wave of $A \sin 2\pi nft$ the slope is, at its maximum,

$$A \cdot 2\pi n f$$

and thus $A = V_{BB}/2\pi n$, provided that the locking signal is applied at B2. The least critical situation of all is to use a square wave with capacitance coupling to get a pulse top running parallel to V_E .

One source of a negative locking pulse is, of course the emitter of a preceding unijunction oscillator. The capacitor needed to couple this point to the base 2 of the

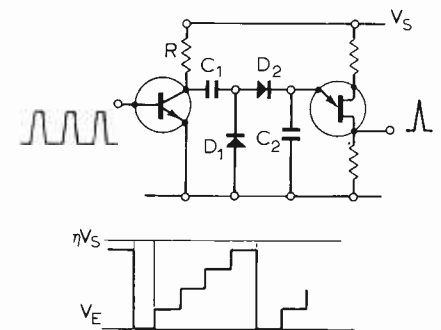


Fig. 10. Diode-pump divider.

following stage then forms part of the timing circuit. With transistors at their present prices the simplicity of a buffer amplifier is almost certainly worth the extra couple of shillings.

Any detailed design must take into account the stability of the locked oscillator itself. If this is taken as 1%, and if the supply voltage is also held to 1% in order to stabilize the size of the locking pulse it is plausible to talk about division ratios of 50 : 1, and realistic to think about 20 : 1.

This type of frequency divider is essentially a constant frequency type (Fig. 10). One application is for use with a crystal oscillator, to obtain a low frequency of very high stability. The unijunction is also useful for dividers of the diode-pump type. Each input pulse raises the emitter voltage by $V_s C_1 / (C_1 + C_2)$, until the emitter reaches ηV_s . The unijunction triggers, and discharges C_2 to re-set the pattern. The drive pulse must be long enough for C_1 to be cleared out through D_1 and the transistor, and the space between the pulses must allow C_1 and C_2 to reach equilibrium through R and D_2 . The loss of charge by C_2 due to diode and unijunction leakage is the limitation on the low frequency end, but within the limits set in this way the circuit will be independent of frequency. A more complicated version, obtained by adding a bootstrap amplifier, gives equal steps in place of the steadily diminishing ones familiar to all diode-pump users.

Closely related to the frequency divider circuits are some circuits which have very high sensitivity and can be triggered by very small input currents. The peak point current

of a unijunction is somewhere in the range 2–20 μA , depending on the price you pay and on your luck. Confining our attention to a unit with $\eta = 0.5$ operated at 20 V we see that in a relaxation oscillator designed for very low frequencies a resistance of 5.1 M Ω in the emitter supply will never be able to get the emitter junction quite over the top. As it is not too convenient to use timing capacitances much above 1 μF , timing circuits are limited to the odd second or two. It is therefore necessary to separate out the circuit which supplies the peak point current from the CR circuit which does the timing, so that the timing resistance does nothing but charge the capacitance.

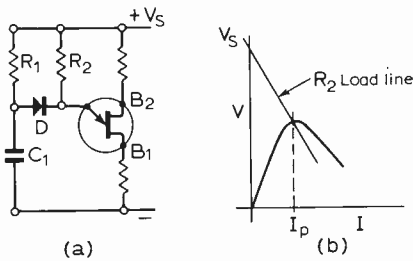


Fig. 11. (a) Heart of long period timer, and (b) steady state unijunction characteristic.

The essential features are shown in Fig. 11. The resistor R_2 is of the order of 10–20 M Ω , if the expensive low-leakage type of unijunction transistor is used. This is chosen to hold the emitter at its peak point, as shown in Fig. 11(b). Typically the current, I_p , will be 1 μA . As it stands this is a perfectly stable situation. The timing capacitance C_1 is charged through R_1 , and for most of the time the diode D is reverse biased. Obviously D must be a very good diode. If C_1 is 1 μF and R_1 is 1000 M Ω the time constant will be 1000s, about a quarter of an hour. C_1 must have a leakage resistance of at least 10,000 M Ω for this situation to make sense.

As it stands, this circuit will not work. When the voltage across the capacitance equals ηV_s the diode will be ready to come into conduction, but the net load line in Fig. 11(b) will shift only slightly as R_1 appears in parallel with R_2 .

At this stage one frequency divider technique comes into play. When a pulse is injected, in the way shown in Fig. 8, the emitter voltage remains at its original value, while the unijunction peak voltage is moved down. The only stable intersections for $V_E > V_{BB}$ is away on the rising part of the characteristic where the current is tens, or

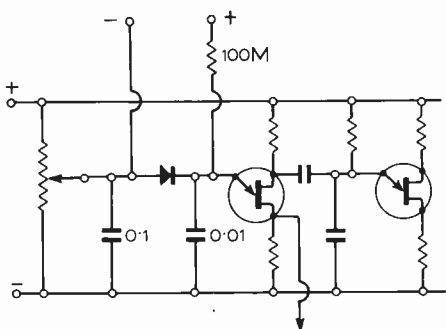


Fig. 12. Very sensitive current detector.

hundreds, of mA. The main timing circuit triggers in the ordinary way. It might be feared that one could get a marginal situation in which each quick test of the circuit just took away enough leakage to hold the C_1 voltage on the threshold. The look lasts only the odd μs , however, and if we are timing 1000s we should hardly look more often than once a second. The wastage duty cycle is too small to worry about. The test pulses are, of course, produced by another unijunction oscillator, using a cheap unijunction. Time delay circuits of this kind are normally used to trigger a thyristor, either directly from base one or through a trigger transformer. There is no reason why the pulses, at one a minute or one an hour, should not operate a binary, or a ring counter, to produce a sequence which switches regularly at these intervals.

The technique used to detect a very small current is similar to the long period timer. The circuit, this time with the test pulse generator included, is shown in Fig. 12. Both capacitors charge quickly to a voltage set by the potentiometer. This must not be high enough for the circuit to trigger. If current is fed in through the 100 M Ω resistor at the top of the diagram it will lift the emitter voltage and at the next test pulse the circuit will trigger. As soon as the 0.01 μF capacitor has supplied the full peak point current and the trigger operation is under way, the 0.1 μF capacitor will be able to discharge and provide a healthy pulse at base 1.

All the circuits discussed so far have been designed to have one stable state. The action of the circuit consists of moving the working points into an unstable region, whereupon the triggering is followed by a resetting operation. Like all negative resistance systems the unijunction circuit provides a negative resistance only in a limited current range and unlike some negative resistance circuits can be safely operated outside these margins. An example of a negative resistance which is not safe is a power transistor up in the avalanche or second breakdown area. This is bounded on the upper side by the small positive resistance of a total loss. With the unijunction we can construct a bistable element. The distorted-in-scale unijunction characteristic is shown in Fig. 13(a) and the circuit which goes with it in Fig. 13(b). The load line for R_1 and V_1 intersects this characteristic in three points, so long as $V_1 < \eta V_E$, and neglecting the effect of R_2 and R_3 . The intersection in the negative resistance region, at B, is not stable, but the other two intersections, at A and C, will be stable. Notice that C is to the right of the valley point. We have

$$V_1 < \eta V_E$$

$$I_C > I_V$$

Rather roughly, since V_{valley} is small

$$R_1 < \eta V_E / I_V$$

A typical value of R_1 would be 1–2 k Ω . This gives a safe dissipation level at C. The transition from one state to the other is easy. If we are at A, a positive pulse applied to the emitter, or a negative pulse applied to B2, will unlatch the system, leaving only an intersection in the region of C. If the circuit

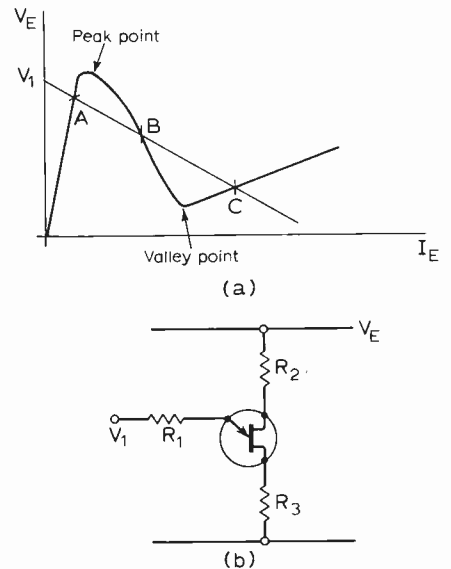


Fig. 13. (a) Bistable load line. (b) Bistable circuit.

is at C, a negative pulse at the emitter will drain off current to leave only one intersection, somewhere below A. By using Thevenin's theorem in reverse we can establish the emitter conditions for a bistable in the way shown in Fig. 14. R_4 is small and is there to detect the changeover. Suppose that R_3 is a 1- Ω resistor and that the effective value of V_1 is just 1 V below the peak point. The current through R_3 will be in the region of 5 mA. Let us use R_3 also as the return path for another piece of equipment which shares the negative line, but not necessarily

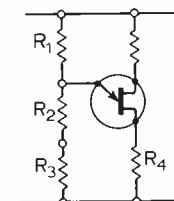


Fig. 14. Single supply bistable.

the positive line, with the circuit of Fig. 14. Should this outside system pass more than about 1.5 A, the emitter will be lifted up to above V_p and the circuit will trigger. A capacitor connected to the emitter can be added to give some extra current when triggering first takes place, although this will slow down the detection process. If the capacitance is across R_2 a sharp rise in I_{R3} will get straight through to the emitter. The pulse at R_4 triggers the shut-down device. Just how delicate you care to make this arrangement is a matter of detailed design. A 1-V margin is very robust indeed.

To monitor for the absence of a signal $R_2 R_3$ can be replaced by a transistor. So long as the base is held positive the circuit stays at point A. Loss of the voltage at the base will cut off the transistor and trigger the circuit.

The uses of this bistable in ring counters, and one or two other applications of the unijunction, will be taken up in a later article, which will also describe the programmable unijunction transistor. This is an attractive variant, which has many advantages and, unfortunately, some disadvantages when compared with the ordinary unijunction transistor.

Electronic Building Bricks

3. The electron and how it moves

by James Franklin

So far we have talked about electrical energy (Part 2) and about the electron (Part 1). The connection, if the reader has not already realized it, is that electrons are the "stuff" by which electrical energy becomes evident as such. Electrical energy can be understood intuitively because it can be experienced and seen in action—but what exactly is the electron?

The sad truth is, that although a multi-million-pound industry is built on what you can do with the electron, nobody really knows what it is. We only infer that the electron exists from certain natural phenomena which have been observed and measured.*

Basically the concept is that the electron is the smallest unit of what we call electricity, and is also one of the constituents of all atoms. A familiar, simplified picture of electrons in an atom is shown in

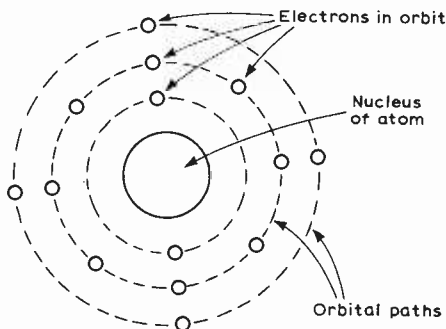


Fig. 1. Simplified diagram of an atom of silicon, an element used to make transistors. (The orbits of the electrons round the nucleus are not actually in the same plane and concentric as shown.)

Fig. 1. As such the electron is represented as a particle. But a particle of what material? According to our theory of the structure of matter, all materials are made up of atoms and the atom is the smallest possible unit of any element. Something which is only a constituent of the atom cannot therefore be a particle of recognizable substance. If it is not a thing, perhaps it is an event. At any rate we will agree that it is an entity. Whatever its real nature, the electron has mass—the same familiar property as possessed by a cricket

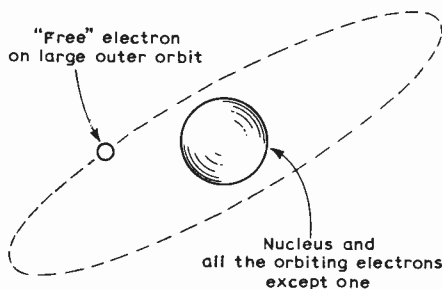


Fig. 2. Atom with "free" electron travelling in large, outer orbit. (For simplicity the inner electrons and nucleus are shown as a solid sphere.)

ball. (And, in fact, the electron can be made to behave in much the same way as a cricket ball—propelled, accelerated, decelerated, brought into collision, deflected and stopped.)

When we say "the smallest unit" we mean the electron is the smallest unit that can be used as a measure of quantity of electricity. (Analogy: in a quantity of ball bearings the smallest unit into which the total weight or volume could be divided is a single ball bearing.) Quantity of electricity is called *charge*, so the electron is the basic unit of electric charge. A larger and more practical unit by which charge can be measured is the coulomb†, which is 6.24×10^{18} electrons. A stationary charge is one form of electrical energy—*potential energy*. As such it can be used to represent static information (Part 2).

A more easily understood property of electricity is the electric current—one thinks analogously of a current of water. An electric current is, in fact, a general

† Named after the French physicist and engineer Charles Augustin de Coulomb (1736-1806).

movement of many electrons—a process known as conduction. It takes place freely through certain materials, such as copper, less freely through others such as water, and hardly at all through others such as nylon. This brings us back to the dual role of the electron as a small quantity of electricity and as a constituent particle of atoms. The atoms of good electrical conductors, such as copper, have "free" electrons travelling in large, outer orbits, as shown in Fig. 2; these are not fully engaged in holding together the atoms of the material, and so are available to take part in the process of electrical conduction. In a cubic centimetre of copper there are about 10^{23} such "free" electrons.

Considered in detail the process of conduction is extremely complicated. It is something like what happens in a tightly packed crowd of people in a room with a door at each end (Fig. 3) if fresh people keep pushing in at one door. As each fresh person pushes in all the people already in the room are forced to change position slightly—in random directions according to where little spaces open up around them—but the net result of all this movement is that people nearest the far door are pushed out of the room.

In a piece of material in which conduction is occurring, each free electron of an atom moves into the nearest "space" in an adjoining atom (made available by a free electron moving elsewhere). The pattern of movement in a small volume is random, but over the whole material there is an aggregate of movement in a given direction. This movement of electrons is another form of electrical energy—*kinetic energy*—and, as we saw in Part 2, can be used to represent dynamic information.

When we speak of the "speed of electricity" we mean the speed of the aggregate movement—that is, the speed at which a disturbance (e.g. "switch-on", the start of electron movement) travels through the material. This speed varies slightly with different materials but is about 3×10^8 metres per second.

When we speak of "current" we mean the *rate* of aggregate movement—that is the total number of electrons moving in a given direction past a certain point in a given period of time. Since, then, electric current is really electron flow rate, it could be measured in electrons per-second, but in practice coulombs-per-second are more convenient. A current of one coulomb (6.24×10^{18} electrons) per second is called an ampere,‡ or "amp".

‡ Named after André Marie Ampère (1775-1836), French physicist and mathematician.

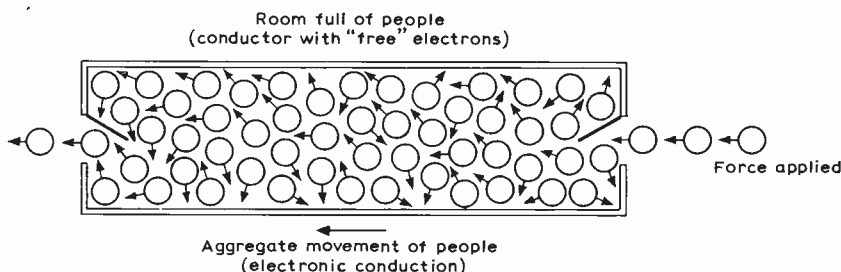


Fig. 3. Human-cum-mechanical analogy of the movement of electrons in a material.

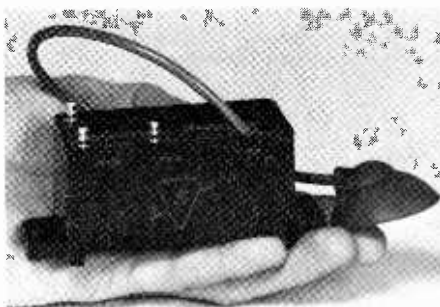
* The idea of the electron was conceived by the Scots physicist Sir Joseph Thomson. He announced it at the Royal Institution, London, in April 1897.

Letter from America

The alleged TV radiation hazard is still provoking arguments here and set-makers are all claiming that *their* sets are harmless anyway . . . As I said before, it's not the radiation that worries me—it's the programmes! Sylvania recently announced details of a high-voltage multiplier device which is said to significantly reduce radiation in colour sets. As a bonus they also say it reduces the chance of fire! The device consists of diodes and capacitors housed in an epoxy enclosure and it replaces the high-voltage rectifier and shunt regulator. Many readers will note the similarity to the EY52 ladder network which supplied the high-voltage potential (25kV, if my memory serves me right) to the old Mullard TV projection tubes. I still have one of the original Schmidt lens systems which I brought across the Atlantic 'in case I could use it for something'. But there it sits gathering dust in the basement—occasionally to be shown to an American unbeliever.

Talking about tubes reminds me of the fantastic new camera tube from RCA. This uses the Silicon Intensifier Target (SIT) with a built-in electronic light amplifier. Basically, it consists of a vidicon-type scanning electron gun and image intensifier separated by a special silicon target with an integrated circuit consisting of no less than 600,000 p-n junction diodes. A brightness magnification of 150,000 is easily achieved enabling a bright television picture to be produced from very low ambient lighting. In fact, it is claimed that useful pictures can be picked up from a scene that is illuminated by a light level equivalent to that supplied by a 100-watt bulb two miles away! Obviously, such a tube will have many industrial and military applications but could be used for ordinary broadcast purposes where the reduction in studio lighting would be very much worth while. Fig. 1 shows a cross-section through one of the diodes. Three types of tube are available at the moment—16, 25 and 40mm.

Morgan Electronics, of Chicago, have released details of an interesting automatic telephone answering system suitable for high-speed voice and data transmission. The recorder/transcriber is a modified Uher U-5000 and the idea is to record at a very low speed (15/16 i.p.s.) transmitting and receiving at a high speed and then playing back at the original speed. Thus,



(A) Sylvania's voltage multiplier which reduces radiation in colour television sets.

transmission time and telephone charges are reduced considerably. Reproduction is said to be better than normal 'phone conversation as connections are made direct to the 'phone circuits, by-passing the hand receiver. Features include automatic level control, a three-digit index counter, full remote control of tape motion and a single button on the microphone for selection of replay and rewind functions so that information can be added or errors corrected.

Quadraphonic sound is still the big topic in audio circles and I suppose at least 70% of the exhibitors at the July Consumer Electronic Show in New York's Americana

and Hilton hotels will be demonstrating some kind of 4-channel sound. Among the contending systems are Harman-Kardon's 'Orban' synthetic idea which uses reverberation and phase-shifting networks, the Hafler which is a fairly simple matrix system, and the Dorren and Feldman systems—both multiplex. Several disc systems are being developed but so far the only one to leave the lab. is the Scheiber which has been demonstrated to various groups including the Audio Engineering Society. Like the Harman-Kardon, it is a synthetic or *psycho-acoustic* system. In other words, although it definitely produces four discrete channels the sound may not be an accurate reproduction of the original performance. RCA are backing the 8-track cartridge for their first venture into the quadraphonic market and they say at least 30 tapes will be on sale in August. Complete systems (tape player, radio and four speakers) were demonstrated back in May. Motorola and Lear-Jet are also putting their faith in the 8-track (Quad-8) format, but Wollensak have just announced a 4-channel cassette recorder! Almost every maker of reel-to-reel machines—Sony, Teac, Telex, Crown, etc—have 4-channel models, although, as yet, few tapes are available apart from Vanguard's series of 14. Fisher will be demonstrating a new 4-channel receiver at the Consumer Show. This is model 701 which is rated at 40 watts (genuine r.m.s. watts) per channel.

While all this flurry and excitement over quadronics has been going on, news has come from Mexico of—wait for it—*stereo on a.m. in the medium wave-band*. It seems that station XTRA down in Tijuana, just across the border, has been broadcasting real, genuine two-channel stereo on 690 kHz using a new system with one sideband handling the left channel and the other carrying the right. The only snag is that two receivers are needed, one tuned higher than normal, and the other lower. (I'd hate to ask my wife to do that!) The result, according to L. R. Kahn, XTRA president, is "true stereo performance."

G. W. TILLET

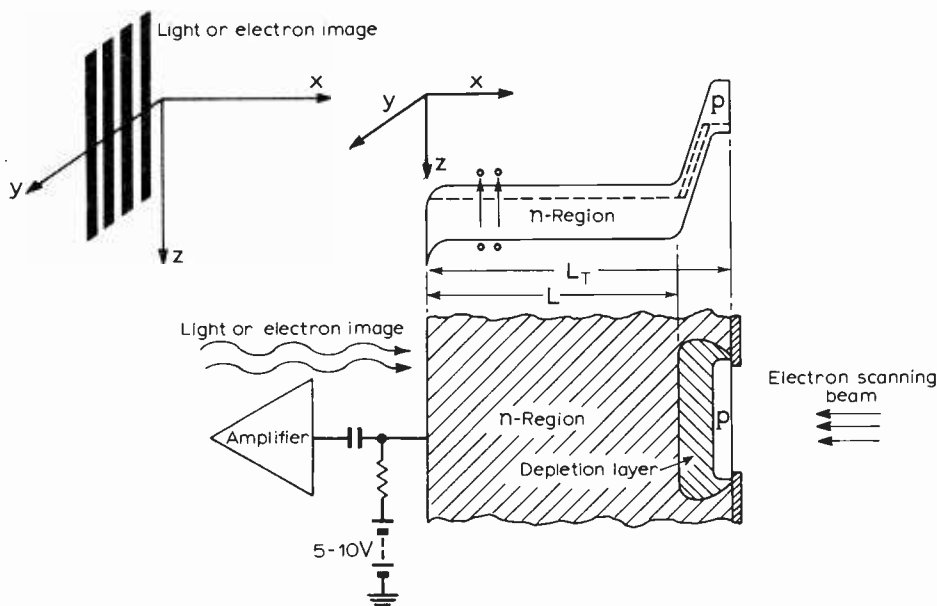


Fig. 1. Target cross-section through one diode of the RCA silicon intensifier tube.

World of Amateur Radio

International prefixes

Until recently, the national prefix, used compulsorily by all amateur stations since 1928, has had as its primary purpose the immediate identification of the country from which the station is transmitting. Lately, however, this seems to play a secondary role to that of attracting special attention as a result of novelty. The Canadians used 3C, instead of VE, to mark their centenary, now AX and ZM respectively replace VK and ZL to celebrate the discovery of Australia and New Zealand by Captain Cook. European "liberation" anniversaries have been marked by 3Z (Poland), OM (Czechoslovakia) and YT (Yugoslavia). Russian club stations have all been allocated new call signs, all having the prefix UK but with a country identification concealed in the number or call-letters. Many amateurs must by now be saying "enough" to this form of organized chaos, and hanker after the days when a prefix was a prefix was a prefix!

Encouraging c.w. operation

Despite the increased use in recent years of s.s.b. on the h.f. bands and the domination of the various telephony modes on v.h.f., hand Morse remains a basic and popular element of amateur radio communication. Because of the possibility of extreme narrow-band reception (of the order of 25 to 50 Hz bandwidth) which is becoming more practicable with the better stability of transmitters and receivers, c.w. continues to offer considerably more scope for weak signal operation than any alternative mode, as well as largely overcoming the language barriers to international communication. But increasingly, apart from maritime and some military communications, the pool of professionally experienced operators is shrinking.

A group of c.w. enthusiasts which, for over 30 years, has aimed at encouraging the use of Morse, and raising the standards of operating (though not without running into some controversy in so doing) has been the "First Class C.W. Operators' Club". Membership of this club is limited to 500. Currently there are members in more than 50 countries. The club imposes a rigorous system of

nominations for membership—every new member has to be recommended by at least five sponsors from at least two continents. Members are expected to be able to operate at speeds of not less than 25 words per minute and to be able to operate on at least two bands. Members are encouraged to work between 25 and 35 kHz from the low-frequency limits of the bands. Secretary of the club since 1967 has been W. H. Windle (G8VG), 121 Laburnum Avenue, Dartford, Kent.

R.S.G.B. "Radiocom 70"

With the amateur radio exhibition this year moving forward in the calendar to August 19th-22nd (Royal Horticultural Society's New Hall, Greycoat Street, London S.W.1) several new features are being introduced, in addition to the normal trade and club exhibits. Vouchers totalling up to £50 are to be awarded for outstanding mobile and portable station performance as judged by contacts with the exhibition stations which will be active on 3.5, 70 and 144 MHz. This contest, under the jurisdiction of Phil Thorogood (G4KD), the exhibition organizer, requires application forms to be obtained in advance from R.S.G.B., 35 Doughty Street, London WC1N 2AE. There is also to be a competition for the best club-constructed equipment. Small "mini-stands" are being introduced both for the trade and to allow non-trade members to exhibit or sell equipment. The traditional "draw" will be for a Hammarlund HQ215 transistor communications receiver.

Band activities

During a sporadic E opening associated with a severe solar storm on June 12th-13th TF3VHF, the 2.5W Icelandic beacon station on 70 MHz, was heard for the first time by many British stations. A 144-MHz 'first' established during this period was a link between Scotland (GM3EOJ) and the Faeroes (OY2BS). The solar storm introduced a signal black-out on some h.f. bands (reported particularly from the United States), and conditions on h.f. continued patchy for most of the remainder of the month,

though this may have been due to the normal summer increase in signal attenuation in the D layer. The 144.950-MHz beacon station near Dundee, GB3ANG, is again operational. The first new Nigerian licence for five years has been issued to Kaduna Polytechnic (5N2KPT). One of the most active amateur television groups in the United States is the Indiana Amateur TV and UHF Club whose members are now operating some 15 amateur television stations, with pictures regularly received over distances of 50 to 200 miles. This group includes W9NTP who (apart from his slow-scan work described in the March issue) operates a 300-watt u.h.f. transmitter with a 64-element collinear aerial array mounted at a height of 50 ft. There now appear to be only two countries (Cambodia and Vietnam) that retain their objections lodged with I.T.U. to international amateur radio operation by their citizens; but for many years there seems to have been little or no amateur licensing by China.

Mobile rallies

With British mobile licences now reported as past the 3000 mark, good attendances are expected at the August mobile rallies. These include: R.S.G.B. National Mobile Rally (9th) at Woburn Abbey (talk-in stations GB2VHF, G3VHF and GB3RS on 144, 70 and 1.8 MHz); Derby (16th) at Rykneld School, Bedford Street; Swindon (23rd) at No 15 M.U., and R.A.F. Wroughton, near Swindon; Preston (30th) at Kimberley Barracks, Deepdale (talk-in stations on 1.8 and 144 MHz). Firms interested in exhibiting at the Wroughton rally should get in touch with G. Windsor, 26 St. Gregory's Road, Deepdale, Preston.

In brief: A. C. Morris, G3SWT, recently became honorary treasurer of the R.S.G.B. following the resignation, due to ill-health, of Norman Caws, G3BVG. One of his immediate concerns will be an "extraordinary general meeting" of the Society in August, called to authorize an increase in subscriptions. . . . The annual convention of the International Amateur Radio Club will be held in Geneva from September 16th to 18th (I.A.R.C., P.O. Box 6, 1211 Geneva 20, Switzerland). . . . As a result of the recent appeal seven Cheshire Homes now have amateur-band receivers. The Homes Amateur Radio Network Fund would welcome the offer of amateur equipment in reasonable working order (offers to W. M. Clarke, G3VUC, 66 Fillace Park, Horrabridge, Yelverton, Devon). . . . What must surely be an exceptionally amateur radio conscious family has been noted recently by A.R.R.L.: comprising grandfather (W8BU), grandmother (WA8EBS), son (WA8ZOD), son-in-law (W8WJC), daughter-in-law (WA8ZOC) and two grandsons (K8TND and WA8ZOA).

PAT HAWKER, G3VA

Personalities

W. E. Hobbs has been appointed manager of the Marconi Electro-Optical Systems Division, at Basildon, of which he was formerly technical manager. He succeeds **J. E. H. Brace** who has resigned. Mr. Hobbs joined Marconi in 1952, working in the Research Department on colour television. In 1954 he moved to the Broadcasting Division and in 1957 to what was then the Closed Circuit Television Division. In 1962 he became development group leader responsible for the development of the vidicon colour camera and the large screen colour projector. A year later he was made deputy development manager, and since 1965 has been technical manager of the Electro-Optical Systems Division where for the past two years he has been responsible for the development and production of the Martel missile system. **M. B. House** succeeds him as technical manager of the Division. Educated at Queen Mary College, London University, Mr. Howe joined Marconi in 1951 as a development engineer. He worked in the Broadcasting Division, first on film scanners and television film recorders, and later on vidicon cameras until he joined Closed Circuit Television Division in 1959. He was appointed development manager in 1968.

Colin Yendell has been appointed product sales manager of the Semiconductor Division of Auriema Ltd, representatives of several American semiconductor manufacturers, the main one being Philco-Ford. Prior to joining Auriema Mr. Yendell was with Marconi-Elliott Microelectronics at Witham as commercial manager of the bipolar i.c. product group.

Alexander M. Poniatoff, founder and chairman of the board of directors of Ampex Corporation, is to retire as chairman on August 25th. He will continue to direct the Alexander M. Poniatoff Laboratory, a specialized research and development organization within Ampex. Mr. Poniatoff founded Ampex (originally Ampex Electric and Manufacturing Company) in

1944. Ampex, which takes its name from his initials plus EX for excellence, was originally formed to produce electric motors and generators for World War II navy radar systems. In 1946, Mr. Poniatoff decided to devote the small company's efforts to development work in the experimental field of magnetic recording. Born in Russia in 1892 Mr. Poniatoff studied mechanical engineering and received an M.E. degree at the technical college, Karlsruhe, Germany.

Henri Busignies, senior vice-president and chief scientist of International Telephone and Telegraph Corporation, has received the Award in International Communication of the I.E.E.E. "for his outstanding leadership and technical contributions in the fields of electronic technology and communication techniques". An authority on radio navigation and radio direction finding, Dr. Busignies has been associated with I.T.T. for more than 40 years. The annual award consists of a plaque, certificate and \$1,000. Dr. Busignies developed the high-frequency radio direction-finding system, known as "huff-duff", used in World War II against enemy submarines. He also invented moving target-indicator (MTI) radar.

James Redmond, F.I.E.E., director of engineering of the B.B.C., has been elected president of the Society of Electronic & Radio Technicians. Mr. Redmond joined the Council of the Society in 1965 and was elected vice-president in 1968. He succeeds Sir Ian Orr-Ewing, Bt. O.B.E., M.A.

H. G. Maguire, general manager of the Marconi International Marine Co. Ltd., since January 1962, has been appointed a director of the company. He began his career with Marconi when he joined as a seagoing radio officer in 1927. He served at sea until 1936, when he won promotion to the shore technical staff at the Glasgow depot. In 1943 he was promoted to

inspector and transferred to Montevideo, returning to Glasgow in 1946. He became Liverpool depot manager in 1951, and moved to the company's head office at Chelmsford in 1955 to take over as manager of the newly formed export sales division. Mr. Maguire is also a director of Norsk Marconikompani, A/S, Oslo, and of Coastal Radio Ltd.

T. B. McCrirrick, F.I.E.E., F.I.E.R.E., is to be the new chief engineer, radio broadcasting, in the B.B.C. on the retirement of **A. P. Monson** who joined the Corporation in 1933 as an engineer in the London Control Room. Mr. Monson's appointments have included those of head of the transcription recording unit, superintendent engineer (recording), superintendent engineer (radio broadcasting), and since 1963, chief engineer, radio broadcasting. Mr. McCrirrick joined the B.B.C. in 1943 and after serving in studios in Edinburgh, Glasgow and London, he transferred in 1949 to the Television Service where he was latterly engineer-in-charge, television studios, and head of engineering, television recording. He left the Television Service in 1969 on his appointment as head of studio planning and installation department. **C. R. Longman**, F.I.E.R.E., Mr. McCrirrick's successor, joined the B.B.C. in 1943 and has been with the Television Service since 1950. Since 1967 he has been head of engineering, television studios, in which position he is succeeded by **R. B. Mobsby** who has been with the B.B.C. since 1943 initially at the Tatsfield Receiving Station and for the past 15 years in the Television Service. He has been head of engineering, television network, since 1967.

R. Monger, who was until recently in charge of digital voltmeter development in Dynamco, has joined Racal Instruments Ltd as chief engineer, d.c. measurements. Racal also announce the appointment of three other senior engineers—all of whom have been with Racal several years. They are **P. Sample**, chief engineer (r.f. measurements); **G. Taylor**, chief engineer (pulse and digital instruments); and **E. W. Parker**, group leader, product engineering group.

E. Ribchester, B.Sc., F.I.E.E., who joined British Communications Corporation Ltd (now one of the Racal group of companies) in 1966 and became chief engineer two years ago, has become technical manager. Mr. Ribchester was previously with the G.E.C. where he was at one time associated with the team working on colour television.

BIRTHDAY HONOURS

Among those upon whom honours were conferred on H.M. The Queen's birthday were:

Knights Bachelor

David C. Martin, C.B.E., executive secretary, the Royal Society.
Arnold Weinstock, managing director, General Electric and English Electric Companies.

C.B.

E. V. D. Glazier, Ph.D.(Eng.), B.Sc., M.I.E.E., director, Royal Radar Establishment.

C.B.E.

W. D. H. Gregson, assistant general manager, Ferranti (Scotland) Ltd.

O.B.E.

D. J. Harris, B.Sc., Ph.D., M.I.E.E., lately professor and head of electrical engineering, Ahmadu Bello University, Zaria, Nigeria.
A. P. Monson, chief engineer, radio broadcasting, B.B.C.
T. S. Robson, M.B.E., assistant director of engineering, I.T.A.
J. Sieger, chairman and managing director, J. & S. Sieger Ltd.
Wing Cdr. R. H. Smith, M.I.E.R.E., R.A.F.
F. N. L. Williams, head of school radio broadcasting, B.B.C.

M.B.E.

D. R. Cockbaine, M.I.E.R.E., British Technical Asst. Officer, Turkey.
Major J. Drennan, M.I.E.R.E., Corps of R.E.M.E.
M. Johnston, engineer-in-charge, Post Office Radio Station, Baldock.
G. D'A. Prichard, manager, information services, Hirst Research Centre.
E. A. Rust-D'Eye, telecoms technical officer, Ministry of Defence.
D. H. A. Scholey, F.I.E.R.E., lately engineer-in-chief, East African Posts & Telegraphs Corp.
T. Shepherd, formerly project leader, C. & W. Bahrain Earth Station.
J. W. N. Yeomans, chief engineer, Redifon Air Trainers Ltd.

OBITUARY

Kenneth Joseph Ayres, managing director of International Aeradio Ltd, died on 4th June aged 48. He served as a navigator in the R.A.F. Bomber Command from 1942 to 1945 when he transferred to air traffic control becoming senior air traffic control officer at the R.A.F. Elementary Flying School, Hullavington, and subsequently at Flying Training Command Headquarters. In 1947 Mr. Ayres joined International Aeradio as an air traffic control officer and after serving at a number of stations overseas became air traffic services manager at the company's headquarters. He was appointed deputy general manager, and then general manager, technical services, and in June 1968 was elected to the board of directors. He had been managing director since August last year.

New Products

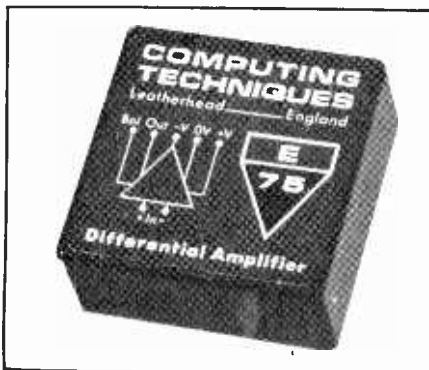
Trimmer Capacitor Range

Two ranges of trimmer capacitors manufactured in the U.S.A. by the JFD Electronics Corporation are now available in the U.K. from ITT Components Group Europe. These are the DV-5 and MVM series of capacitors. The DV-5 series of subminiature ceramic-disc variable capacitors employs special ceramic materials in a monolithic structure. The capacitors occupy about 1mm of printed circuit board space. Six models are available covering a minimum of 2.5pF to 9pF capacitance up to a maximum of 5pF to 30pF. Working voltages are 100V d.c. from -55 to $+85^{\circ}\text{C}$ and 50V d.c. up to $+125^{\circ}\text{C}$, with an insulation resistance of $10^{10}\ \Omega$ at 25°C at the rated voltage. The MVM series of microminiature air variable capacitors is designed for high frequency applications that demand extreme stability, small size and a high Q factor. The working voltage for each of the four models is 250V d.c. with an insulation resistance of $10^{12}\ \Omega$ at 500V d.c. and 25°C . ITT Components Group Europe, Capacitor Product Division, Brixham Road, Paignton, Devon.

WW324 for further details

Low Input-current Op.Amp.

An encapsulated amplifier, type E75, has been added to the 'E' range of compatible amplifiers by Comtec. Fitted with an f.e.t. differential input stage, it has an input impedance of $10^{13}\ \Omega$ and an input bias current of 1pA. Common mode rejection is 66dB with a voltage range of $\pm 10\text{V}$. The open loop gain is 5×10^5 dB, and the output level $\pm 10\text{V}$

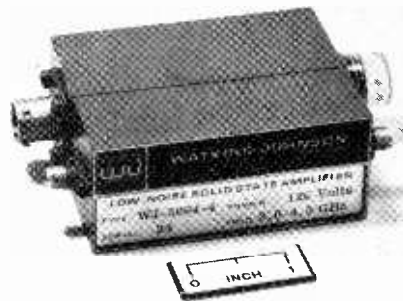


at $\pm 10\text{mA}$ from $\pm 15\text{V}$ supplies up to 20kHz. Using silicon devices throughout, the amplifier is encapsulated in epoxy resin and is housed in a plastic case 38mm square and 15mm thick. It is fully protected against short circuits from output to ground and input to supply rails. Computing Techniques Ltd, Westminster Bank Chambers, Bridge Street, Leatherhead, Surrey.

WW326 for further details

Low-noise S-band Transistor Amplifier

Watkins-Johnson has developed an S-band transistor amplifier with a noise figure of 7dB. Designated WJ-5004-4, the amplifier delivers a power output (for 1dB gain compression) of +5dBm and small



signal gain of 25dB. The overall design is consistent with the environmental requirements of MIL-E-16400F, and MIL-E-5400K, class 2. Watkins Johnson International, Shirley Avenue, Windsor, Berks.

WW320 for further details

Electroluminescent Diodes

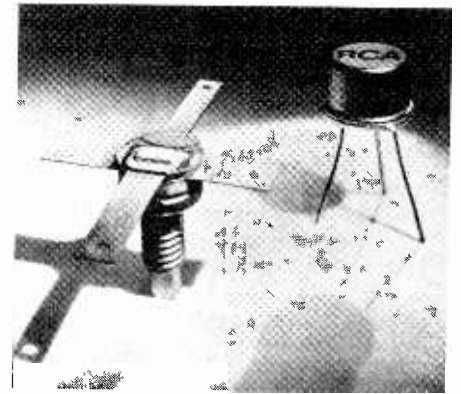
Latest additions to Plessey's range of electroluminescent diodes are two red light emitting types, designated GPL 1 and GPL 2. Both types are based on single crystal gallium phosphide which gives particularly good performance at low operating bias—typically brightnesses at 10mA of 765 cd/m^2 (GPL 2) and 306 cd/m^2 (GPL 1), corresponding to a luminous flux of 3 and 1.2 millilumens respectively. Guaranteed optical powers

are 120 and 40 microwatts for the two types. Continuous operation is possible up to 25mA with increased brightness, and pulsed operation of the diodes is possible up to 1A subject to a mean dissipation of 50mW. The response time is 300ns. The Plessey Company Ltd, Microelectronics Division, Optoelectronic and Microwave Unit, Wood Burcote Way, Towcester, Northants NN12 7JN.

WW327 for further details

V.H.F./U.H.F. Power Transistors

Three power transistors for v.h.f./u.h.f. class C amplifiers have been introduced by RCA. Two of the devices, designated the 2N5914 and 2N5915, are incorporated in a radial-lead stud package and are designed for stripline or lumped-constant circuits. The third device, designated the 2N5913, is built into a three-lead TO-39



type package. All three devices are epitaxial silicon n-p-n planar transistors with an overlay emitter electrode construction. Typical ratings of the 2N5913 device at 12.5V is 2W at 250MHz (9dB gain) and at 8V is 1.5W at 250MHz (7dB gain). These devices are available from Electronic Components Division, RCA Ltd, Sunbury-on-Thames, Middlesex, and from RCA's distributors in the UK: Semicomps Northern Ltd, ECS Ltd and REL Equipment and Components Ltd.

WW319 for further details

Triple Output Power Supply

A triple output, stabilized power supply is announced by Oltronix. The unit—designated B60-IT—has output ranges of 0-6V, 0-30V and 0-60V at 4, 2 and 1A respectively. Stability is 0.005% or 1mV for 10% line change. Noise is 0.05mV r.m.s. Recovery time from 100% overload is 50 μs . Environmental temperature coefficient is less than $\pm 100\text{ppm}/^{\circ}\text{C}$. Adjustment is provided by a 10-turn potentiometer which gives a dial reading of the chosen output voltage to an accuracy of $\pm 250\text{mV}$ on the 30V and 60V ranges and $\pm 25\text{mV}$ on the 6V ranges. Range selection is by front panel switch which simultaneously indicates selected voltage and current, potentiometer scale factor and full scale value for the output monitoring meter. This is a

dual meter which shows voltage and current on separate scales. Also on the front panel are constant-voltage and current-limit indicators, monitoring-meter range expansion push buttons, a control for setting the current limit between 10 and 110% of rated output and graphs of voltage/current characteristics. A new overvoltage protection circuit is incorporated on the six-volt range which clamps the output at 7V and automatically resets to the chosen output after an overvoltage condition is cleared. A sensor lights a "hot" lamp on the front panel and switches the supply off if a long high voltage condition occurs. Input can be 110, 117, 220 and 235V a.c. $\pm 10\%$, 50-60Hz. Dimensions are 165mm long \times 133mm high \times 228mm deep. Oltronix UK Ltd, Hunting Gate, Hitchin, Herts.

WW323 for further details

5W, 7 to 12.5GHz Pulsed Gunn-effect Diode

An X-band high power pulsed Gunn-effect diode, Type TEPO 1, has been introduced by Plessey to their range of pulsed and c.w. Gunn diodes. Power outputs are available in the frequency range 7 to 12.5GHz. Typical operating conditions are bias voltages from 25 to 40V, and currents in the range 2 to 5A and an efficiency of about 5%. The maximum pulse repetition frequency is dependent on the pulse length—e.g. for a 0.5 μ s pulse the maximum p.r.f. is 10kHz. Fast switch-on of the device is possible if the full supply voltage can be fed to the Gunn diode in about 1ns. The device is suitable for operation in a waveguide or coaxial cavity, and is available in a standard S4 package. The Plessey Company Ltd, Microelectronics Division, Optoelectronic and Microwave Unit, Wood Burcote Way, Towcester, Northants NN 12 7JN.

WW325 for further details

Potentiometer for P.C. Boards

An addition to Plessey's MP range of moulded carbon-track potentiometers, designated type MP WT, has been specifically designed for use with 0.1in (2.54mm) grid printed circuit boards, and its 3.175mm long pins conform to this configuration. This potentiometer offers 0.25-W rating at 70°C, with standard resistance values from 1k Ω to 2.2M Ω . A wide range of non-standard values is also



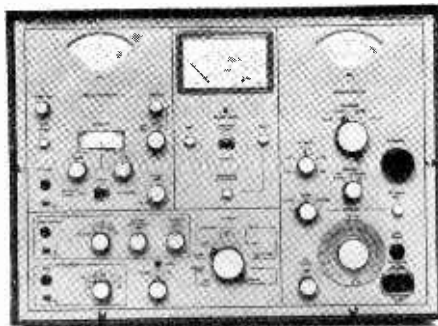
available. The Plessey Company Ltd, Resistor Division, Cheney Manor, Swindon, Wilts.

WW322 for further details

Mobile Radio Test Set

Marconi Instruments have introduced a versatile mobile radio test set which combines in one unit, many functions normally only found in a number of different instruments. This compact instrument, type TF 2950, is operated from rechargeable internal batteries. It can be used to check, service and calibrate a.m./f.m. mobile radio equipment designed for the frequency ranges 65-180 MHz and 420-470 MHz, with maximum transmitter powers of 15W continuous or 15-25W short term. The 65-180 MHz range is covered in three steps.

The instrument is composed of a signal generator, an audio-frequency voltmeter,



a modulation monitor, a power meter and an audio-frequency oscillator. The voltmeter measures between 0 and 300mV in four ranges and 0-10V in three ranges. The modulation monitor measures amplitude and frequency modulation over the same ranges as the signal generator but in two bands instead of four. The amplitude modulation depth measurement range is 0-80% and f.m. deviation is measured in two ranges with maximum readings of 5kHz and 25kHz. The power meter measures both forward and reflected power up to 15W continuously, and up to 25W for short periods. The audio-frequency oscillator generates a 1kHz signal variable by $\pm 1\%$ and its output can be chosen from one of four ranges between 0-3V and is indicated on the main meter. Battery state is also shown on the main meter. Price of the TF 2950 is £800 f.o.b. U.K. It weighs 16kg and measures 315 \times 420 \times 230mm. Marconi Instruments Ltd, St. Albans, Herts.

WW336 for further details

U.H.F. and I.F. TV Transistors

Four new transistors from SGS cover the requirements of the u.h.f. converter and i.f. amplifier stages of single- or dual-standard TV receivers. All are encapsulated in TO-72 packages. The two u.h.f. types, the BF272 and BF316 are intended for grounded base operation and have standard connections. These two devices, by using a p-n-p configuration, are

claimed to give a performance not previously equalled by silicon transistors. The main advantage is the low noise figure—typically 3.5dB at 800MHz—added to very low reverse transfer capacitance ($C_{rb}=0.09$ pFmax) giving a high power gain (13dB typical at 800MHz) with adequate stability. The two v.h.f. devices—BF270 and BF271—are intended for grounded emitter operation and have the base and emitter connections reversed, resulting in reduced feedback capacitance and isolation of input from output circuits, giving improved stage gain. The BF270 is for use as an a.g.c. i.f. amplifier giving a stability limited gain of 28dB at 36MHz and an a.g.c. control range of 60dB with low base-current drive requirements. The BF271 is designed for the final i.f. amplifier stage. Its power dissipation (240mW at 25°C ambient) allows more than adequate output without excessive temperature rise and non-linearity. It has a gain of 28dB at 36MHz. SGS (United Kingdom) Ltd, Planar House, Walton Street, Aylesbury, Bucks.

WW321 for further details

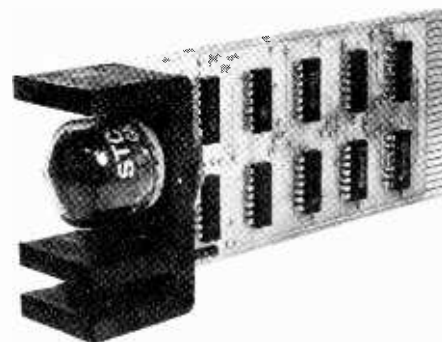
Gain-tracking T.W.T.

Latest addition to the series of ITT gain-tracking, low-noise travelling wave tubes is type W3MT/4A. Tubes already available cover the frequency ranges 2-4 and 4-7.5 GHz, and the W3MT/4A now extends this range from 7.5 to 12 GHz. Gain varies over the operating frequency band from 30 to 36 dB and all tubes follow a mean gain-with-frequency curve to within ± 1.5 dB. A fixed input voltage of +1,300V with respect to earth is required, plus 6.5V d.c. supply for the cathode heater. Saturated output power is +7 to +17 dBm and noise less than 15dB. ITT Components Group Europe, Valve Product Division, Brixham Road, Paignton, Devon.

WW332 for further details

Reversible Decade Counters

A reversible, or up/down, counter module type DCM1711, announced by Quarndon Electronics, incorporates t.t.l. logic i.cs and a numerical indicator tube to provide readout. It is intended for industrial control and counting applications at up to 15MHz in either direction. A carry/borrow circuit provides a zero-sense output for sign change purposes. Another decade counter, model DCM1709, will operate up to 10MHz and an alternative version of this module,

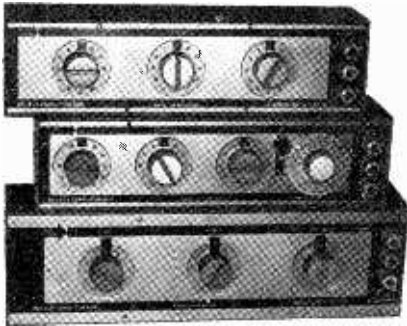


the DCM1708, is wired with a discrete component display decoder to improve the clarity. Quarndon Electronics (Semiconductors) Ltd, Slack Lane, Derby DE3 3ED.

WW334 for further details

R, C and L Boxes

A wide range of resistance, capacity and inductance boxes are available from Lionmount & Co. Ltd, having one to five decades. Resistance boxes cover the range 0.1Ω to $11M\Omega$ with an accuracy of 0.1%:



capacitor boxes span the range $8pF$ to $111\mu F$ and inductance boxes using ferrite materials are available up to $11H$. Lionmount & Co. Ltd, Bellevue Road, New Southgate, London N.11.

WW339 for further details

Miniature Zener Diodes

Latest additions to the Mullard range of miniature components are some zener diodes with voltages of 5.6 to 12V. Called type BZX84, the new diodes are intended for use with thick and thin film circuits, but they can also be used with advantage in many other applications. The BZX84 diodes have a voltage tolerance of $\pm 5\%$ and a dissipation rating of $150mW$ at an ambient temperature of $25^\circ C$ when mounted on a ceramic substrate $5 \times 5 \times 1$ mm. The maximum permissible forward current is $100mA$, and the thermal resistance $0.5^\circ C/mW$. Mullard Ltd, Mullard House, Torrington Place, London, W.C.1. **WW333 for further details.**

M.O.S. Shift Registers

Two new m.o.s. static shift registers are available from Plessey. The MP220B can be programmed on a package pin to be either 80 bits or 56 bits long. Data-stream select logic is incorporated on the input to the register, thus facilitating recirculation of data. The device also features an equivalence gate enabling data in the final bit to be compared with external data, and an appropriate output derived. The device is available in either flat pack or d.i.l. packages. The MP225B is a 100-bit static shift register which also incorporates data-stream select logic on the input. The device is available in a TO-5 package. Both devices operate from d.c. to $1MHz$ over the temperature range

-20 to $+70^\circ C$, and interfacing with t.t.l. can be achieved with a few discrete components. The shift registers are completely compatible with the MP100 series m.o.s. logic. Microelectronics Division, Plessey Components Group, Cheney Manor, Swindon, Wilts.

WW330 for further details.

Reference Voltage Cell

A robust miniature reference cell which can be soldered to a printed circuit board has been introduced by Muirhead. Designated type K-391-A, this new cell is claimed to have performance characteristics equal to those of the best reference cells available. It measures only $70mm \times 11mm$, and can be mounted or transported in any position. The e.m.f. is 1.019 to $1.0193V$ at $25^\circ C$ and the temperature coefficient (10 to $40^\circ C$) is less than $-3\mu V/^\circ C$. Each cell is supplied with a certificate of test with e.m.f. stated to the nearest $10\mu V$. This value is traceable to the National Physical Laboratory Volt with an estimated uncertainty not exceeding $10\mu V$ (0.001%). Muirhead Ltd, Beckenham, Kent.

WW335 for further details

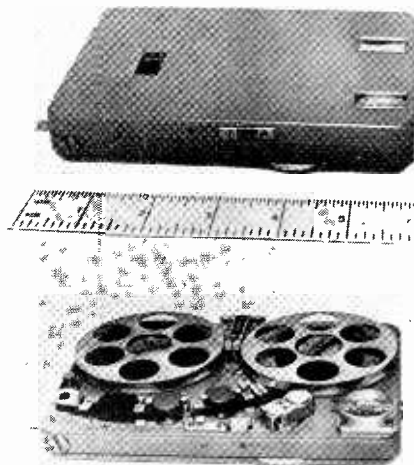
Digital Probe

A pocket-size digital probe has been announced by Aircraft Supplies. It is suitable for on-the-spot checking of electronic equipment and it replaces the oscilloscope where this instrument is unavailable or inconvenient to use. The probe is light and easy to handle and is powered by rechargeable nickel cadmium cells. There are two modes of operation: as an indicator of static logic levels (0 and 1 corresponding to lamp on and off respectively); and as an indicator of pulse trains. Retail price is $\pounds 19$ 15s. Aircraft Supplies Ltd, 506 Wallisdown Road, Bournemouth, Hants.

WW338 for further details

Miniature Tape Recorder

The Nagra SN miniature tape recorder, available from Hayden Laboratories, will fit into a coat pocket, has a signal-to-noise ratio (relative to 2% 3rd harmonic



distortion) of $60dB$, and a frequency response of $80-16000Hz \pm 2dB$ at 3.75 i.p.s. Average speed stability is $\pm 0.5\%$, and wow and flutter $\pm 0.1\%$ at 3.75 i.p.s. The recorder uses $3.81mm$ (0.15in) tape and will play for 52 minutes at 1.875 and 26 min at 3.75 i.p.s. Power can be supplied from manganese batteries, alkaline sealed accumulators, or from an optional mains operated power supply. An omnidirectional capacitor microphone ($48 \times 18 \times 10mm$) is also available as an extra. Price of basic recorder is $\pounds 365$. Hayden Laboratories Ltd, East House, Chiltern Avenue, Bucks.

WW337 for further details

Watchkeeping Receiver

A new watchkeeping receiver for use on the international $2182kHz$ R/T distress frequency is available from Redifon. Designated R.492, the receiver is crystal controlled, simple to operate, and compact. It is completely independent of other radio



equipment and can be preset to a volume low enough to avoid annoyance, while still producing full volume whenever a two-tone alarm signal is received. A receiving range control provides adjustment of the receiver to suit the particular aerial in use. Protection against damage to the receiver input circuits from powerful signals is provided by a fast-acting muting system. An external speaker output is provided. The receiver operates from a ship's main a.c. supply or from a $24V$ d.c. source. Redifon Ltd, Broomhill Road, Wandsworth, London, S.W.18.

WW329 for further details

High-level Gate-turnoff S.C.R.s

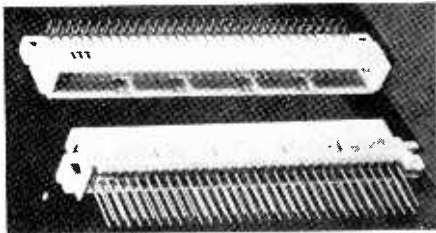
Transitron has introduced a series of high-level gate-turnoff thyristors. Design features of the new devices—designated RTGD02—include pulse turnoff up to $5A$; typical $5A$ turnoff gain of $10-15$; typical turnoff time under $5\mu s$; and operating temperatures up to $125^\circ C$. Repetitive peak-off-state voltages and repetitive peak reverse voltages for the five devices in the range are: RTGD0206, $60V$; RTGD0210, $100V$; RTGD0220, $200V$; RTGD-

0230, 300V; and RTGD0240, 400V. Absolute maximum ratings include (at 80°C) average on-state current, 1A; r.m.s. on-state current, 1.6A; peak one-cycle surge current (60Hz), 10A; peak reverse gate voltage, 5V; peak gate power, 500mW; and average gate power, 100mW. Packaging is in standard TO-5 cans. Transistron Electronics Ltd, Gardner Road, Maidenhead, Berks.

WW331 for further details.

64-pole P.C.B. Connector

A sixty-four-pole electrical connector for the indirect connection of printed circuit boards has been introduced by ITT Components Group Europe. The GO7 connector is designed for use with the ITT Standard Equipment Practice (ISEP)



system and complements the existing ISEP connector range. Within the connector's overall length of 94mm (3.7in), sixty-four contacts are arranged in two rows of thirty-two with a contact pitch of 2.54mm (0.1in). By the use of external coding pins, polarization without loss of contact is possible. The connector is available to special order equipped with only thirty-two poles, either in line on one side or staggered. ITT Components Group Europe, ITT Manufacturing Services Division, Equipment Practice Sales Office, Edinburgh Way, Harlow, Essex.

WW311 for further details

2-GHz Transistor

TRW Semiconductors Inc. has added another member to its GHz transistor family—the PT8610. This provides 10W output at 2GHz, with 7dB gain and 15% bandwidth. It is a single chip device in a low parasitic package. Companion transistors are the PT8611, at the 5W level, the PT8612, at 2.5W, and the PT8613, at 1W. These devices are designed for use in common-base circuits. MCP Electronics Ltd, Alperton, Wembley, Middlesex, HAO 4PE.

WW310 for further details

Low Phase-distortion Audio Transformers

Gardners Transformers have announced a new standard range of low phase-shift audio transformers capable of handling steep-sided transient signals. The transformers employ toroidal winding and nickel-iron ribbon of extremely high permeability. Phase-shift over the audio-frequency band is less than five degrees

from 20Hz to 20kHz, and frequency response is within 0.5dB from 10Hz to 80kHz (13 octaves). A steep-sided transient signal can be handled without generation of overshoot up to +12dBm at 20Hz and +20dBm at 50Hz. One type in particular, the MU7590, which is designed for 600-Ω line-bridging applications, will handle voltage levels up to +24dBm at 20Hz. The transformers are electrostatically and magnetically shielded, and are assembled in a cylindrical mumetal case 60.5mm in diameter and 71mm high and mounted on an international octal plug-in base. Gardners Transformers Ltd, Christchurch, Hants.

WW318 for further details

50A Complementary Transistors

Two pairs of complementary silicon power transistors, p-n-p types 2N5683 and 2N5684 and n-p-n types 2N5685 and 2N5686, introduced by Motorola, are each rated at a maximum collector current of 50A. Together with a collector breakdown voltage of 60 to 80V, this high current rating makes the transistors suitable for high-power amplifying applications. Minimum current gains of 15 at 25A and 5 at 50A are exhibited. The devices can also be used in switching circuits such as 1kW inverters and converters, motor controllers and lamp drivers, a maximum collector-to-emitter saturation voltage of only 1V at 25A ensuring low-loss operation in saturated switching circuits. Transition frequency is 2MHz (max.) at 5A. Housed in a TO-3 case, each device dissipates a total of 300W at a case temperature of 25°C. Motorola Semiconductors Ltd, York House, Empire Way, Wembley, Middx.

WW313 for further details

Microphone Amplifier

I.C. type TAA970 from Mullard can be used with piezoelectric and dynamic microphones as an amplifier for telephone circuits. The gain of the amplifier is independent of the polarity of the supply. Typical voltage gain and output impedance is either 180dB and 115Ω or 130dB and 80Ω depending on pin interconnections. The encapsulation is TO-74. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.

WW 304 for further details

High C.M.R. Differential Amplifier

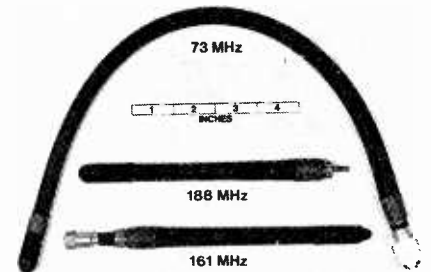
A new differential amplifier type E71, by Computing Techniques, has an input bias current of 10pA, common mode rejection of 100dB and a common mode voltage range of ±10V. It has an overload recovery time of 1μs, slew rate of 2.5V/μs, open loop gain of 10⁵ and will drive a 2kΩ load to ±10V from ±15V supplies without limiting. Using silicon

transistors throughout, the E71 is protected against damage by short circuits from output to earth. It is especially suitable for applications requiring an f.e.t. input stage with good common mode performance and fast overload recovery time. Computing Techniques Ltd, Westminster Bank Chambers, Bridge Street, Leatherhead, Surrey.

WW317 for further details

V.H.F. Communications Aerial

An addition to the Panorama range of v.h.f. communications aerials is the FX helical spring which is only one-third the length of a comparable quarter-wave rod. Its flexibility, ruggedness and low profile provide considerable protection against rough handling and accidental breakage,



especially when used with portable equipment. Available with 4B.A. end stud as standard or fitted with customer designated connector, the FX aerial is supplied to specified frequencies within the range 70-240MHz. Panorama Radio Co. Ltd, 73 Wadham Road, London S.W.15.

WW312 for further details

Reflex Klystron

English Electric has added a low-voltage, rugged reflex klystron (type K3078) to their range of oscillator klystrons. A direct equivalent to the VA203B/6975, this tube has improved vibration f.m. performance, and will operate under severe environmental conditions. The frequency range is 8.5GHz to 9.6GHz, mechanically tuned by a single screw. Output power (typical) is 35mW. English Electric Valve Co. Ltd, Chelmsford, Essex.

WW315 for further details

Dual-in-line Sockets

A range of 14-pin dual-in-line sockets is now available from EF Electronics, Tovil, Maidstone, Kent. The new socket features a generous lead-in for easy loading and a large central channel for easy removal of i.c.s. The body is glass-filled nylon. Contacts are beryllium or phosphor bronze, both with 1 micron of hard gold over a nickel flash, or phosphor bronze with no finish. Contact resistances are 15mΩ, 25mΩ or 50mΩ maximum according to contact finish and measured after 1000 insertions. Insulation is

$10^3 M\Omega$ at 500V and capacitance is 2pF maximum measured between any two adjacent contacts. Cost varies from 2s 9d to 6s 0d according to quantity. EF Electronics, Church Road, Tovil, Maidstone, Kent.

WW314 for further details

High Noise-immunity I.Cs

Two t.t.l. integrated circuits announced by Mullard have a noise immunity figure of not less than $\pm 6V$. The integrated circuits, types GRL111 and GRL101 are intended to provide interface connections with a balanced pair cable, the GRL111 acting as the transmitter and the GRL101 as the receiver. They can be used to complete a compatible link between two independent logic systems. Although designed for use with the Mullard FJ family of integrated circuits, they can be used with almost all saturated logic families. Typical propagation delay for GRL111 is 14ns, and 25ns for GRL101. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.

WW316 for further details

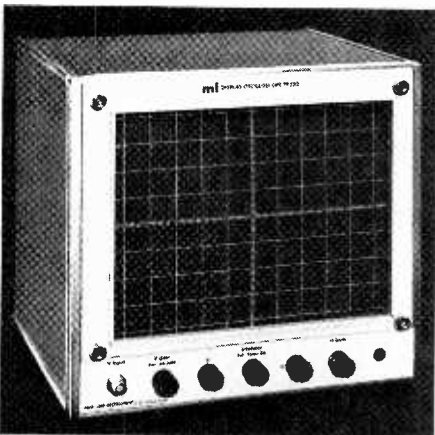
High Current Thyristors

Two new series of 10A and 20A silicon controlled rectifiers, for power switching, voltage regulation and control applications, are available from RCA. The 10A s.c.r.s, designated 40737 to 40748, are intended for 120-V line, 240-V line and high voltage operation and are incorporated in metal packages of press fit, stud, or isolated stud design. The 20A s.c.r.s, designated 40749 to 40760 are also available in press fit, stud and isolated package designs. V_{drom} (repetitive peak off-state voltage) is 100V, 200V, 400V, and 600V for both series which are available from RCA's distributors: Semicomps Northern Ltd, of Kelso; E.C.S. Ltd, of Windsor; and R.E.L. Equipment and Components Ltd, of Bancroft, Herts.

WW 303 for further details

X-Y Display Oscilloscope

Marconi Instruments have produced an X-Y display monitor with a screen area of 170×220 mm. The unit, TF 2212, complements the existing range of the



company's sweep generators. Vertical sensitivities are calibrated 5mV/cm and 50mV/cm positions with continuously variable control. The vertical bandwidth is from d.c. to 10kHz. Horizontal sensitivity is 100mV/cm (approx.) with continuously variable control. The horizontal bandwidth is d.c. to 1kHz. Price about £180 in U.K. Marconi Instruments Ltd, St. Albans, Herts.

WW 302 for further details

Power Microcircuits

The PM range of power hybrid microcircuits from WEL is designed for low-cost power control applications. They are particularly suited for stepless speed control of universal motors and variable power supplies. Various combinations of thyristors and/or diodes are encapsulated in epoxy resin mounted on a heat sink with connections made by spade tags. Due to the high thermal conductivity of the heat sink, currents of up to 12A may be handled by the circuits. Three types of circuit are in production: the PM5, a thyristor and diode combination with current load capability up to 12A, for use as a half-wave motor speed control system; PM7, a full-wave rectifier bridge; and PM6, diode pairs. From these two latter types a variety of d.c. power supplies can be produced with outputs up to 9A. They can also be combined to form three-phase bridges, solid state a.c./d.c. switches and high voltage stacks. All three microcircuits are available with a variety of operating voltages—PM5 from 200-800V, PM6 and 7 from 200-1400V. The price of a 5A 400V universal motor controller type PM7, output 9 amps, is 16s 9d (100 pieces). WEL Components Ltd, 5 Loverock Road, Reading, Berks.

WW 301 for further details

Broadband Suppressors

A range of interference suppressors—the Ammonite range—is available from Birch-Stolec. Although designs are possible for cut-off frequencies as low as 2kHz, it is expected, by the manufacturers, that the most frequent applications will be in the 20-100kHz region. The range has a voltage rating up to 250V a.c. 50Hz, rated current of 0.5 to 15A and a cut-off frequency from 5kHz to 50kHz. In the discoidal (grommet) Ammonite, interference energy is converted to heat. Birch-Stolec Ltd, Ponswood Industrial Estate, Windmill Road, Hastings, Sussex.

WW 307 for further details

8-track Magnetic Recording Head

Multi-track operation in small computers is now made possible, claim Phi Magnetronics, by their new 8/8 magnetic head. Gap scatter is claimed to be better than $25\mu s$ at $7\frac{1}{2}$ i.p.s. Designed for use with quarter-inch tape, the new head, type



DHM/030, has a track width of 0.5mm and track spacing of 0.81mm. Inductance at 1kHz is $30mH \pm 20\%$. Playback full level is $85\mu V \pm 1.5dB$. Crosstalk from a tape recorded to saturation level on seven tracks, measured on the unrecorded track, is better than $-20dB$. Signal current is $300\mu A$ r.m.s. and peak bias 1.7mA at 50kHz. Phi Magnetronics (Sales) Ltd, Penwerris Lane, Falmouth, Cornwall.

WW 305 for further details

M.O.S. Random Access Memory

A low-cost 64-bit semiconductor random access memory constructed with m.o.s. transistors (type MC1170L) has been introduced by Motorola. Access time is 400ns. Organized as 16 words of four-bits each, it uses a four-input binary address and contains full decoding circuitry. An ENABLE input is provided for easy address expansion. Read/write buffer circuits on the output bit lines, which allow as many as 20-bit lines to be "wired ORed", simplify the design of larger memory systems using this unit. Further simplification is afforded by the single-phase clock used by the device. Designed for use in memory systems with access times of less than 500ns, the MC-1170L is intended primarily for small buffer memories but, because the stored data is read nondestructively, it can find application in systems where destructive-readout delay-line memories are used. Motorola Semiconductors Ltd, York House, Empire Way, Wembley, Middx.

WW 309 for further details

F.E.T. Op. Amp

A low-cost f.e.t.-input differential amplifier, the Fairchild Controls ADO-84/10, announced by G.D.S. (Sales) has 50pA maximum initial bias current, 25pA offset current and $50\mu V/^\circ C$ maximum offset drift. Open-loop gain is 100dB with a small-signal bandwidth of 1MHz. Full output bandwidth is 75kHz at $\pm 10V$ and $\pm 5mA$, slew rate being $4V/\mu s$. Full short circuit protection is built in. Both common-mode and differential input impedances are $10^{12}\Omega$ with 60dB common-mode rejection. The amplifier is suitable for operation over the temperature range $-25^\circ C$ to $+85^\circ C$ and needs $\pm 15V$, 10mA supply. A mating socket (ASO-2) is also available. Price £7 2s 10d. G.D.S. (Sales) Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Bucks.

WW 306 for further details

Literature Received

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

ACTIVE DEVICES

We have received two pocket books from Newmarket Transistors Ltd, Exning Rd, Newmarket, Suffolk.

Custom hybrid microcircuits WW401
Products mini portfolio WW402

A frequency-sensitive switch microcircuit type FX101 is described in leaflet D/026 from Consumer Microcircuits Ltd, 142/146 Old St, London, E.C.1. WW403

The phase-locked-loop microcircuit type NE560B and NE561B manufactured by Signetics is described in a leaflet from LST Electronic Components Ltd, 7 Coptfold Rd, Brentwood, Essex. WW404

National Semiconductor, 2900 Semiconductor Drive, Santa Clara, California 95051, U.S.A., have produced an interesting brochure called "Reliability report—m.o.s. integrated circuits". The data is compiled from 1,479,000 life test device hours WW405

A 36-page publication giving data on the AEG range of thyristors, triacs and diodes may be obtained from Electronic Component Services (Worcester) Ltd, Victoria House, 63-66 Foregate St, Worcester WW406

Over 200 c.r.t. types are covered in the new brochure from Brimar (Thorn Radio Valves and Tubes Ltd, 7 Soho Square, London, W.1.). The brochure is called "Brimar industrial cathode ray tubes" and consists of 30 pages WW407

Application note No.3 from Hivac Ltd, Stonefield Way, Ruislip, Middlesex, discusses a glow diode for photocell switching, describes flash tubes and gives details on calculating the operating conditions of neon lamps WW408

Full circuit diagrams and component lists with relevant constructional information for a complete multi-channel proportional radio control system is given in the publication "A six-channel digital proportional radio control system" which costs 3s 6d from Ferranti Ltd, Gem Mill, Chadderton, Oldham, Lancs.

A new application note from Mullard (TP1149) describes a high input impedance f.e.t. input stage for an operational amplifier. I.E.D., Mullard Ltd, Mullard House, Torrington Place, London, W.C.1. WW409

"A novel shaper circuit for d.t.l. and t.t.l. input interfacing" is the title of an application note produced by ITT Semiconductors,

Footscray, Sidcup, Kent WW410

We have received a variety of application notes from RCA Electronic Components, Harrison, New Jersey 07029, U.S.A.

AN4124. "Handling and mounting RCA moulded plastic transistors and thyristors" WW411
1CAN6218. "Gate-oxide protection circuit in RCA cos/m.o.s. digital integrated circuits" WW412
AN4242. "A review of thyristor characteristics and applications" WW413
1CAN6267. "Astable and monostable oscillators using RCA cos/m.o.s. digital integrated circuits" WW414
AN4277. "Description and application of RAC Numitrons" WW415
We have also received from RCA their "Receiving Tube manual" (RC27) consisting of 672 pages devoted to entertainment valves and tubes. Price \$2.

Filing Instruction No.16 is available for the AEI Semiconductors Technical Data Handbook. AEI Semiconductors Ltd, Carholme Rd, Lincoln WW416

Ferranti, Gem Mill, Chadderton, Oldham, Lancs, have sent us a good deal of literature on their 7400 series t.t.l. for industrial temperature ranges WW417

"Electronic component selector guide" from Celdis Ltd, 37-39 Loverock Rd, Reading, Berks RG3 1ED, lists a wide range of products, mostly semiconductor, from a large number of manufacturers WW418

PASSIVE COMPONENTS

Rank-Bush-Murphy have produced their first catalogue of electronic components. The catalogue, which is not a catalogue of replacement parts for R-B-M receivers, lists 1,800 components. Rank-Bush-Murphy Ltd, Drayton Rd, Boreham Wood, Herts .. WW419

The current ITT Electronic Services (Edinburgh Way, Harlow, Essex) stock catalogue has been enlarged to 1168 pages and lists a vast range of electronic components .. WW420

"Advance Data—No.18" from AMP of Great Britain Ltd, Terminal House, Stanmore, Middlesex, is devoted mainly to the "Termin-twist" connection system WW428

We have received the following literature from

F. C. Lane Electronics Ltd, Slinfold Lodge, Horsham, Sussex.

Short-form catalogue (plugs and sockets) WW421
Rendar price list WW422
Ether price list WW423

A smart set of cards in a cardboard wallet describes the expanded range of Amphenol min-rac 17 plug and socket connectors. Amphenol Ltd, Thanet Way, Whitstable, Kent WW424

A 26-page catalogue containing details of a variety of switches is available from Carlingswitch Ltd, Victoria Works, Water Lane, Watford, Herts. WW425

Heat sinks, racks, printed cards and reed and mercury relays are listed in a catalogue, in French, available from S.E.E.M., 8, rue Boutard, 92-Neuilly, France WW426

West Hyde Developments Ltd, Ryefield Cres., Northwood Hills, Northwood, Middlesex, have produced a range of illuminated push-button switches which are described in a leaflet WW427

EQUIPMENT

"Dana—A world of measurement capability" is the short-form catalogue of Dana Electronics Ltd, Bilton Way, Dallow Rd, Luton, Beds. It lists a variety of test equipment WW429

The latest short-form catalogue from the Croydon Precision Instrument Company, Hampton Rd, Croydon CR9 2RU, lists ranges of bridges, precision potentiometers, resistance boxes and standards, supply units, voltage ratio boxes, etc WW430

Spectrum analysers, noise and field intensity meters, a.c.-d.c. standards and precision measuring equipment, synco test equipment, voltmeters, frequency meters and generation equipment are featured in the new short-form catalogue from Singer Instrumentation which is available from Roberts Electronics, 17 Hermitage Rd, Hitchin, Herts WW431

"Keithley engineering notes" Vol.18, No.1, describes a d.c. current source (0.005% regulation, 0.02% resolution and 500V capability), a picoampere source (10^{-14} to 10^{-4} A, accuracy 0.25%) and a unity gain isolating amplifier ($10^{12}\Omega$ input isolation, $\pm 0.3\%$ gain linearity). It is available from Keithley Instruments Inc., 28775 Aurora Rd, Cleveland, Ohio 44139, U.S.A. WW432

A logic tutor, Computakit-1, is described in a leaflet from Limrose Electronics, Lymm, Cheshire WW433

GENERAL INFORMATION

A directory of the laboratories approved by the British Calibration Service can be obtained from: The British Calibration Service, Stuart House, 23-25 Soho Square, London, W.1. WW434

Anyone interested in joining the British Amateur Electronics Club should send for the latest copy of the B.A.E.C. Newsletter to C. Bogod, "Dickens", 26 Forest Rd, Penarth, Glamorgan.



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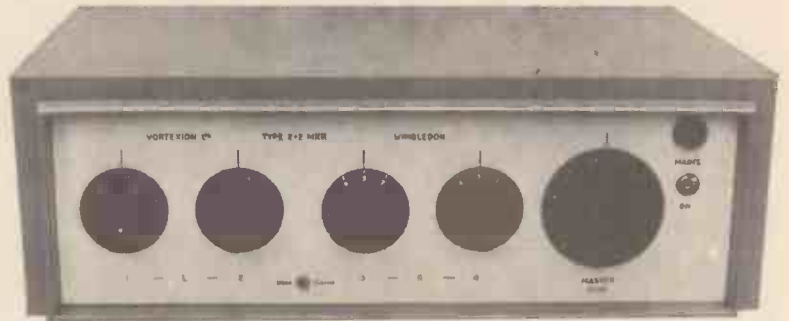
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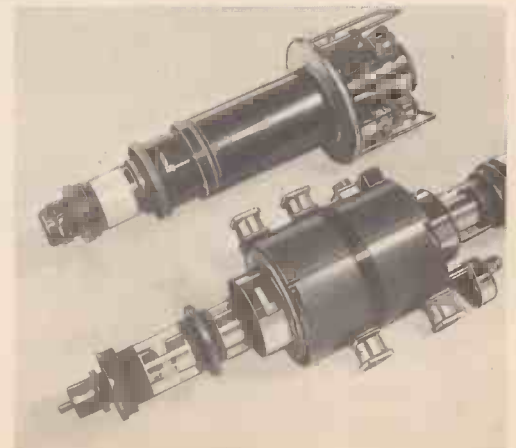
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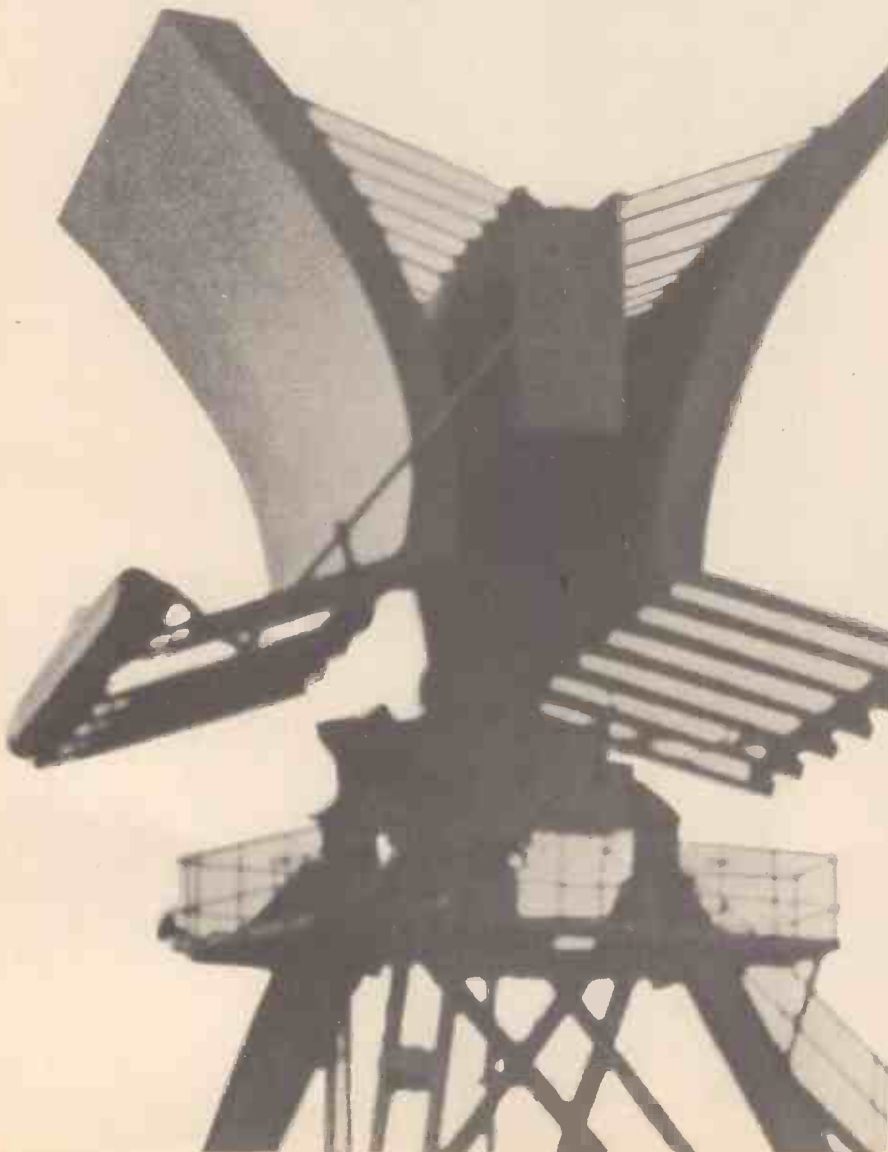
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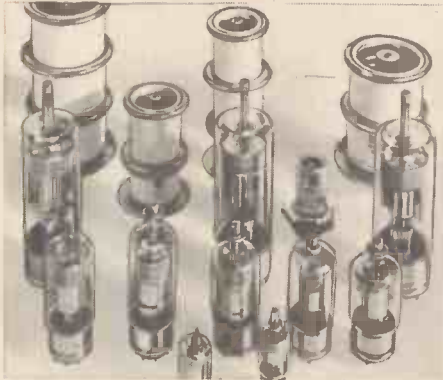


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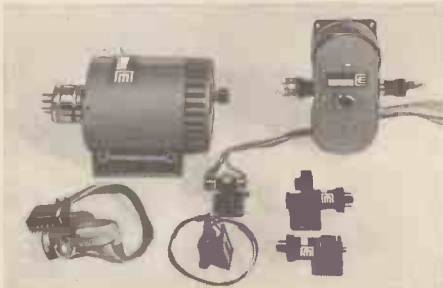
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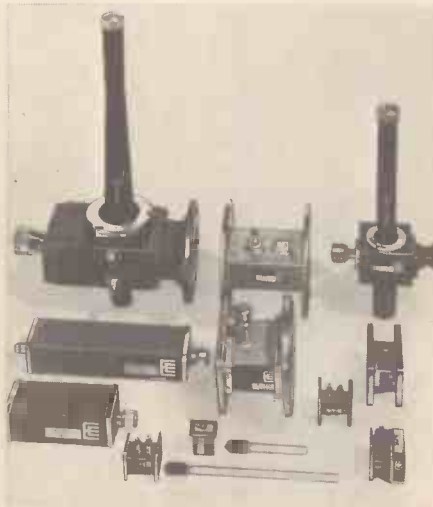
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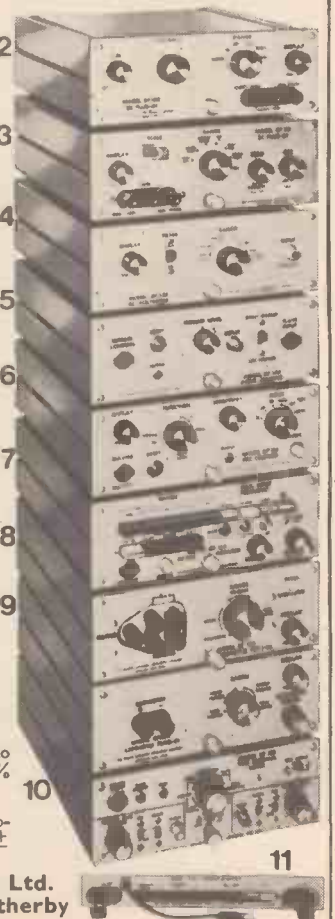
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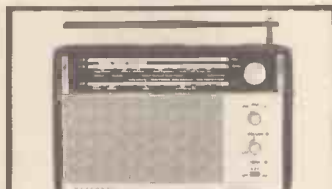
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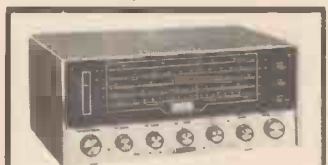
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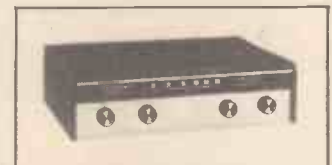
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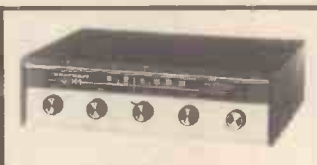
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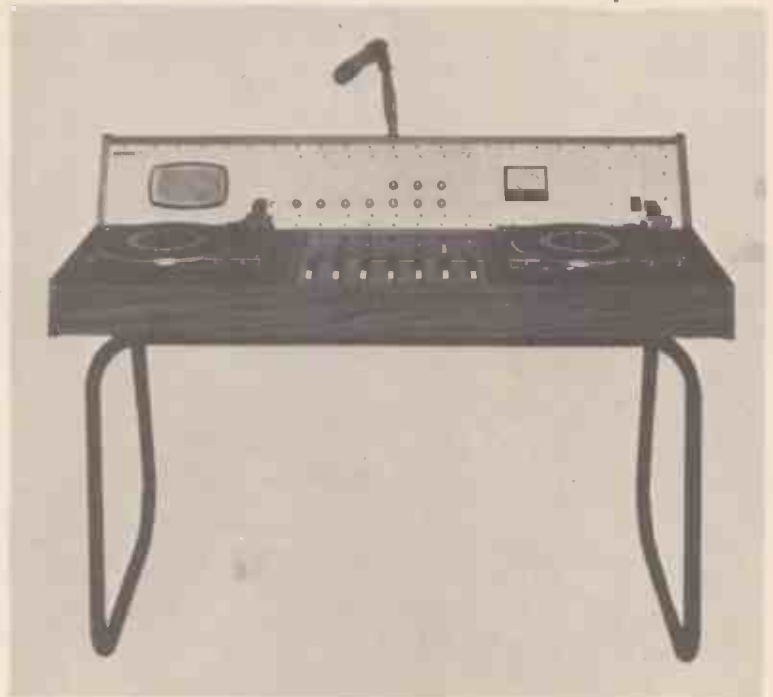
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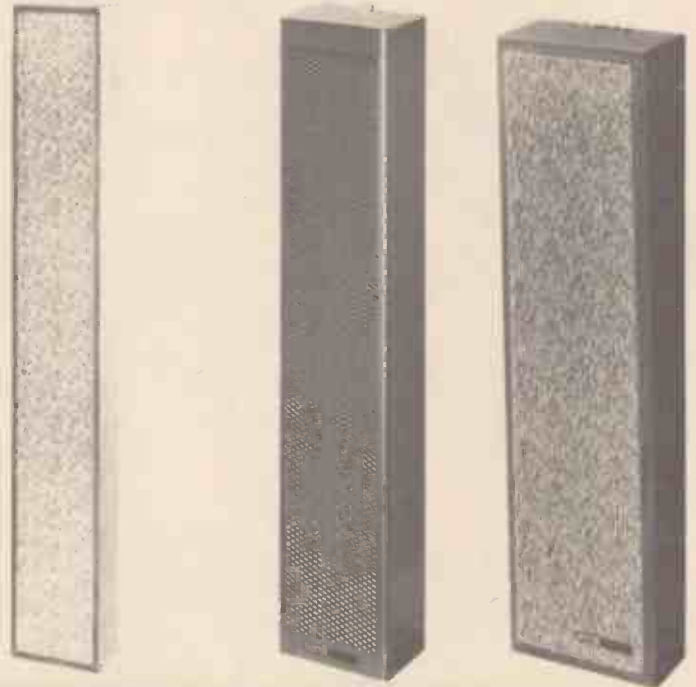
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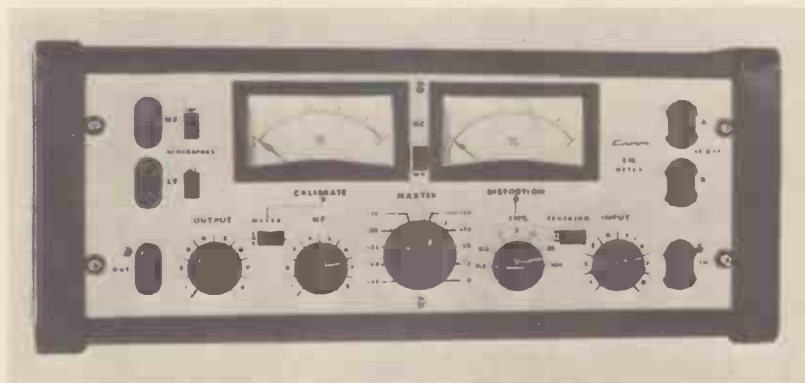
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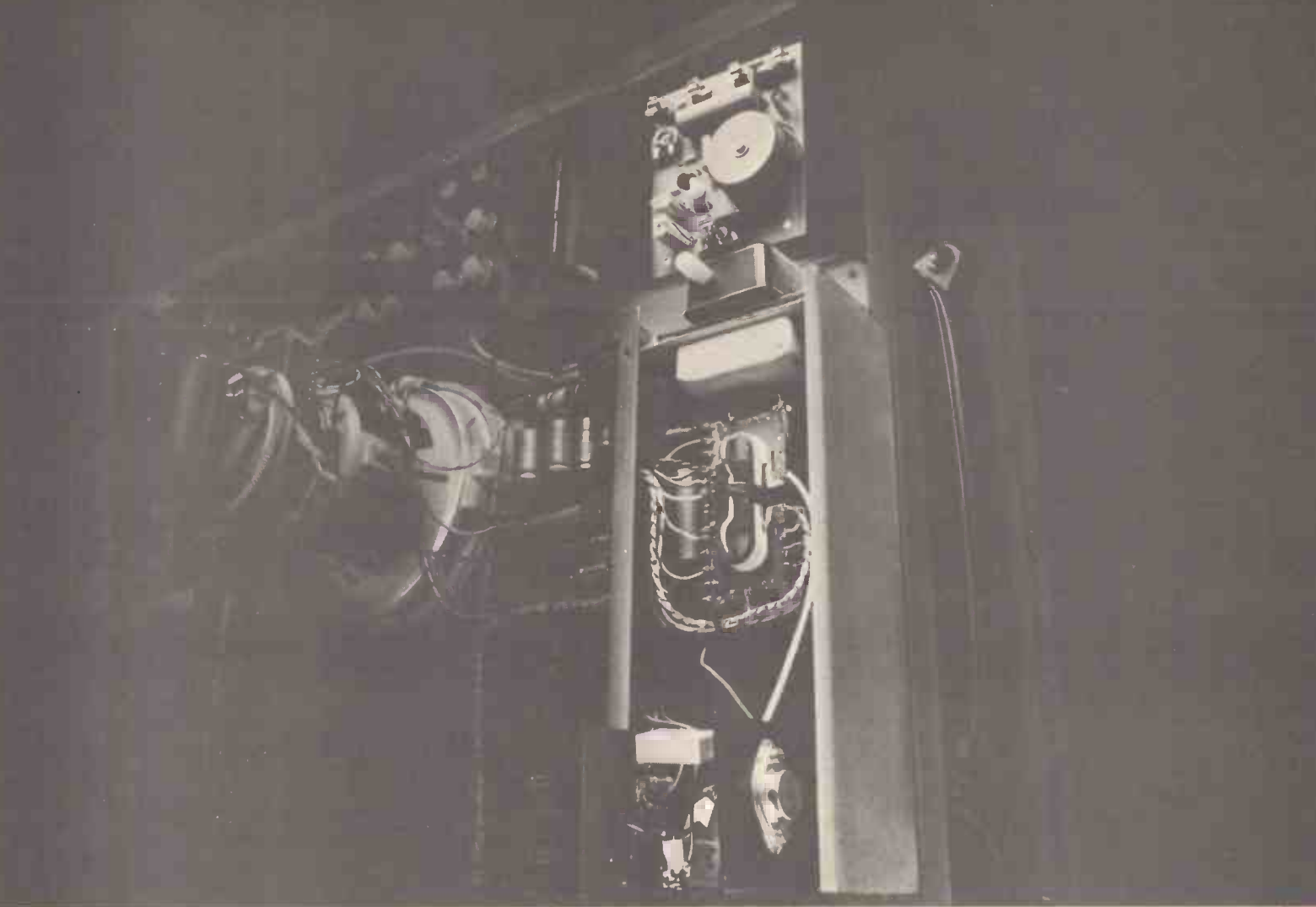


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One of the major decisions that manufacturers of TV components have faced is the choice between high and low voltage line output circuitry. On the basis of an extended evaluation programme, Mullard settled for the high-voltage solution some three years ago, and started work to solve the specific device problems. This decision was based on the specialised knowledge which our Central Applications Laboratory had of the advantages this solution would bring to Setmakers.

Once the development tasks had been set, all our resources were co-ordinated to make a concentrated effort to develop these necessary and most complex devices—the TV line output transistor BU105 and the BT106 thyristor.

The BU105 is technically outstanding. It can operate at a maximum peak collector-to-emitter voltage of 1.5kV, and one device can supply the scanning and e.h.t. power for 110° monochrome TV,

which can be as high as 3 000VA. For colour TV, where the VA can rise to 5 000VA, two BU105's are usually used in series, and the nominal peak operating voltage of 2kV is well within the combined ratings of the two transistors. The peak collector current requirement is adequately covered by the BU105's 2.5A rating.

At the same time that the BU105 was being developed, a second team was working on the problems of providing a fully protected and regulated power supply for TV. This was built around the rugged Mullard Thyristor BT106. The circuit was developed using techniques our designers have employed for the speed control of domestic appliances, and is designed to supply a stabilised line of up to 200V at up to 700mA. A number of special passive components are used in these circuits; and these were developed at the same time within the Mullard organisation.

Why the Mullard High-Voltage Solution is the Answer. By using our line output transistor BU105 and thyristor BT106, Setmakers are able to build receivers of excellent stability, and at the same time save on component costs, space, and lower the heat level within the television cabinet. The old bulky and expensive mains transformer can be eliminated together with its incumbent magnetic field.

Uniquely the BU105 transistor also acts as its own efficiency diode with no loss of

linearity, thereby saving yet more components.

The BT106 power supply circuitry has a high safety factor even under fault conditions. It is compact and has extremely low dissipation. Together, the BU105 and BT106 and their associated circuits represent what is probably the most advanced television scanning plus power supply concept in the world today.

Worth it? Our unique experience in components for consumer electronics allows us to bring many resources to bear on individual problems and in this case made possible an outstanding TV circuit solution. We can also be sure that our products will give continuous and consistent service—our detailed knowledge of their use helps us to relate the highest quality with the best possible price, and this is something which applies across the very wide Mullard component range.

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213	1.0A	0-12V @ 1 Amp x 2	3 1/2 x 2 x 2	1 0	17/6 16/2
71	2.0A	0-12V @ 1 Amp x 2	2 1/2 x 2 1/2 x 2 1/2	1 0	23/11 21/4
68	3.0A	0-12V @ 3 Amp x 2	3 1/2 x 2 1/2 x 2 1/2	2 0	28/8 26/6
18	4.0A	0-12V @ 2 Amp x 2	3 1/2 x 2 1/2 x 2 1/2	2 4	32/4 29/11
85	5.0A	0-12V @ 5 Amp x 2	4 x 3 1/2 x 3 1/2	3 2	36/11 34/11
70	6.0A	0-12V @ 6 Amp x 2	4 x 3 1/2 x 3 1/2	3 12	39/- 36/11
108	8.0A	0-12V @ 4 Amp x 2	4 x 3 1/2 x 3 1/2	4 6	44/1 40/8
72	10.0A	0-12V @ 5 Amp x 2	3 1/2 x 4 1/2 x 4	6 3	51/3 47/5
17	16.0A	0-12V @ 8 Amp x 2	4 1/2 x 4 1/2 x 4	7 8	79/- 73/11
115	20.0A	0-12V @ 10 Amp x 2	4 1/2 x 4 1/2 x 4	11 13	100/6 92/11
187	30.0A	0-12V @ 15 Amp x 2	5 1/2 x 4 1/2 x 4 1/2	16 12	185/6 171/7

Ref. No.	PRIMARY VOLTAGE 200-250V		SECONDARY VOLTAGE 24V		Price
	Current	Secondary Windings	Dimensions inches	Weight lbs. ozs.	
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71	1.0A	0-12V @ 1 Amp x 2	2 1/2 x 2 1/2 x 2 1/2	1 7	23/11 21/4
18	2.0A	0-12V @ 2 Amp x 2	3 1/2 x 2 1/2 x 2 1/2	2 4	32/4 29/11
114	3.0A	0-12-24V @ 3 Amp x 2	2 1/2 x 3 x 3	3 6	39/- 36/11
108	4.0A	0-12V @ 2 Amp x 2	4 x 3 1/2 x 3 1/2	4 6	44/1 40/8
72	5.0A	0-12V @ 5 Amp x 2	4 x 4 1/2 x 3 1/2	5 12	51/3 47/5
116	6.0A	0-24V @ 6 Amp x 2	4 x 3 1/2 x 3 1/2	6 3	61/6 56/11
17	8.0A	0-12V @ 8 Amp x 2	4 1/2 x 3 1/2 x 4	7 8	79/- 73/11
115	10.0A	0-12V @ 10 Amp x 2	4 1/2 x 4 1/2 x 4	11 13	100/6 92/11
187	15.0A	0-12V @ 15 Amp x 2	5 1/2 x 4 1/2 x 4 1/2	16 12	185/6 171/7

Ref. No.	PRIMARY VOLTAGE 200-250V		SECONDARY VOLTAGE 30V		Price
	Current	Secondary Taps	Dimensions inches	Weight lbs. ozs.	
112	0.5A	0-12-15-24-30V	3 1/2 x 2 1/2 x 1 1/2	1 4	17/6 16/2
79	1.0A	"	2 1/2 x 2 1/2 x 2 1/2	2 0	23/7 21/10
3	2.0A	"	3 1/2 x 2 1/2 x 3	3 2	31/10 29/4
20	3.0A	"	4 x 3 1/2 x 3 1/2	4 6	43/11 39/-
21	4.0A	"	4 x 3 1/2 x 3 1/2	6 0	51/3 47/5
51	5.0A	"	4 1/2 x 3 1/2 x 4	6 8	63/11 58/4
117	6.0A	"	4 1/2 x 3 1/2 x 4	7 8	75/10 70/11
88	8.0A	"	5 1/2 x 3 1/2 x 4 1/2	9 6	100/6 92/11
89	10.0A	"	5 1/2 x 4 x 4 1/2	12 2	124/11 114/8

Ref. No.	PRIMARY VOLTAGE 200-250V		SECONDARY VOLTAGE 50V		Price
	Current	Secondary Taps	Dimensions inches	Weight lbs. ozs.	
102	0.5A	0-19-25-33-40-50V	2 1/2 x 2 1/2 x 2 1/2	1 11	23/11 21/4
103	1.0A	"	3 1/2 x 2 1/2 x 2 1/2	2 0	33/10 31/4
104	2.0A	"	4 x 3 1/2 x 3 1/2	5 0	46/8 43/3
105	3.0A	"	4 x 3 1/2 x 3 1/2	6 0	63/7 58/8
106	4.0A	"	4 1/2 x 4 1/2 x 4	9 4	84/- 77/8
107	6.0A	"	4 1/2 x 4 1/2 x 5 1/2	12 4	124/11 114/8
118	8.0A	"	5 1/2 x 5 1/2 x 4 1/2	18 9	162/- 149/10
119	10.0A	"	6 1/2 x 4 1/2 x 6 1/2	19 12	203/- 187/8

Ref. No.	PRIMARY VOLTAGE 200-250V		SECONDARY VOLTAGE 60V		Price
	Current	Secondary Taps	Dimensions inches	Weight lbs. ozs.	
124	0.5A	0-24-30-40-48-60V	3 1/2 x 3 1/2 x 2 1/2	2 4	23/7 21/10
126	1.0A	"	3 1/2 x 3 x 3	3 0	32/10 30/4
127	2.0A	"	4 x 3 1/2 x 3 1/2	5 6	46/8 43/3
125	3.0A	"	4 1/2 x 3 1/2 x 4	7 0	75/10 70/11
123	4.0A	"	4 1/2 x 3 1/2 x 4 1/2	10 6	100/6 92/11
40	5.0A	"	5 1/2 x 5 x 5 1/2	13 4	121/- 111/11
120	6.0A	"	5 1/2 x 4 1/2 x 4 1/2	16 12	145/7 134/7
21	8.0A	"	6 1/2 x 5 1/2 x 4 1/2	20 3	192/8 177/8
122	10.0A	"	6 1/2 x 5 x 6 1/2	23 2	241/- 223/-
189	12.0A	"	5 1/2 x 6 1/2 x 6 1/2	31 0	289/6 267/6

Ref. No.	PRIMARY VOLTAGE 200-250V		SECONDARY WINDINGS 240V CENTRE TAPPED AND EARTH SHIELDED		Price
	V.A.	For alternative 115 Volt Secondaries quote Ref. No.	Dimensions inches	Weight lbs. ozs.	
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61	100	192	4 x 3 1/2 x 3 1/2	5 12	45/7 42/6
30	200	193	4 1/2 x 4 x 4	9 12	82/5 76/4
62	250	194	3 1/2 x 5 x 4 1/2	12 4	100/11 93/3
55	350	195	5 1/2 x 5 1/2 x 4 1/2	17 6	137/4 127/-
63	500	196	6 1/2 x 4 1/2 x 6 1/2	27 0	194/8 180/11
96	750	197	5 1/2 x 6 1/2 x 6 1/2	31 0	277/8 256/9
92	1000	198	7 x 7 x 8 1/2	40 0	358/8 331/8
97	1250	199	7 x 7 x 8 1/2	47 0	440/8 407/7
128	2000	200	9 1/2 x 8 1/2 x 6	63 0	593/8 548/7
129	3000	201	8 1/2 x 8 1/2 x 8	84 0	927/7 857/11
190	6000	202	12 1/2 x 14 x 6 1/2	178 0	1,524/2 1,409/7

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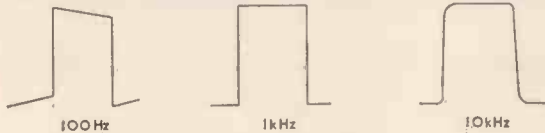
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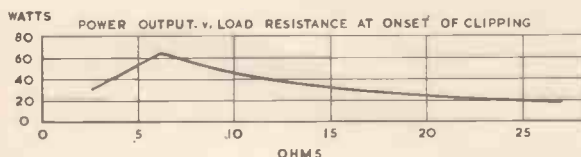
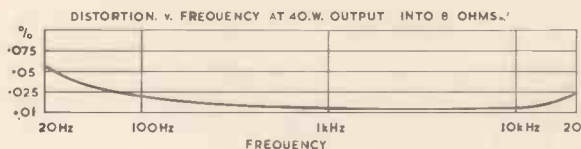
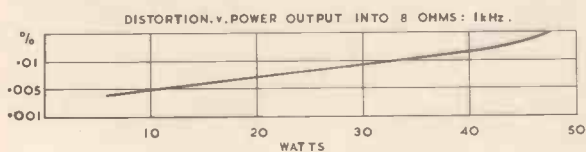
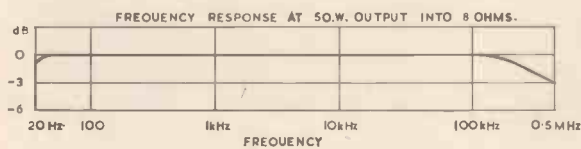
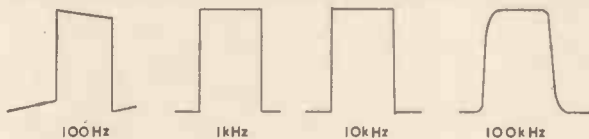
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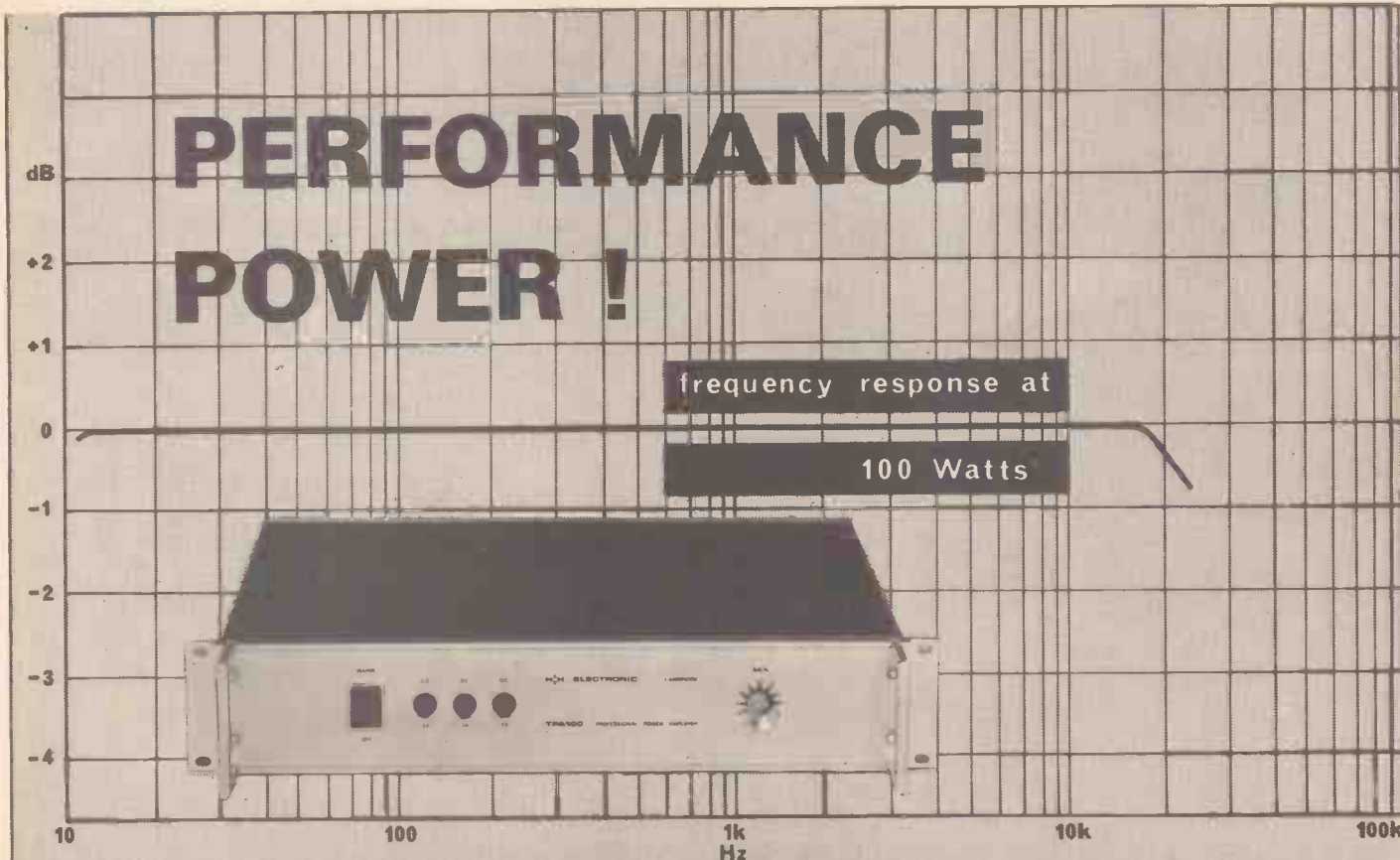


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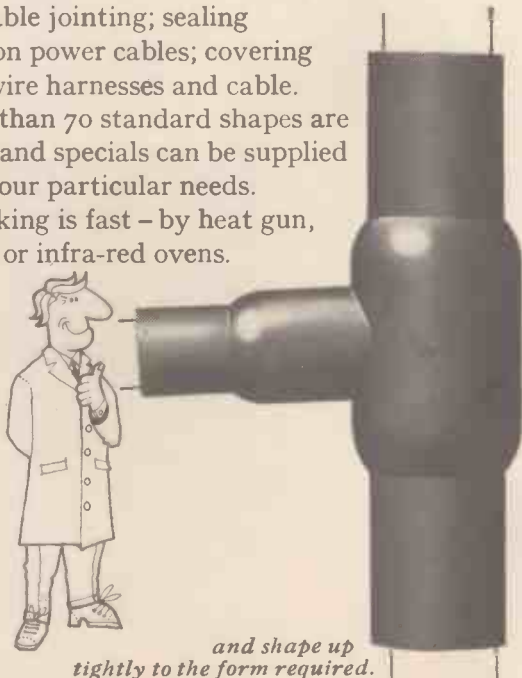
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PS-510

TS-510

VFO-5D

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TS-510 SSB TRANSCEIVER

- Receive and Transmit Frequencies: 3.5MHz-29.7MHz
- Receive Sensitivity: 0.5 μ V, S/N ratio of 10dB at 2.5MHz-21MHz
1.5 μ V, S/N ratio of 10dB at 28MHz
- DIMENSIONS: 13"(W), 7"(H), 13-5/8"(D).

VFO-5D VARIABLE FREQUENCY OSCILLATOR

- Frequency Range: 3.5MHz-29.7MHz
- Oscillator Method: VFO unit-clapp Osc. Circuit Xtal Osc. Unit-Pierce C-B Circuit
- DIMENSIONS: 7-7/8"(W), 8-21/32"(H), 7-9/16"(D).

PS-510 POWER SUPPLY AND SPEAKER

- Designed as an A.C. power supply unit exclusively for the SSB transceiver TS-510
- 6-1/2" communication speaker is incorporated
- DIMENSIONS: 8"(W), 7-1/8"(H), 14-5/8"(D).



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Output Attenuation:	0-110 dB continuously variable.
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Monitor Output Meter:	Scaled 0-3, 0-10, and dBm.
Mains Input:	100 V.-250 V. 50/60 Hz.
Size:	17½ x 11 x 8 in.
Weight:	25 lb.
Price:	£150.

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Specification	
Frequency Range:	20 Hz-20 kHz (6 ranges).
Distortion Range:	0.01%-100% f.s.d. (9 ranges).
Sensitivity:	100 mV.-100 V. (3 ranges).
Meter:	Square law r.m.s. reading.
Input Resistance:	100 kOhms.
High Pass Filter:	3 dB down at 350 Hz. 30 dB down at 45 Hz.
Frequency Response:	±1 dB from second harmonic of rejection frequency to 250 kHz.
Power Requirements:	Included battery.
Size:	17½ x 11 x 8 in.
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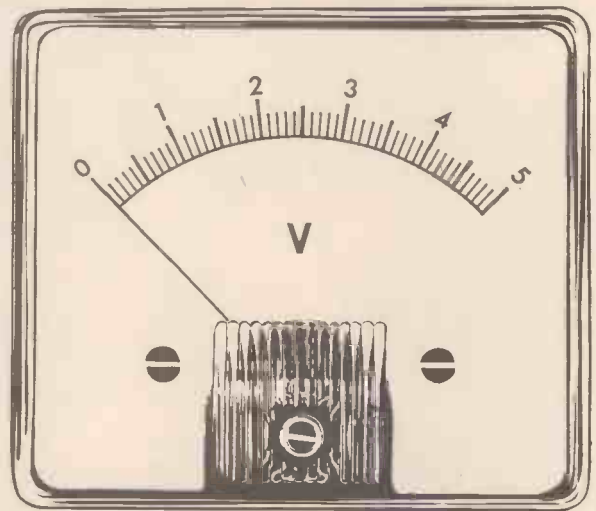
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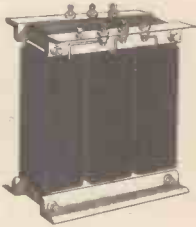
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Transformers, Chokes

Saturable Reactors

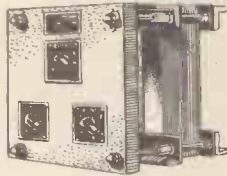
Voltmobile voltage regulators

Rectifier Sets



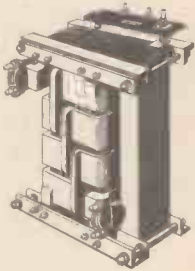
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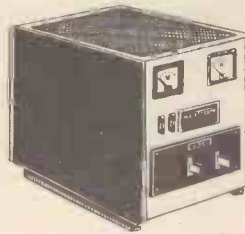
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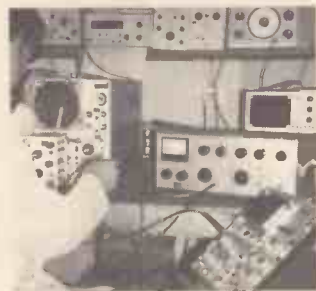
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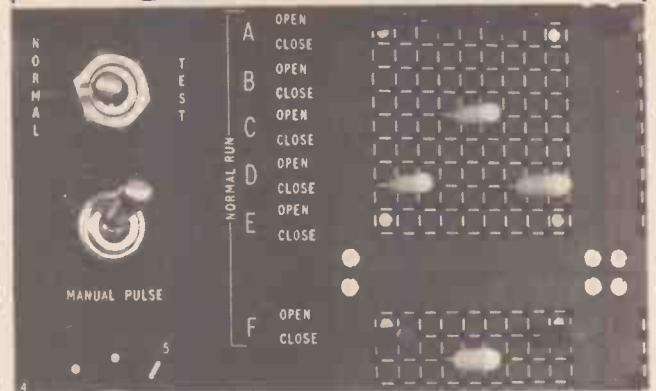
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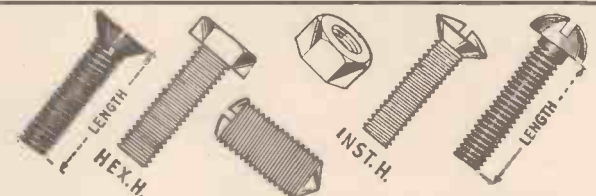
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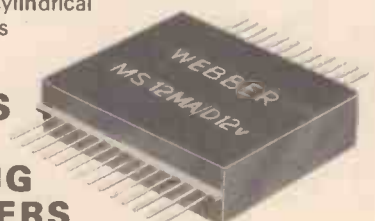
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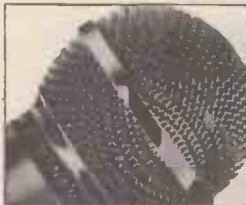
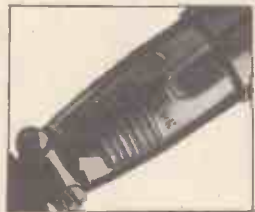
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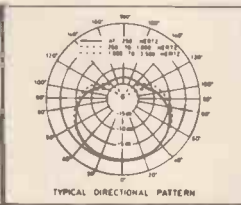
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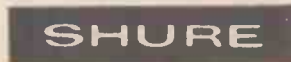
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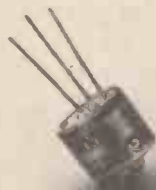
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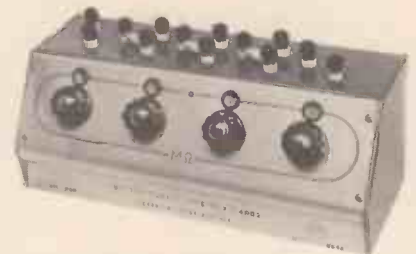
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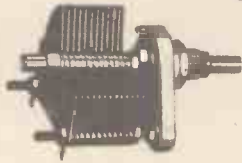
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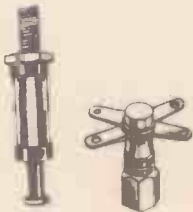
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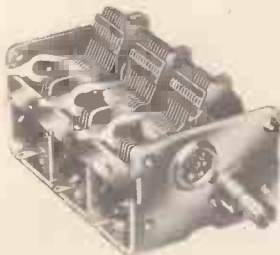
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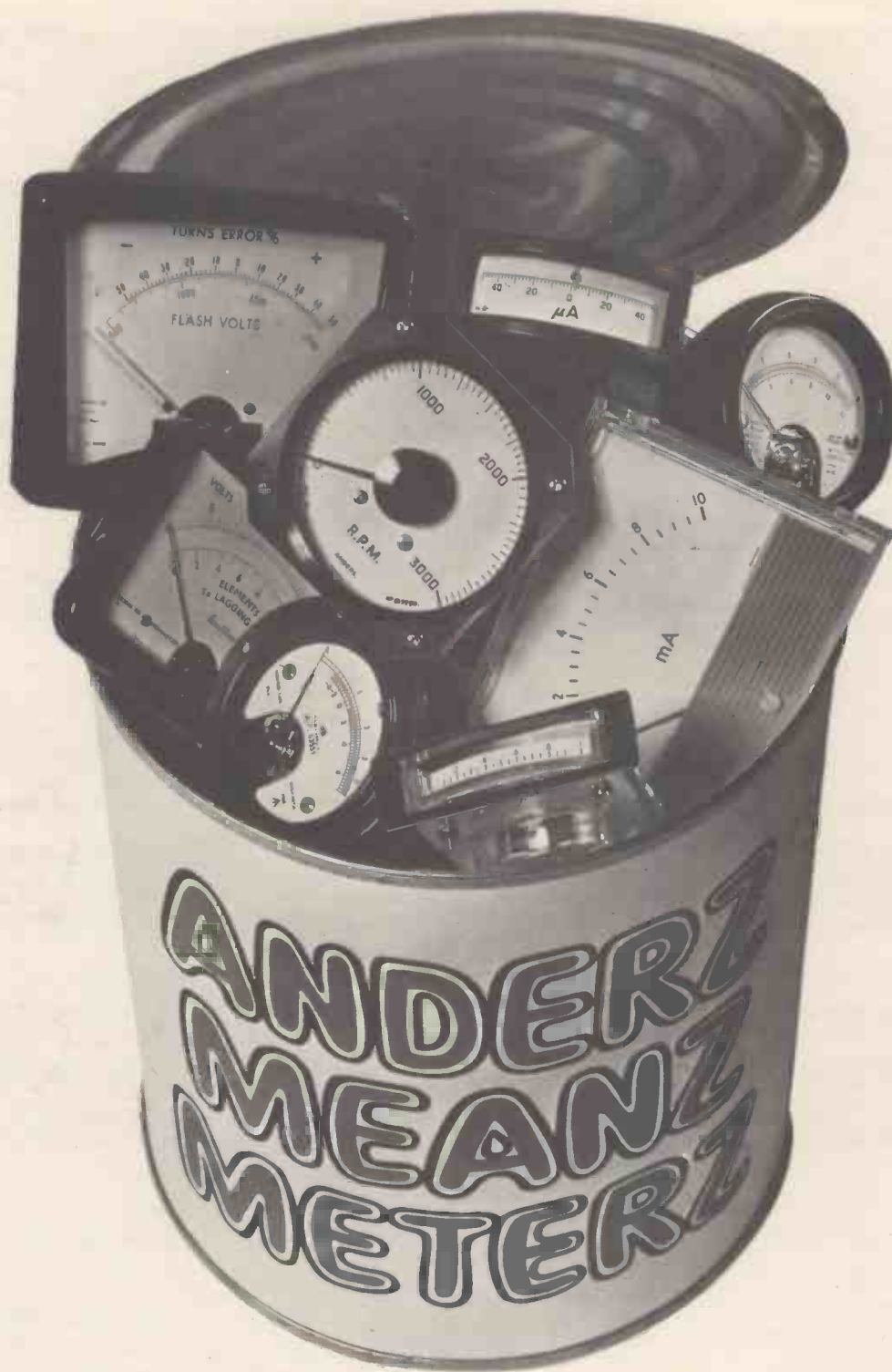
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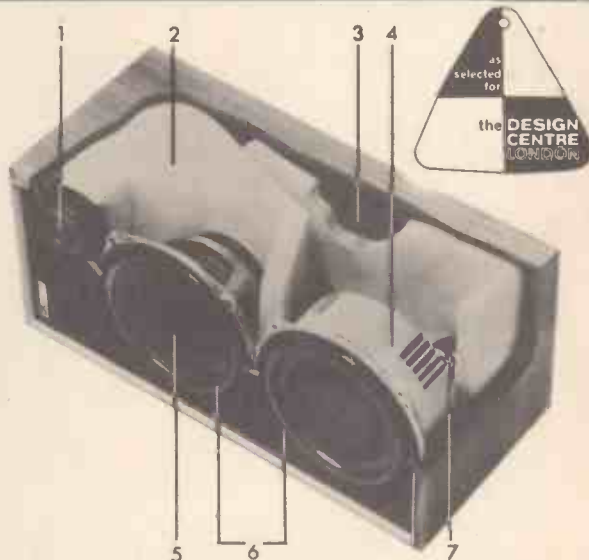
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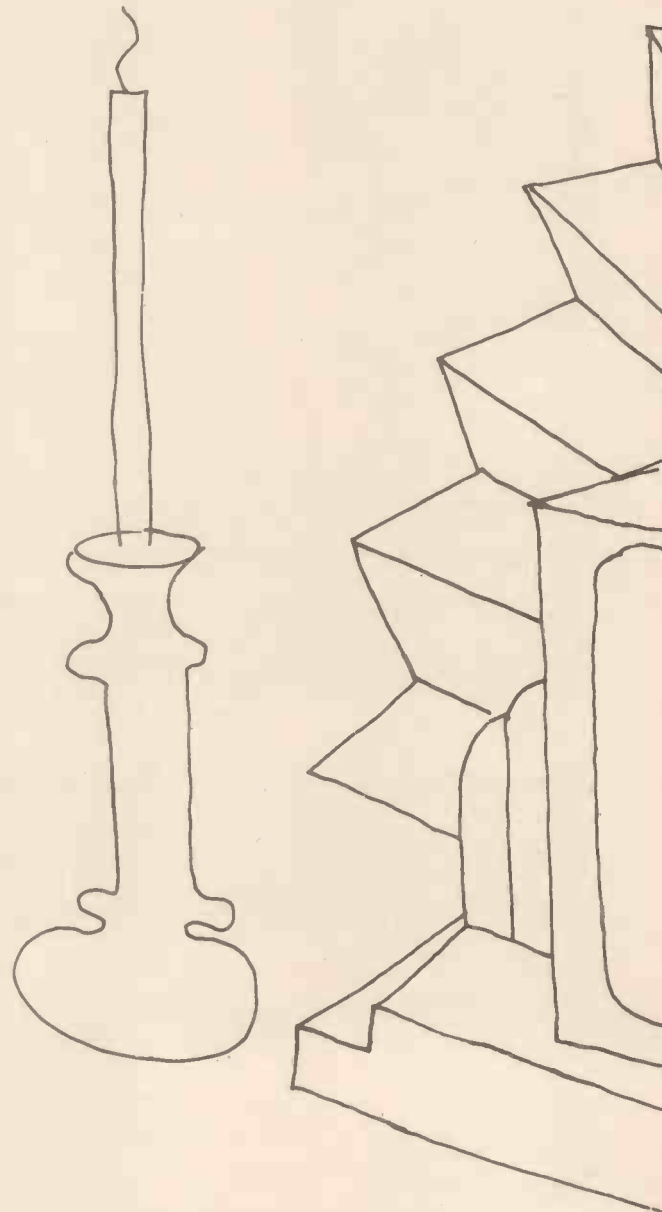
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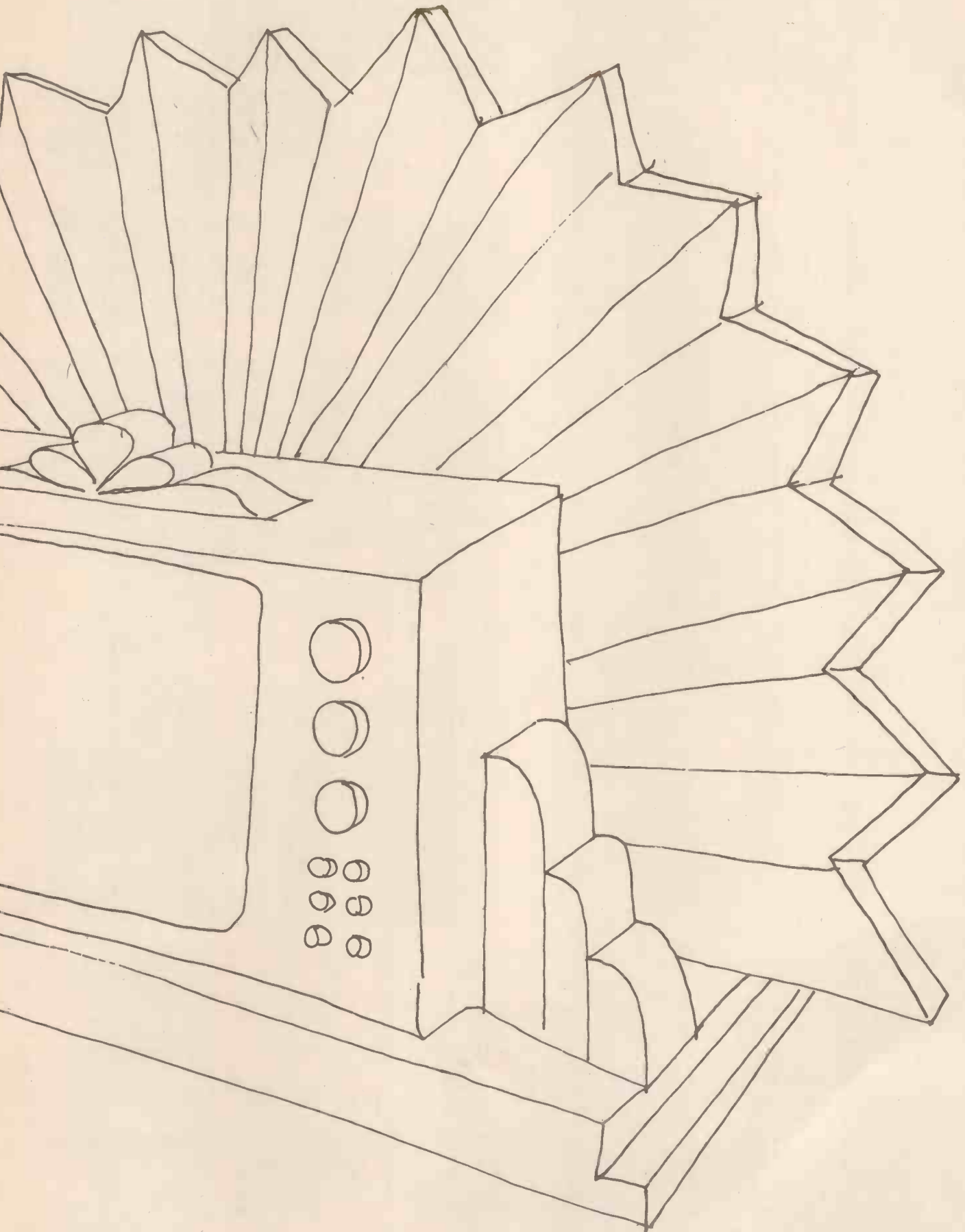
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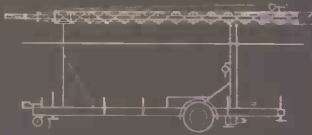
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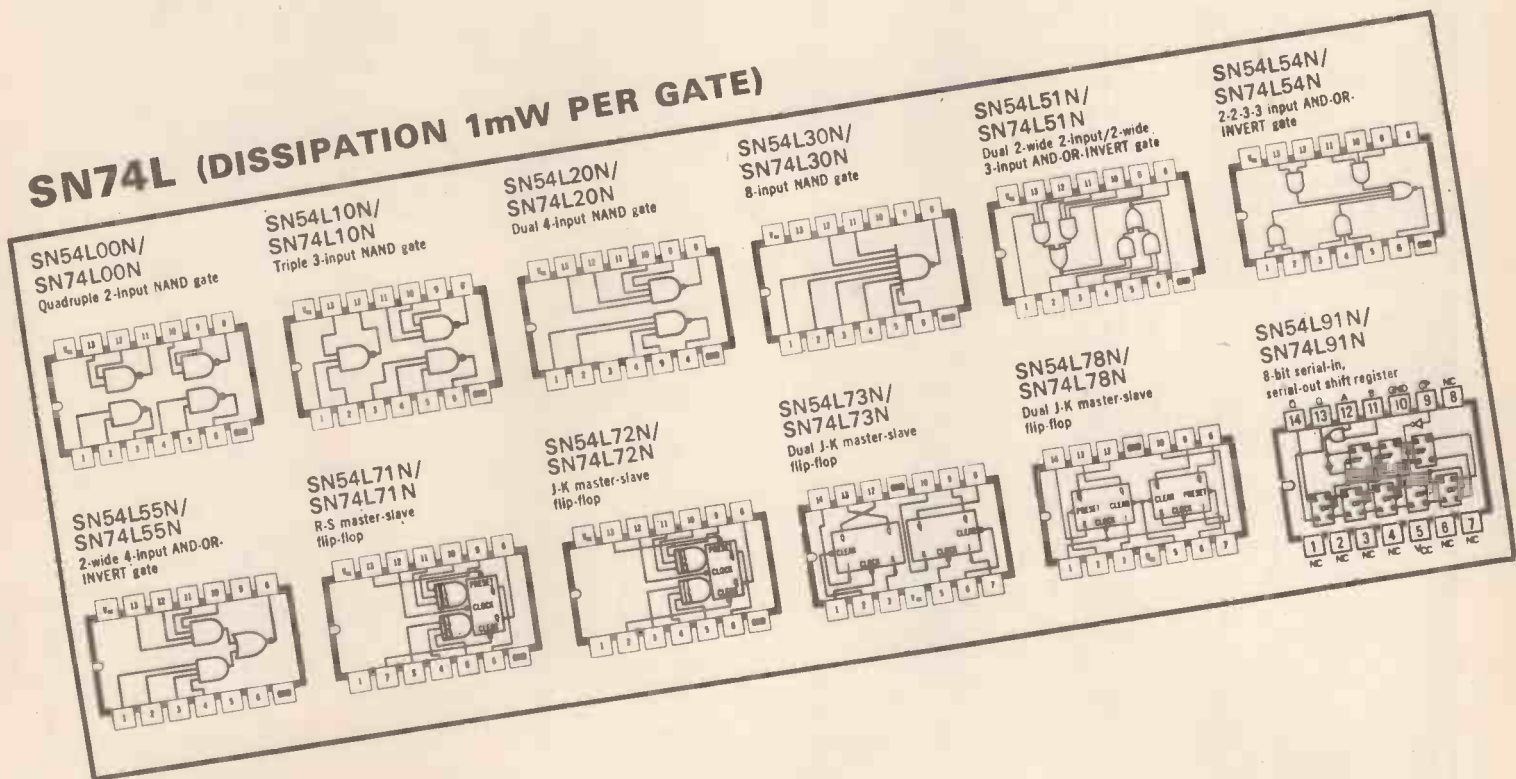
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Wireless World

Electronics, Television, Radio, Audio

Sixtieth year of publication

August 1970

Volume 76 Number 1418



Although not exclusively associated with the subject of this month's main article (colour EVR) our cover illustration typifies colour television reproduction. The photograph of a Mullard tube was taken by students at the Polytechnic School of Photography, Regent Street, London.

IN OUR NEXT ISSUE

Inductorless stereo decoder which uses a phase-locked loop to regenerate the suppressed subcarrier.

Transistor breakdown-voltage meter providing direct reading at fixed reverse currents.

Increasing the bandwidth of the Hartley 13A double-beam oscilloscope.

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We regret Pt. 13 of Active Filters has had to be held over.



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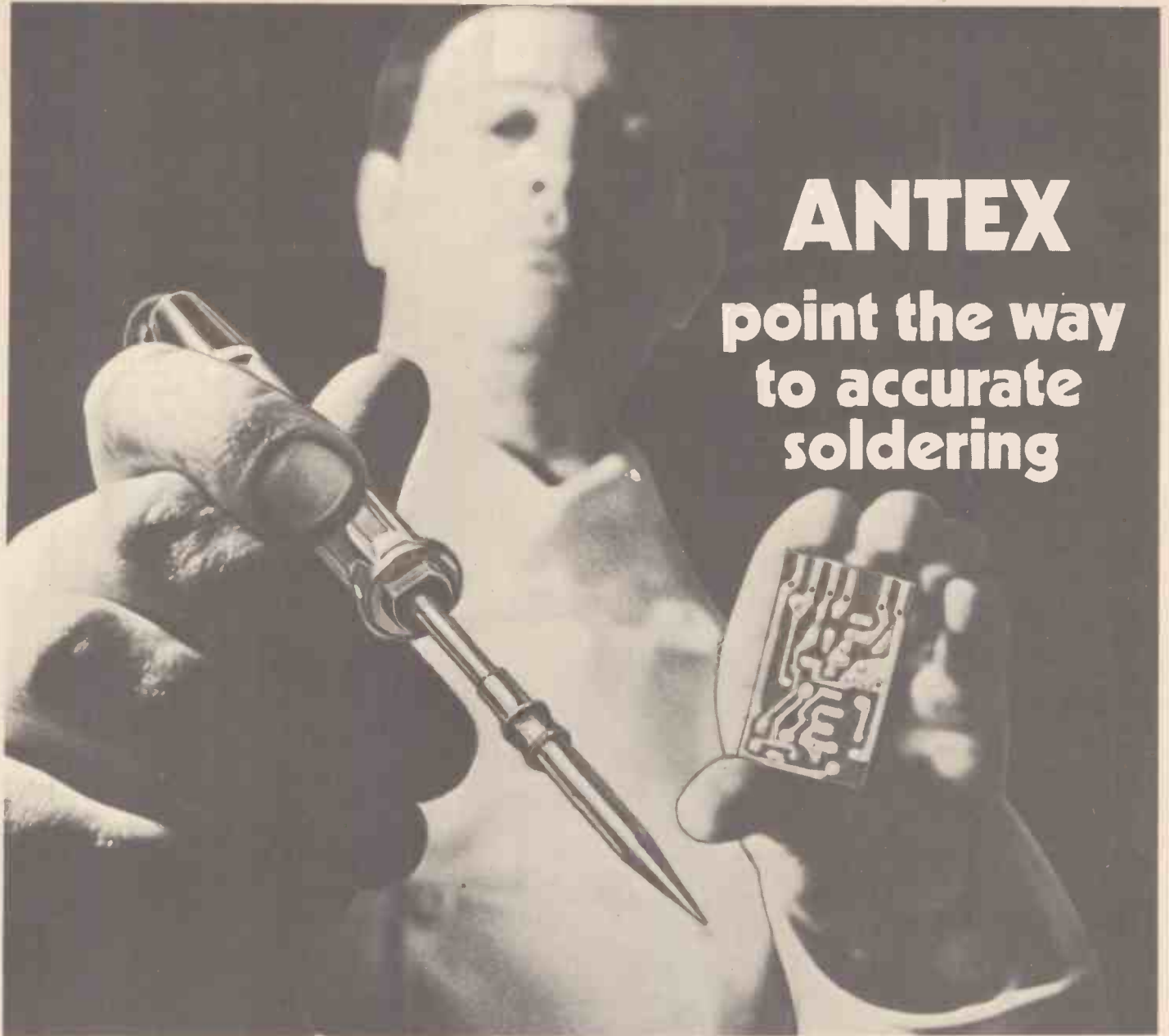


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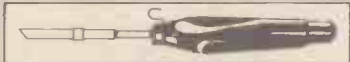


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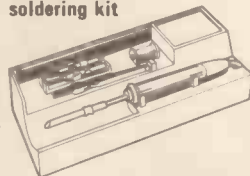


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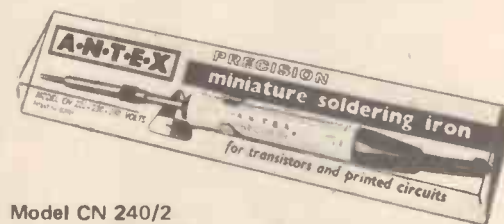


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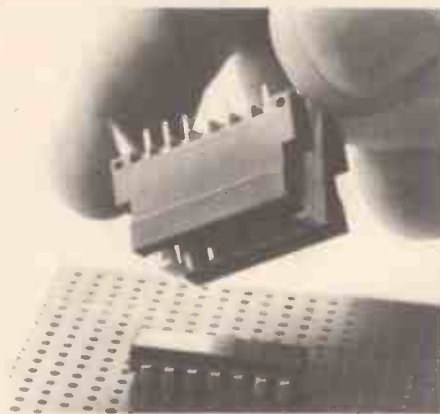
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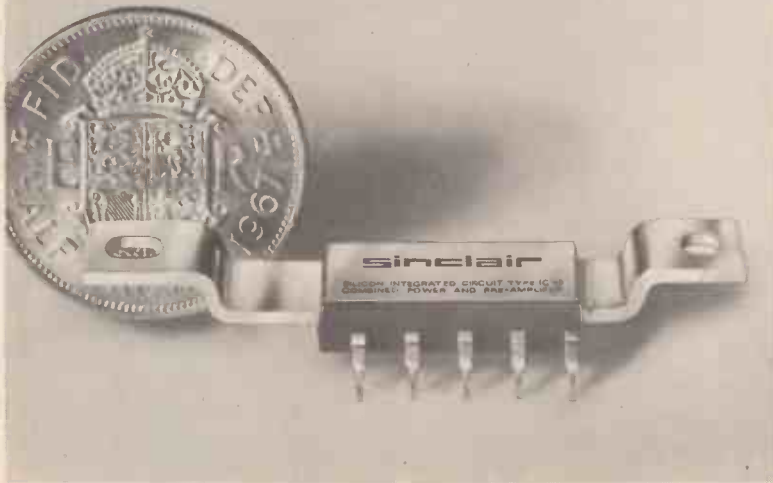
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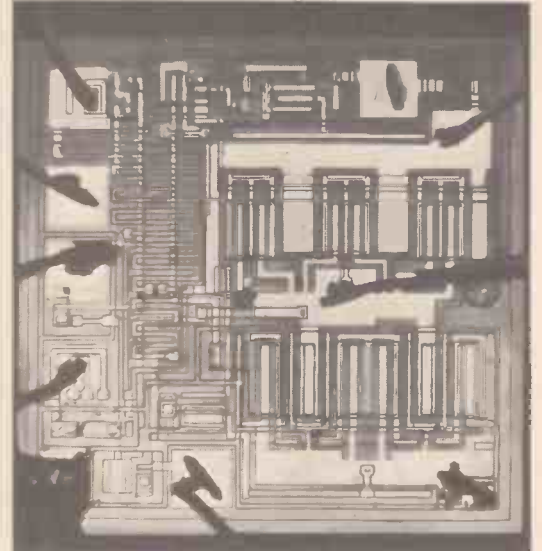
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Frequency response:	5 Hz to 100 KHz \pm 1dB
Total harmonic distortion:	Less than 1% at full output.
Load impedance:	3 to 15 ohms.
Power gain:	110dB (100,000,000,000 times) total.
Supply voltage:	8 to 18 volts.
Size:	1 x 0.4 x 0.2 inches.
Sensitivity:	5mV.
Input impedance:	Adjustable externally up to 2.5 M ohms.

■ CIRCUIT DESCRIPTION

The first three transistors are used in the pre-amp and the remaining 10 in the power amplifier. Class AB output is used with closely controlled quiescent current which is independent of temperature. Generous negative feedback is used round both sections and the amplifier is completely free from cross-over distortion at all supply voltages, making battery operation eminently satisfactory.

■ APPLICATIONS

Each IC-10 is sold with a very comprehensive manual giving circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include stabilised power supplies, oscillators, etc. The pre-amp section can be used as an R.F. or I.F. amplifier without any additional transistors.

SINCLAIR

IC-10

with IC-10 manual
Post free.

59'6

sinclair

SINCLAIR RADIONICS LTD. 22 NEWMARKET ROAD, CAMBRIDGE
Telephone: 0223 52731

WW—074 FOR FURTHER DETAILS

Project 60

laboratory-standard high fidelity modules

Sinclair Project 60 comprises a range of modules which connect together simply to form a compact stereo amplifier with really excellent performance. So good, in fact, that only 2 or 3 amplifiers in the world can compare in overall performance. Now with the addition of three new modules to the range, the constructor has choice of assemblies with either 20 or 40 watts output per channel, with or without filter facilities.

The modules are: 1. The Z-30 and Z-50 high gain power amplifiers, each of which is an immensely flexible unit in its own right. 2. The Stereo 60 pre-amplifier and control unit. 3. The Active Filter unit with both high and low audio frequency cut-offs. 4. The PZ-5 and PZ-6 power supplies. A complete system could comprise, for example, two Z-30's, one Stereo-60, and a PZ-5. The P-Z6 is stabilised and should be used where the highest possible continuous sine wave rating is required. An A.F.U. may be added as required. In a normal domestic application, there will be no significant difference between using a PZ-5 or PZ-6 unless loudspeakers of very low efficiency are being used, in which case the PZ-6 will be required. For assemblies using two Z-50's there is the new PZ-8 stabilised supply unit to ensure maximum performance from these more powerful amplifiers.

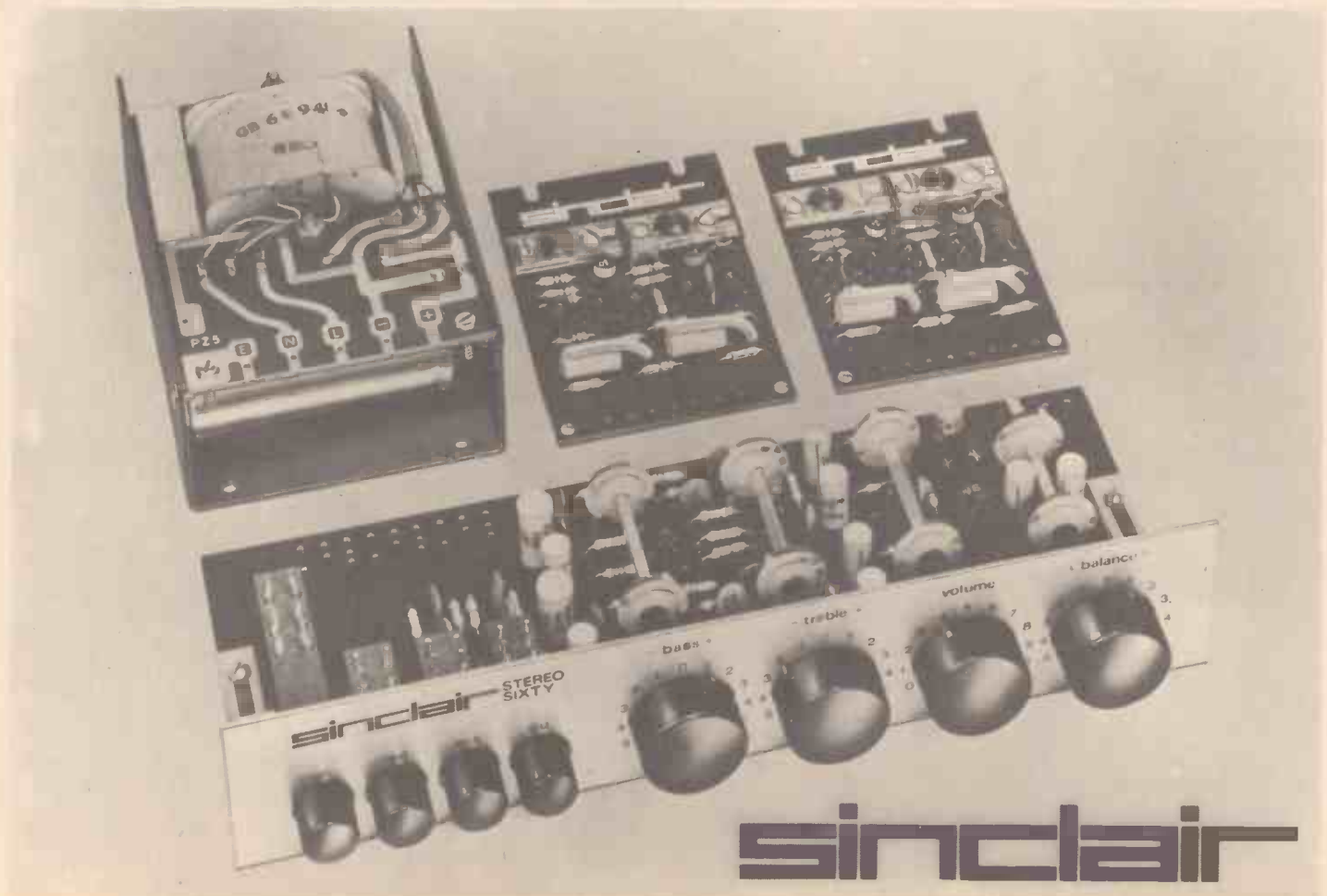
All you need to assemble your Project 60 system is a screwdriver and soldering iron. No technical skill or knowledge whatsoever is required and, in the unlikely event of you hitting a problem, our customer service and advice department will put the matter right promptly and willingly. Project 60 modules have been carefully designed to fit into virtually all modern plinth or cabinets and only holes need be drilled into the wood of the plinth to mount the control unit and the A.F.U. Any slight slip here will be covered by the aluminium front panels of these two units.

The Project 60 manual gives all the building and operating instructions you can possibly want, clearly and concisely. Perhaps the greatest beauty of the system is that it is not only flexible now but will remain so in the future as the latest additions to the range show. A stereo F.M. tuner is next to come. These and all other modules we introduce will be compatible with those already available and may be added to your system at any time. And because Sinclair are the largest producers of constructor modules in Europe, Project 60 prices are remarkably low.

SINCLAIR RADIONICS LIMITED

22 NEWMARKET ROAD CAMBRIDGE

Telephone 0223 52731



sinclair

PHOTOCONDUCTIVE CELLS

Cadmium Sulphide Cells (Cds)

Inexpensive light sensitive resistors which require only simple circuitry to work as light triggering units in a wide range of devices, such as: flashing or breakdown lights, exposure meters, brightness controls, automatic porch lights, etc. Not polarity conscious—use with A.C. or D.C. Spectral response covers whole visible light range.



MKY101-C



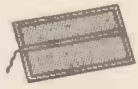
MKY71

Epoxy sealed. 1/2 in. diam. x 1/2 in. thick. Resistance at 100 Lux—500 to 2,000 ohms. Maximum voltage 150 A.C. or D.C. Maximum current 150mA. MKY 101C 10/6 post free

Glass sealed with M.E.S. base. Glass envelope 3/8 in. diam., overall length 1 in. Resistance at 100 Lux—50 Kohms to 150 Kohms. Maximum voltage 150 A.C. or D.C. Maximum current 75 mW. MKY 71 8/6 post free

PHOTOGENERATIVE CELLS

Seelenium cells in which light energy is converted into electricity directly measurable on microammeter or used with amplifier as light trigger for alarm and counting devices, luminous fluxmeters, exposure meters, colorimeters, etc. Spectral response covers visible light range.



Type 1—1 1/4 x 1 3/8 in. Output 1 mA at 0.6 volts at 1,000 Lux. 5/- post free
Type 2—100 x 50 mm. Output 4 mA at 0.6 volt at 1,000 Lux. 22/6 post free

REED SWITCH COILS AND CAPSULES



Compact assemblies of reed switches and operating coils that permit the design of an infinite variety of multiple switch circuits in an extremely small space. They eliminate the bulk and open contact disadvantage of electro-mechanical relays; hermetically sealed contact isolation ensures long life reliability. Small enough to combine with solid-state components on printed circuit boards. Ideal for switching machines, binary kits, control systems, etc. These were removed intact from highly expensive computer mechanisms and are guaranteed to be in perfect working order. Each capsule consists of a rare-metal screened, 24 volt D.C. operating coil on a nylon former with one detachable end for the removal and replacement of reed switches.

Types available:
R/D2 Two reed switches, contacts normally open. Size overall: 1 1/2 x 1/2 x 1/2 in. 5/- post free
R/C4 Four reed switches, contacts normally open. Size overall: 1 1/2 x 1/2 x 1/2 in. 10/- post free
R/C6 Six reed switches, 4 contacts normally open, 2 normally closed. Size overall: 1 1/2 x 1/2 x 1/2 in. 15/- post free

RCA TRIAC—CA40432



45/- post free

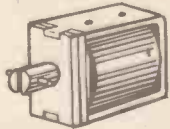
Suitable for light dimming and motor control circuits. Gate-controlled, full-wave, A.C. silicon switch with integral trigger that blocks or conducts instantly by applying reverse polarity voltage. Suitable for A.C. operation up to 250 volts; controls currents up to 1440 watts. Size only 1/2 in. diam. x 3/8 in. high. Complete with heat sink, data and applications information.

VARIABLE SPEED FOOD MIXER MOTOR ASSEMBLY P. & P. 3/6



Exceptionally robust, brush-type, series wound motor designed as power unit for a quality British food mixer and supplied with detachable mixer blades. Open frame construction terminates in 1/2 in. diameter drive shaft at one end and die-cast, enclosed gearbox with twin shaft output into right-angled drive shafts at other. Tapped windings provide switch selection of any of three speeds. Switch not supplied. Size overall: 5 1/2 in. long x 2 1/2 in. diam. x 8 1/2 in. New.

LOW VOLTAGE SOLENOIDS



SPECIAL OFFER PRICE - 2 FOR 12/6

Exceptionally powerful pull-type solenoid for 4½-6 volts D.C. operation. Compact, lubricated construction with tapped holes at sides and rear to provide versatile mounting. 1 1/2 in. long x 3/8 in. diam. Bolt has conical tapered plunger to ensure maximum pull and forked connecting end with pivot pin. Size overall: (closed) 1 1/2 in. long x 1 in. high x 3/8 in. wide. Current consumption: 0.4 A. at 6 V.

QUARTZ HALOGEN FLOODLAMPS



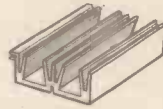
Standard tubular pattern with ceramic end-contact fittings and supplied complete with ceramic holders. For 200/240 volts mains operation. Two types available:
Type 1. 600 watts. Length overall 115/120 mm. Diam. 10 mm. Filament length 70 mm. 27/6 post free
Type 2. 1500 watts. Length overall 255 mm. Diam. 10 mm. Filament length 175 mm. 45/- post free

CONTROL THERMISTOR



Type A25 by 8TC retained on 1 x 1 1/4 in. paxolin board with solder tags and mounting lug with captive screws. Bead type thermistor is contained in 1 in. long x 3/8 in. diam. gas-filled glass bulb and is particularly suitable for amplitude control, timing devices, current surge suppression, etc. Safe power dissipation, 60 mW. Sensitivity 3.5° C/mW. Maximum temperature: Ambient 160°C. Bead 300°C. Resistance at 20°C: 200,000 ohms. Average dissipation at 60 mW in free air at 20°C: 575 ohms. Usual price 15/9 each. Brand new. Special bargain offer: 5 for 15/- post free.

POWER TRANSISTOR HEAT SINKS



Heavy gauge aluminium extrusions with fitting for one pair of power transistors. Size overall: 4 x 3 1/2 x 1 1/2 in. high. Base is 3/8 in. thick and ready punched to accept all standard types. Seven cooling fin surfaces ensure adequate heat dissipation. Brand new. Special offer: two for 12/6 post free.

INFRA-RED TRANSMITTERS & RECEIVERS

Unique devices in a brand new electronic field that can be exploited in a wide range of applications. Miniaturized construction and solid state circuit design is combined with outstanding modulation and switching capabilities to provide infinite possibilities as short distance speech and data links, remote relay controls, safety devices, burglar alarms, batch counters, level detectors, etc. etc.



MGA 100 35/- post free

MSP 3 85/- post free

GALLIUM ARSENIDE LIGHT SOURCE—MGA 100 Filamentless infra-red emitter in a robust, sealed cylinder coaxial with beam to facilitate optical alignment and heat sinking. Max Ratings: Forward current IF max.: 400 mA. Forward peak current IF max.: (pk): 6A. Power dissipation*: 600 mW. Derating factor for Tamb greater than 25°C.: 7.5 mW/°C. Reverse voltage VR max.: 1.0 V. * When mounted on an aluminium heat sink 1 in. x 1/2 in. x 1/2 in.

INFRA-RED PHOTO RECEIVER—MSP3

Ultra sensitive detector/amplifier for infra-red (Gallium Arsenide) or visible light optical links reception. Spectral response 8500 A Robust, cylindrical package is coaxial with incident light to facilitate optical alignment and heat sinking. Max Ratings: Total dissipation (in free air, Tamb = 25°C.): 100 mW. Derating factor: 2 mW/°C. Output current: 100 mA. Voltage: 25 V. Operating temperature: from -30° to +125°C. Supplied complete with suitable lenses, full technical data and application sheets, including line of sight link link.



INDUCTION MOTOR

12/- P. & P. 2/6

High-grade unit with diecast rotor frame fitted with lifetime lubricated bearings and 1 1/2 in. long x 0.2 in. drive shaft. Off load speed: 2800 r.p.m. Size overall: 2 1/2 x 2 1/4 x 1 1/4 in. deep (less shaft).

EXTRACTOR FANS

35/- P. & P. 3/6

Brand new, 230/250 Volts A.C. mains operated fans, complete except for external shrouding which can be readily made up from simple sheet metal wrapping to suit any particular installation. Makes an ideal extractor fan for kitchens and other domestic and light industrial purposes. Continuously rated, smooth, silent running induction motor; balanced 2-bladed, 6 in. fan. Size 7 1/2 in. diam. x 4 in. deep.



HIGH GRADE MINIATURE 12 Volt D.C. MOTORS Two for 12/6 post paid

Top quality, all-British manufacture, 12-volt D.C. permanent magnet motors. Wave-wound armature has 8-segment machined copper commutator contacted by spring-loaded, long-life carbon brushes in heavy brass holders. Steel rotor shaft runs in lifetime lubricated bronze bearings. Totally enclosed in tough plastic case with flying lead connections. Size: 1 1/2 in. diam. x 2 1/2 in. long (including 1/8 in. long x 3/8 in. diam. drive shaft). Speed: 8,000 r.p.m. Current consumption: 0.3 to 0.7 A. depending on load. Special offer.

ELECTRIC BLANKET HEATER CABLE

Min. order 20 yds. of one type, plus 2/6 P. & P.

Nickel alloy ribbon spirally wound onto a fibre core and insulated by an outer cover of clear, silicone plastic. Originally intended as heating elements for high-grade electric blankets but suitable also for underoil heating in propagating trays and many other low temperature applications. Cable diam. 2.5 mm. Available in various resistance ranges as follows: 14.5, 15.9, 21.5, 28.8, 41, 48, 151 and 177 ohms per yard. State type required.



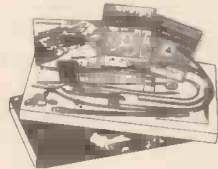
STANDARD CRADLE TYPE TELEPHONES Two for 35/- Carr. 5/-

Standard type complete with dial and approx. 10 ft. cord. Not new, but guaranteed unbroken and serviceable.

FIBRE OPTICS

Highly flexible light guides that transmit light to inaccessible places as easily as electricity is conducted by copper wires. Fibre optics make it possible to control, miniaturize, split, reflect or transfer light from one source to many places at once and to operate photo devices, logic circuits, or illuminate in ways never before possible. Proops offer both glass fibre optics or inexpensive Crofon plastic fibres for hundreds of experiments or serious applications in a fascinating new science.

Rank Taylor-Hobson Engineers' Kits



Basic fibre optic components that demonstrate new ways of employing light in serious applications. Two kits are available: each contains high-grade glass-fibre light guides consisting of thousands of fibres tightly bundled in flexible sheaths with (ruffled, optically polished ends, together with connecting and light source components. Each is supplied complete with card wallet containing technical and application data.

Kit 1

Contains: 1.5 mm x 24 in., 3 mm x 18 in. and 6 mm x 12 in. light guides, plus 24 in. long x 2 exit component for punched card or coding applications. Also battery operated light source, 2-way "Y" adaptor with non-random separation and 3 mm./3 mm. and 3 mm./1.5 mm. connectors. £16 post free

Kit 2

Contains: 3 mm. x 18 in., 6 mm. x 12 in. light guides; 1.5 mm. "Y" guide with two 12 in. long tails; 24 in. long 12 exit component for coding or punched card applications, 24 in. lengths of Crofon 64 filament and monofilament plastic light guide. Also, coherent solids consisting of 25 mm. diam. field flattening lens, 6 mm. x 12 in. image conduit with polished ends, 4 mm. x 25 mm. image inverter. Complete with 2-way adaptor, fibre optic torch and batteries, 3 mm./3 mm. and 3 mm./1.5 mm. connectors. £28 post free

SPECIAL OFFER OF IMAGE FIBROSCOPES

£5 post free

Between 50,000 and 90,000 coherently arranged, 15 micron glass fibres that provide (with appropriate optics) perfect visual inspection into otherwise inaccessible areas. Originally made by Rank Taylor-Hobson for use in industrial and medical fibroscopes at £72 each, these have slight, superficially imperceptible faults and are assembled in transparent, lay-flat tubing instead of opaque, flexible conduit, as usual. Ends are ground polished and metal capped. Absolutely ideal for demonstration in schools and technical colleges and for many other applications that require highly sophisticated means of access to enclosed, difficult to get at places. Length overall: 3 ft. Cross sectional area: 3 x 3 mm. Resolution: 10 LP/mm. to 20 LP/mm.

LOW COST CROFON FLEXIBLE LIGHT GUIDES



Newly developed plastic light transmitting media by Dupont, which can be used for both serious projects and inexpensive prototype work. Ends can be ground flat, dyed or capped with epoxy resin. Temperature range: -40° to +170°F. No loss of light through bending. 12 page Data and Applications booklet supplied with each order.

Types available: Multi-strand—64 special plastic fibres, tightly bundled together in a tough, flexible conduit. 8/6 per foot. Minimum order two feet, 17/- P. & P. 1/6. Monofilament—Single 0.040 in. plastic fibre which is specially useful for light indications in confined spaces. 4/- per foot. Minimum order three feet, 12/- P. & P. 1/6.



SIXTEENTH H.P. MAINS MOTOR 35/- Carr. 7/6

Superb quality motor to BS1906 spec. by A.E.I. for IBM computer installations. Exceptionally quiet running. Complete with mounting cradle with resilient mounts and starting capacitor. Fin 1/2 in. diam. drive shaft fitted with 1 1/2 in. and 1 in. diam. double pulley. Size overall: 7 1/2 x 4 1/2 x 5 in. high. For 230/250 V. A.C. mains at 0.85 A. Speed: 1,425 r.p.m. Continuously rated.

GENERAL PURPOSE PUMP £7. 10. 0 P. & P. 5/-

Compact, totally enclosed unit has stainless steel and tough plastic construction, with powerful all-British continuously rated motor to ensure long operating life under rigorous outdoor and marine use. Maximum head 10 ft. Output in excess of 300 g.p.h. Ideal for use as bilge pump in small boats, caravan showers, drainage, fuel transfer, etc. Size overall only 12 in. long x 2 1/2 in. diam. Complete with stand-off mounting bracket. Standard model, 12 V. D.C. 30 watts. 24 V. model available. Guaranteed 12 months.



QUARTZ HALOGEN LAMP OFFER 17/6 post paid 12 Volts, 50 Watts operation

High-grade British manufacture complete with high temperature ceramic base fitted with flying leads. Suitable for projector, car spotlamp adaptation, or high intensity lighting applications. New and fully guaranteed.



COMPACT LOW GEAR MOTOR 17/6 Post and packing 2/6

Totally enclosed synchronous motor has built-in gearbox providing output speed of 1 1/2 r.p.m. Drive is 28-tooth, 1 in. diam. gearwheel, removable to leave 1 in. diam. applied shaft. Size: 1 1/2 in. diam. x 1 1/2 in. deep, plus drive and mounting lugs. Counter clockwise rotation. For A.C. mains operation.

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TYPE SW. 100
100 x 80 mm.

50µA	69/6
100µA	67/8
500µA	62/6
1mA	59/8
20V. D.C.	59/6

BAKELITE PANEL METERS



TYPE S-80
80 mm. square fronts

50µA	62/6	50V. D.C.	49/6
100µA	59/6	1 amp. D.C.	49/6
500µA	52/6	5 amp. D.C.	49/6
1mA	49/6	300V. A.C.	52/6
20V. D.C.	49/6	VU Meter	67/6

"SEW" CLEAR PLASTIC METERS

Type MR.85P. 4 1/4 in. x 4 1/4 in. fronts.



50µA	72/-
50-0-50µA	62/-
100µA	62/-
100-0-100µA	52/-
200µA	57/6
500µA	55/-
500-0-500µA	52/-
1mA	52/-
1-0-1mA	52/-
5mA	52/-

Type MR.38P. 1 21/32 in. square fronts.

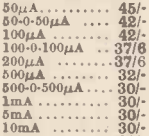


200mA	27/6
300mA	27/6
750mA	27/6
1 amp.	27/6
2 amp.	27/6
5 amp.	27/6
10 amp.	27/6
3V. D.C.	27/6
10V. D.C.	27/6
15V. D.C.	27/6
20V. D.C.	27/6
100V. D.C.	27/6
150V. D.C.	27/6
300V. D.C.	27/6
500V. D.C.	27/6
750V. D.C.	27/6
15V. A.C.	27/6
50V. A.C.	27/6
150V. A.C.	27/6
300V. A.C.	27/6
500V. A.C.	27/6
8 meter 1mA	32/-
VU meter	42/-

Type MR.52P. 2 1/4 in. square fronts.

50µA	62/-	10V. D.C.	40/-
50-0-50µA	52/-	20V. D.C.	40/-
100µA	52/-	50V. D.C.	40/-
100-0-100µA	47/6	300V. D.C.	40/-
500µA	45/-	15V. A.C.	40/-
1mA	40/-	300V. A.C.	40/-
5mA	40/-	8 Meter 1mA	42/-
10mA	40/-	VU Meter	62/-
50mA	40/-	1 amp. A.C.*	40/-
100mA	40/-	5 amp. A.C.*	40/-
500mA	40/-	10 amp. A.C.*	40/-
1 amp.	40/-	20 amp. A.C.*	40/-
5 amp.	40/-	30 amp. A.C.*	40/-

Type MR.45P. 2 in. square fronts.



50µA	45/-	5 amp.	30/-
50-0-50µA	42/-	10V. D.C.	30/-
100µA	42/-	20V. D.C.	30/-
100-0-100µA	37/6	50V. D.C.	30/-
200µA	37/6	300V. D.C.	30/-
500µA	32/-	15V. A.C.	30/-
500-0-500µA	30/-	300V. A.C.	30/-
1mA	30/-	8 meter 1mA	37/6
5mA	30/-	VU meter	45/-
10mA	30/-	1 amp. A.C.*	30/-
50mA	30/-	5 amp. A.C.*	30/-
100mA	30/-	10 amp. A.C.*	30/-
500mA	30/-	20 amp. A.C.*	30/-
1 amp.	30/-	30 amp. A.C.*	30/-

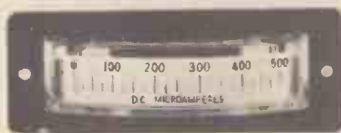
"SEW" BAKELITE PANEL METERS

Type MR.65. 3 1/4 in. square fronts.



25µA	70/-	500mA	35/-
50µA	47/6	1 amp.	35/-
100µA	45/-	5 amp.	35/-
50-0-50µA	45/-	10 amp.	35/-
100µA	45/-	30 amp.	35/-
100-0-100µA	45/-	50 amp.	35/-
500µA	42/-	5V. D.C.	35/-
1mA	35/-	10V. D.C.	35/-
1-0-1mA	35/-	20V. D.C.	35/-
5mA	35/-	50V. D.C.	35/-
10mA	35/-	150V. D.C.	35/-
50mA	35/-	300V. D.C.	35/-
100mA	35/-	30V. A.C.*	35/-
		50V. A.C.*	35/-
		150V. A.C.*	35/-
		300V. A.C.*	35/-
		500mA A.C.*	35/-
		1 amp. A.C.*	35/-
		5 amp. A.C.*	35/-
		10 amp. A.C.*	35/-
		20 amp. A.C.*	35/-
		30 amp. A.C.*	35/-
		VU meter	62/-

*MOVING IRON — ALL OTHERS MOVING COIL
Please add postage



EDGWISE METERS

Type PE.70. 3 17/32 in. x 1 15/32 in. x 2 1/4 in. deep.

50µA	60/-	500µA	52/-
50-0-50µA	57/8	1mA	47/6
100µA	57/8	300V. A.C.	47/6
100-0-100µA	55/-	VU meter	65/-
200µA	55/-		

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This range of Multimeters, manufactured by Tachikawa Radio Instrument Co. of Japan, offers excellent value for money combined with quality and accuracy of measurement.

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MD. 120 PL. 436 500 5025



LAB TESTER TW. 50K

MODEL TW 20CB

FEATURES
RESETTABLE
OVERLOAD
BUTTON

Normally only found on meters costing over £25.



★ All models fitted overload protection and supplied with batteries, prods and instructions.

Sensitivity: 20kΩ/Volt D.C. 5kΩ/Volt A.C. D.C. Volts: 0-0.6, 2.5, 10, 50, 250, 1,000V. A.C. Volts: 0-2.5, 10, 50, 250, 1,000V. D.C. Current: 0-0.05, 0.5, 5, 50, 500mA. 10 amp. Resistance: 0-5K, 50K, 0-500K. 5 MEGΩ. Decibels: -20 to +52db. Plastic case with carrying handle. Size 5 1/2 in. x 4 in. x 2 1/4 in. approx.
£11.10.0 p/p 3/6

MODEL MD-120 Features Mirror Scale, Low Loss Switch and Robust Movement. Sensitivity: 20kΩ/Volt D.C. 10kΩ/Volt A.C. D.C. Volts: 30, 60, 300, 600, 3,000V. A.C. Volts: 6, 120, 1,200V. D.C. Current: 60µA, 12, 300mA. Resistance: 60K, 6 MEGΩ. Decibels: -20 to +63db. Rugged High Impact Plastic Case, size 3 1/2 in. x 4 1/4 in. x 1 1/2 in.	£4.12.6
MODEL PL 436 Features Mirror Scale and Wood Grain Finish Front Panel. Sensitivity: 20KΩ/Volt D.C. 8KΩ/Volt A.C. D.C. Volts: 6, 3, 12, 30, 120, 600V. A.C. Volts: 3, 30, 120, 600. D.C. Current: 50, 600µA, 60, 600mA. Resistance: 10K, 100K, 1MEG, 10MEGΩ. Decibels: -20 to +45db. Rugged High Impact Plastic Case with Handle, size 5 1/2 in. x 4 1/4 in. x 2 1/4 in.	£6.19.6
MODEL TW-50K Features 46 ranges, mirror scale. Sensitivity 50kΩ/Volt D.C. 5kΩ/Volt A.C. D.C. Volts: 125, 25, 125, 2.5, 5, 10, 25, 50, 125, 250, 500, 1,000V. A.C. Volts: 1.5, 3, 5, 10, 25, 50, 125, 250, 500, 1,000V. D.C. Current: 25, 50µA, 2.5, 5, 25, 50, 250, 500mA, 5, 10 amp. Resistance 10K, 100K, 1 MEGΩ, 10 MEGΩ. Decibels: -20 to +81dB. Plastic case with carrying handle. Size 4 1/4 in. x 2 1/4 in. x 6 1/4 in.	£8.10.0
MODEL 500 Features Mirror Scale and Buzzer Short Circuit Check. Sensitivity: 30KΩ/Volt D.C. 15KΩ/Volt A.C. D.C. Volts: 25, 1, 2.5, 10, 25, 100, 250, 500, 1,000V. A.C. Volts: 2.5, 10, 25, 100, 250, 500, 1,000V. D.C. Current: 50µA, 5, 50, 500mA, 12 amp. Resistance: 60K, 6MEG, 60MEGΩ. Decibels: -20 to +56db. Handsome Dustproof Black Plastic Case, size 3 5/16 in. x 6 1/16 in. x 2 1/4 in.	£8.17.6
MODEL 5025 Features 67 Ranges, Giant 5 1/2 in. Meter, Polarity Reverse Switch. Sensitivity: 50KΩ/Volt D.C. 5KΩ/Volt A.C. D.C. Volts: 125, 25, 125, 5, 10, 25, 50, 125, 250, 500, 1,000V. A.C. Volts: 1.5, 3, 5, 10, 25, 50, 125, 250, 500, 1,000V. D.C. Current: 25, 50µA, 2.5, 5, 25, 50, 250, 500mA, 5, 10 amp. Resistance: 2K, 10K, 100K, 1MEG, 10MEGΩ. Decibels: -20 to +85db. Plastic Case with Carrying Handle, size 6 1/4 in. x 2 1/4 in. x 5 1/4 in.	£12.10.0
MODEL 100,000 O.P.V. LAB TESTER Features Unique Range Selector, 6 1/2 in. Scale Buzzer Short Circuit Check. Sensitivity: 100,000 Ω/Volt D.C. 5KΩ/Volt A.C. D.C. Volts: 5, 2.5, 10, 50, 250, 1,000V. A.C. Volts: 3, 10, 50, 250, 500, 1,000V. D.C. Current: 10, 100µA, 10, 100, 500mA, 2.5, 10 amp. Resistance: 1K, 10K, 100K, 1MEG, 10MEGΩ. Decibels: -10 to +49db. Plastic Case with Carrying Handle, size 7 1/4 in. x 6 1/4 in. x 3 1/4 in.	£18.18.0

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HL141DD	4/6	PCF83	10/-	UAB080	6/6	U404	10/6	AC168	7/6	BF154	8/6	GET896	4/6	OC46	8/3
HL141DD	4/6	PCF84	7/6	U402	4/6	U4020	7/6	AC168	4/6	BF163	4/6	GET897	4/6	OC48	8/6
HL242DD	9/-	PCF86	8/6	U41	3/6	U403	3/6	AC176	11/-	BF163	4/6	GET897	4/6	OC48	8/6
HL242DD	9/-	PCF88	15/-	U403	3/6	U403	3/6	AC177	5/6	BF173	7/6	GET897	4/6	OC48	8/6
HL242DD	9/-	PCF89	15/-	U403	3/6	U403	3/6	AC177	5/6	BF180	6/6	GET897	4/6	OC48	8/6
HL242DD	9/-	PCF90	15/-	U403	3/6	U403	3/6	AC177	5/6	BF181	8/6	GET897	4/6	OC48	8/6
HL242DD	9/-	PCF91	15/-	U403	3/6	U403	3/6	AC177	5/6	BF186	8/6	GET897	4/6	OC48	8/6
HL242DD	9/-	PCF92	15/-	U403	3/6	U403	3/6	AC177	5/6	BF186	8/6	GET897	4/6	OC48	8/6
HL242DD	9/-	PCF93	15/-	U403	3/6	U403	3/6	AC177	5/6	BF186	8/6	GET897	4/6	OC48	8/6
HL242DD	9/-	PCF94	15/-	U403	3/6	U403	3/6	AC177	5/6	BF186	8/6	GET897	4/6	OC48	8/6
HL242DD	9/-	PCF95	15/-	U403	3/6	U403	3/6	AC177	5/6	BF186	8/6	GET897	4/6	OC48	8/6
HL242DD	9/-	PCF96	15/-	U403	3/6	U403	3/6	AC177	5/6	BF186	8/6	GET897	4/6	OC48	8/6
HL242DD	9/-	PCF97	15/-	U403	3/6	U403	3/6	AC177	5/6	BF186	8/6	GET897	4/6	OC48	8/6
HL242DD	9/-	PCF98	15/-	U403	3/6	U403	3/6	AC177	5/6	BF186	8/6	GET897	4/6	OC48	8/6
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STEREO AMPLIFIER SA.10-10.



Developed from the very successful SA.8-B amplifier giving first-class stereo amplification featuring separate volume controls for each channel, bass and treble controls. 10 watts per channel into 5 to 8 Ω. Kit £19/7/6 nett; built £24/16/8 nett. Suitable 8Ω wide range speakers available £13/15- each nett.

MAINLINE AMPLIFIER KITS

RCA/SGS designed main amplifier kits. Input sensitivity 500-700mV for full output into 8Ω.

Power	Kit price including components	Suitable unreg. power supply kit
12W	168/- nett	92/-
25W	190/- nett	N/A
40W	210/- nett	115/1
70W	252/- nett	138/10

30 WATT BAILEY AMPLIFIER PACK

Special summer reduction (to Sept. 30th 1970 only)
Sensitivity 1.2V for full output into 8Ω.
Transistors for one channel £7/5/6 list, £6 only nett.
Transistors for two channels £14/11/- list, £11 only nett.
Capacitors and resistors (metal oxide), 30/- per channel nett.
Complete unregulated power supply pack, 87/6 nett.

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PLESSEY SL403A 3 watts into 7.5 ohms. Data book supplied FREE when two of these units are purchased. Price per unit, nett 48/6.

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Axial leads: 50/50, 1/9; 100/25, 1/9; 100/50, 2/6; 250/25, 2/6; 250/25, 2/6; 250/50, 3/9; 500/25, 3/9; 500/50, 4/6; 1000/25, 4/-; 1000/50, 6/-; 2000/25, 6/-.

SMALL ELECTROLYTICS
Axial leads: 4.7/10, 4.7/25, 5/50, 1/- each; 10/10, 10/25, 10/50, 33/10, 50/10, 1/- each; 25/25, 25/50, 47/25, 100/10, 220/10, 1/3 each.

RESISTORS

Code	Power	Tolerance	Range	Values available	1 to 9	10 to 99	100 up
C	1/20W	5%	82Ω-220KΩ	E12	18	16	15
C	1/8W	5%	4.7Ω-330KΩ	E24	2.5	2	1.75
C	1/4W	10%	4.7Ω-10MΩ	E12	2.5	2	1.75
C	1/2W	5%	4.7Ω-10MΩ	E24	3	2.5	2.25
C	1W	10%	4.7Ω-10MΩ	E12	6	5	4.5
MO	1/2W	2%	10Ω-1MΩ	E24	9	8	7
WW	1W	10% ± 1/20Ω	0.22Ω-3.9Ω	E12		15d. all quantities	
WW	3W	5%	12Ω-10KΩ	E12		15d. all quantities	
WW	7W	5%	12Ω-10KΩ	E12		18d. all quantities	

Codes: C = carbon film, high stability, low noise.
MO = metal oxide, Electroil TR5, ultra low noise.
WW = wire wound, Plessey.

Values:
E12 denotes series: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
E24 denotes series: as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and their decades.

ZENER DIODES 5% full range E24 values:
400mW: 2.7V to 30V, 4/6 each; 1W: 6.8V to 82V, 9/- each; 1.5W: 4.7V to 75V, 12/- each.
Clip to increase 1.5W rating to 3 watts (type 266F), 9d.

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long spindles. Double wiper ensures minimum noise level.
Single gang linear 220Ω to 2.2MΩ, 2/6; Single gang log, 4.7KΩ to 2.2MΩ, 2/6; Dual gang linear, 4.7KΩ to 2.2MΩ, 8/6; Dual gang log, 4.7KΩ to 2.2MΩ, 8/6; Log/antilog, 10K, 47K, 1MΩ only 8/6; Dual antilog, 10K only, 8/6. Any type with 1/2 A.D.P. mains switch, extra 2/3.
Please note: only decades of 10, 22 and 47 are available within ranges quoted.

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1.5μF, 4/2; 2.2μF, 4/9

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10/16; 10/64; 12.5/25; 16/40; 20/16; 20/64; 25/6.4;
25/25; 32/4; 32/10; 32/40; 32/64; 40/16; 40/2.5;
50/6.4; 50/25; 50/40; 64/4; 64/10; 80/2.5; 80/16;
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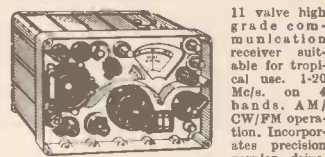
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ADMIRALTY B.40 RECEIVERS



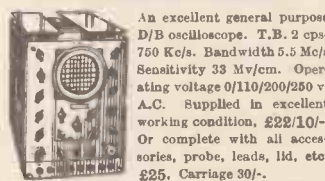
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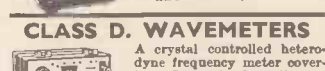
11 valve high grade communication receiver suitable for tropical use. 1-20 Mc/s. on 4 bands. AM/CW/FM operation. Incorporates precision vernier drive, B.F.O. Aerial trimmer, internal speaker and 12v. D.C. internal power supply. Supplied in excellent condition. fully £15.00 Carr. tested and checked. 20/-.

TYPE 13A DOUBLE BEAM OSCILLOSCOPES BARGAIN



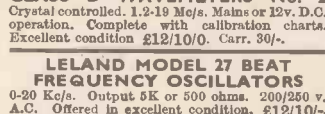
An excellent general purpose D/B oscilloscope. T.B. 2 cps-750 Kc/s. Bandwidth 5.5 Mc/s. Sensitivity 33 Mv/cm. Operating voltage 0/110/200/250 v. A.C. Supplied in excellent working condition, £22/10/-. Or complete with all accessories, probe, leads, lid, etc. £25. Carriage 30/-.

MARCONI CT44 TF956 AF ABSORPTION WATTMETER



1 μwatt to 6 watts. £20. Carr. 20/-.

CLASS D. WAVEMETERS



A crystal controlled heterodyne frequency meter covering 1.7-8 Mc/s. Operation on 6 v. D.C. Ideal for amateur use. Available in good used condition £5.19.8 Carr. 7/6. Or brand new with accessories £7.18.6 Carr. 7/6.

CLASS D WAVEMETERS No. 2

Crystal controlled. 1.2-19 Mc/s. Mains or 12v. D.C. operation. Complete with calibration charts. Excellent condition £12/10/0. Carr. 30/-.

LELAND MODEL 27 BEAT FREQUENCY OSCILLATORS

0-20 Kc/s. Output 5K or 500 ohms. 200/250 v. A.C. Offered in excellent condition, £12/10/0- Carriage 10/-.

VOLTAGE STABILISER TRANSFORMERS.

180-260v. input. Output 230v. Available 150w or 225w. £12.10.0. Carr. 5/-.

TO-2 PORTABLE OSCILLOSCOPE

A general purpose low cost economy oscilloscope for everyday use. Y amp. Bandwidth 2 CFS-1 MHz. Input Imp. 2 meg Ω. 25 PF. Illuminated scale. 2" tube. 115 x 180 x 230 mm. Weight 8lbs. 220/240v. A.C. Supplied brand new with handbook. £22/10/- Carr. 10/-.

TO-3 PORTABLE OSCILLOSCOPE. 3" TUBE

Y amp. Sensitivity. 1v p-p/CM. Bandwidth 1.6 cps-1.5 MHz. Input Imp. 2 meg Ω. 25 PF. X amp sensitivity. 5v p-p/CM. bandwidth 1.6 cps-800 KHZ. Input Imp. 2 meg Ω. 20 PF. Time base. 5 ranges 10 cps-300 KHZ. Synchronization. Internal/external. Illuminated scale. 140 x 215 x 330 mm. Weight 11lbs. 220/240 V. A.C. Supplied brand new with handbook. £37.10.0 Carr. 10/-.

CRYSTAL CALIBRATORS NO. 10

Small portable crystal controlled wavemeter. Size 7in. x 7in. x 4in. Frequency range 500 Kc/s-10 Mc/s (up to 30 Mc/s on harmonics). Calibrated dial. Power requirements 300 V.D.C. 15mA and 12 V.D.C. 0.8A. Excellent condition. 89/6. Carr. 7/6.

MARCONI TF885 VIDEO OSCILLATORS

0-6 mc/s Sine Square Wave £45. Carr. 20/-.

MARCONI TF195M BEAT FREQUENCY OSCILLATORS

0-40 kc/s. £20. Carr. 30/-.

WS62 TRANCEIVERS

Large quantity available for EXPORT! Excellent condition. Enquiries invited.

UNR-30 4 BAND COMMUNICATION RECEIVER

Covering 550 Kc/s-30 Mc/s. Incorporates BFO. Built-in speaker and phone jack. Metal cabinet. Operation 220/240 v. A.C. Supplied brand new, guaranteed with instructions. 13gns. Carr. 7/6.

EDDYSTONE V.H.F. RECEIVERS

770R. 19-165 Mc/s. £150. Both types in excellent condition.



LAFAYETTE SOLID STATE HA600 RECEIVER

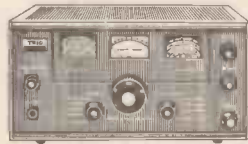
5 BAND AM/CW/SSB AMATEUR AND SHORT WAVE. 150 kc/s-400 Kc/s AND 550 Kc/s-30 Mc/s. F.E.T. front end ● 2 mechanical filters ● Huge dial ● Product detector ● Variable BFO ● Notchlimiter ● 8 meter ● 24in. Bandspread ● 230 v. A.C./12 v. D.C. neg earth operation ● RF gain control. Size 16in. x 8in. x 8in. Wt. 18 lbs. EXCEPTIONAL VALUE £45. CARR. 10/- S.A.E. FOR FULL DETAILS.

RUSSIAN CI-16 DOUBLE BEAM OSCILLOSCOPE

5 mc/s Pass Band. Separate Y1 and Y2 amplifiers. Rectangular 5in. x 4in. C.R.T. Calibrated triggered sweep from 2 μsec. to 100 mill-sec. per cm. Free running time base 500/s-1m/s. Built-in time base calibrator and amplitude calibrator. Supplied complete with all accessories and instruction manual. £37. Carr. paid.



TRIO COMMUNICATION RECEIVER MODEL 9R-59DE



4 band receiver covering 500 Kc/s to 30 Mc/s, continuous and electrical bandspread on 10-15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and 2 phone jacks. SSB-CW ● ANL ● Variable BFO ● 8 meter. ● Sep. Bandspread dial ● LF 455 Kc/s ● audio output 1.5 w. ● Variable RF and AF gains controls. 115/250 v. A.C. mains. Beautifully designed. Size 7x15x10in. With instruction manual and service data. £42. Carriage paid Trio Communication Type Headphones. Normally £5.19.6. Our price £3.15.0 if purchased with above receiver.

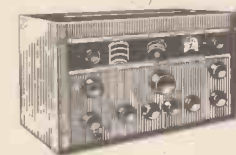
TRIO TS 510 Amateur Transceiver with speaker and mains P.S.U. £180
TRIO JR 500SE 10-80 Metre Amateur Receiver £65

LAFAYETTE HA.800 SOLID STATE AMATEUR COMMUNICATION RECEIVER SIX BANDS 3.5-4, 7-7.3, 14-14.35, 21-45, 28-29.7, 50-54 Mc/s.

Dual conversion on all bands. 2 x 455 Kc/s mechanical filters. Product detector. Variable B.F.O. 100 Kc/s crystal calibrator. '8' meter. Huge slide rule dial. Operation 230v AC or 12v DC. Size 15" x 9 1/2" x 8 1/2". Complete with instruction manual. £57.10.0. Carr. Paid. (100 Kc/s Crystal 39/6 extra.)



TRIO JR-310 NEW AMATEUR BAND 10-80 METER RECEIVER IN STOCK £77.10.0



RCA COMMUNICATIONS RECEIVERS AR88D

Latest release by ministry BRAND NEW in original cases. 110-250v. A.C. operation. Frequency in 6 Bands. 535 Kc/s-32 Mc/s continuous. Output impedance 2.5-600 ohms. Incorporating crystal filter, noise limiter, variable BFO, variable selectivity, etc. Price £65. Carr. £2.



LAFAYETTE PF-60 SOLID STATE VHF FM RECEIVER

A completely new translocated receiver covering 182-174 Mc/s. Fully tuneable or crystal controlled (not supplied) for fixed frequency operation. Incorporates 4 INTERGRATED CIRCUITS. Built-in speaker and illuminated dial. Squelch and volume controls. Tape recorder output. 75 Ω aerial input. Headphone jack. Operation 230 v. A.C./12 v. D.C. Neg. earth. £37/10/- Carr. 10/-.

TELETON MODEL CR-10T AM/FM STEREO TUNER AMPLIFIER



A new model from Teleton. 31 solid state devices. 4+4 watt output. Inputs for ceramic/crystal cartridge. Frequency range AM 540-1600 KHz. FM 88-108 MHz. Automatic FM Stereo reception. Stereo Indicator. Controls: Tuning, function selector, Tone and B & L volume controls. AF3 switch. Stereo headphone socket. Size 13 1/2in. x 3 1/2in. x 9 1/2in. approx. Price £34/0/0. Carr. 7/6.

SEW PANEL METERS

Type MR.35P. 1 21/32in. square fronts.

50μA	40/-	50mA	27/6	100V. D.C.	27/6
60.0-50μA	37/6	100mA	27/6	150V. D.C.	27/6
100μA	37/6	150mA	27/6	300V. D.C.	27/6
100.0-100μA	35/-	200mA	27/6	500V. D.C.	27/6
200μA	35/-	300mA	27/6	750V. D.C.	27/6
500μA	30/-	500mA	27/6	15V. A.C.	27/6
500.0-500μA	27/6	750mA	27/6	50V. A.C.	27/6
1mA	27/6	1 amp	27/6	300V. A.C.	27/6
1.0-1mA	27/6	2 amp	27/6	500V. A.C.	27/6
5mA	27/6	5 amp	27/6	8 meter 1mA	38/-
2mA	27/6	10V. D.C.	27/6	VU meter	42/-
10mA	27/6	15V. D.C.	27/6		
20mA	27/6	20V. D.C.	27/6		

FULL RANGE OF OTHER SIZES IN STOCK—SEND SAE FOR LEAFLET

POWER RHEOSTATS

High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range available ex-stock. Single hole fixing. 1/2in. dia. shafts. Bulk quantities available. 25 WATT. 10/25/50/100/250/500/1000/1500/2500 or 5000 ohms. 14/6. P. & P. 1/6. 50 WATT. 10/25/50/100/250/500/1000/2500 or 5000 ohms. 21/-. P. & P. 1/6. 100 WATT. 1/5/10/25/50/100/250/500/1000 or 2500 ohms. 27/6. P. & P. 1/6.



BELCO DA-20 SOLID STATE DECADE AUDIO OSCILLATOR



New high-quality portable instrument. Sine 1 Hz to 100 KHz. Square 20 Hz to 20 KHz. Output max. +10 dB (10 K ohms). Operation 220/240 v. A.C. Size 215 mm x 150 mm x 120 mm.

Price £27.10.0 Carr. 5/-.

MARCONI TF142E DISTORTION FACTOR METERS

Excellent condition. Fully tested £20. Carr. 15/-.

T.E.40 HIGH SENSITIVITY A.C. VOLTMETER



10 meg. input 10 ranges: .01/.03/1/3/10/30/100/300 v. R.M.S. 4 cps-1.2 Mc/s. Decibels -40 to +50 dB. Supplied brand new complete with leads and instructions. Operation 230 v. A.C. £17/10/- Carr. 5/-.

PLESSEY SL 403A

3-watt. integrated amplifier circuit. 49/6 post paid.

TE-45 VALVE VOLTMETER



High quality instrument with 28 ranges. D.C. volts 1.5-1,500 v. A.C. volts 1.5-1,500 v. Resistance up to 1,000 megohms. 220/240v. A.C. operation. Complete with probe and instructions £17/10/0. P. & P. 6/- Additional Probes available; R.F. 35/- H.V. 42/6.

COSSOR 1049 DOUBLE BEAM OSCILLOSCOPES

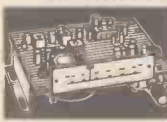
D.C. coupled. Band width 1 Kc/s. Perfect order. £25. Carr. 30/-.

AM/FM SIGNAL GENERATORS



Oscillator Test No. 2. A high quality precision instrument made for the Ministry by Alrmec. Frequency coverage 20-50 Mc/s. AM/CW/FM. Incorporates precision dial, level meter, precision attenuator 1μV-100Mv. Operation from 12 volt D.C. or 0/110/200/250 v. A.C. Size 12 x 8 1/2 x 8 1/2 in. Supplied brand new condition complete with all connectors, fully tested. £45. Carr. 20/-.

TRANSISTOR FM TUNER



6 TRANSISTOR HIGH QUALITY TUNER. SIZE ONLY 6in. x 4in. x 2 1/2in. 3 I.F. stages. Double tuned discriminator, ample output to feed most amplifiers. Operates on 9 volt battery. Coverage 88-108 Mc/s. Ready built ready for use. Fantastic value for money. £6/7/6. P. & P. 2/6.

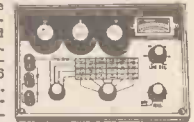
STEREO MULTIPLEX ADAPTORS, 99/6.

TE-16A TRANSISTORISED SIGNAL GENERATOR



5 Ranges 400 KHZ-30 MHz. An inexpensive instrument for the handyman. Operates on 9v. battery. Wide easy to read scale. 800 KHZ modulation. 6 1/2" x 5 1/2" x 3 1/2". Complete with instructions and leads. £7/19/6. P/P 4/-.

TRANSISTORISED L.C.R. A.C. MEASURING BRIDGE.



A new portable bridge offering excellent range and accuracy at low cost. Ranges: E. 1Ω-11.1 MEG Ω. 6 Ranges ± 1%. L. 1μH-111 HENRIES. 6 Ranges-2%. C. 10PF±1110MFD. 6 Ranges ± 2%. TURNING RATIO 1:1/1000-1:11100. 6 Ranges ± 1%. Bridge voltage at 1,000 CFS. Operated from 9 volts. 100μA. Meter indication. Attractive 2 tone metal case. Size 7 1/2" x 5" x 2". £20. P. & P. 5/-.


AUTO TRANSFORMERS

0/115/230v. Step up or step down. Fully shrouded 150 W. 42/6. P. & P. 3/6
300 W. 65/- P. & P. 4/6
500 W. 24/10/0. P. & P. 8/6
1,000 W. 26/10/0. P. & P. 7/6
1,500 W. 27/19/6. P. & P. 8/6
7,500 W. 215/10/0. P. & P. 20/-.


G. W. SMITH & Co. (Radio) Ltd.

ALSO SEE OPPOSITE PAGE

BELCO AF-5A SOLID STATE SINE SQUARE WAVE C.R. OSCILLATOR
 Sine 18-200,000 Hz; Square 18-500,000 Hz.
 Output max. +10 dB (10 K ohms). Operation internal batteries. Attractive 2-tone case. 7 1/2 in. x 5 in. x 2 in.
Price £17.10
 Carr. 3/6



TE-20RF SIGNAL GENERATOR
 Accurate wide range signal generator covering 120 kc/s-250 Mc/s on 6 bands. Directly calibrated. Variable R.F. attenuator. Operation 200/240 v. A.C. Brand new with instructions. £15.
 P. & P. 7/6. S.A.E. for details.



PEAK SOUND PRODUCTS
 Full range of Amplifiers, kits, Speakers in stock.

TE22 SINE SQUARE WAVE AUDIO GENERATORS
 Sine: 20 cps to 200 kc/s. on 4 bands. Square 20 cps to 30 kc/s. Output impedance 5,000 ohms, 200/240 v. A.C. operation. Supplied brand new and guaranteed with instruction manual and leads. £16.10-0.
 Carr. 7/6.




LAFAYETTE TE-46 RESISTANCE CAPACITY ANALYSER
 2 pf-2,000 mfd. 2 ohms-200 megohms. Also checks impedance turns ratio insulation. 200/250 v. A.C. Brand new. £17.10
 Carr. 7/6.



TY75 AUDIO SIGNAL GENERATOR
 Sine Wave 20 CPs-200 Kc/s. Square Wave 20 CPs-30 Kc/s. High and low impedance output. Output variable up to 6 volts. 220/240 volts A.C. Brand new with instructions. £16. Carr. 7/6. Size 210 x 150 x 120 mm.



TE-20D RF SIGNAL GENERATOR
 Accurate wide range signal generator covering 120 Kc/s-500 Mc/s on 6 bands. Directly calibrated. Variable R.F. attenuator, audio output. Xtal socket for calibration. 220/240V. A.C. Brand new with instructions. £15. Carr. 7/6. Size 140 x 215 x 170 mm.



ADVANCE TEST EQUIPMENT
 Brand new and boxed in original sealed cartons.
JIB. AUDIO SIGNAL GENERATOR
 15 c/s to 50 Kc/s. Sine wave. Output 600 ohms or 5 ohms. £30.0.0.


VM79. UHF MILLIVOLT METER
 100 Kc/s to 1,000 Mc/s. A.C. 10 mV to 3v. D.C. 10 mV to 3v. Current 0.01 uA to 0.3 mA. Resistance 1 ohm to 10 megohm. £125.0.0.

TT15. TRANSISTOR TESTER
 Full range of facilities for testing PNP or NPN transistors in or out of circuit. £37.10.0.
 Carriage 10/- per item.

SOLARTRON CD 711S2 DOUBLE BEAM OSCILLOSCOPES
 D.C. to 9 Mc/s. Perfect order. £65. Carr. 50/-.

AVO CT.38 ELECTRONIC MULTIMETERS
 High quality 97 range instrument which measures A.C. and D.C. Voltage, Current, Resistance and Power Output Ranges D.C. volts 25 mV-10,000V. (10 meg Ohm input). D.C. current 10uA-25 amps. Ohms. 0-1,000 meg Ohm. A.C. volt 100mV-250V (with R.F. measuring head up to 250 Mc/s). A.C. current 10uA-25 amps. Power output 50 micro-watts-5 watts. Operation 0/110/200/250V. A.C. Supplied in perfect condition complete with circuit lead and R.F. probe. £25. Carr. 15/-.

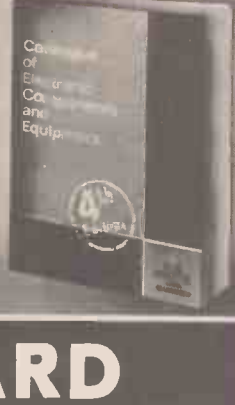
SOLID STATE VARIABLE A.C. VOLTAGE REGULATORS
 Compact and panel mounting. Ideal for control of lamps, drills, electrical appliances etc. Input 230/240 v. A.C. Output continuously variable from 20 v.-230 v. Model MR 2305 5 amp 68 x 46 x 43 mm. £8.7.6. Model MR 2310 10 amp 90 x 68 x 60 mm. £11.19.6. Postage 2/6.



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SL65	£11.12.6	A70/11	£11.19.6
		401	£25.0.0


Carriage 7/6 extra each item.

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 1. For 8P25, SL65, SL65, 3000, 2026/T/C, 2025, 1000, £4.10.0.
 2. For AP75, SL75, SL95, £5.19.6.
 3. For 8P25 etc. to operate with lid in place £5.19.6. Carriage 7/6 extra each type.

SPECIAL OFFERS
 Garrard SP25 fitted Goldring G800 cartridge and wooden plinth. Total list price £32.8.5.
OUR PRICE £19.15.0. Carr. 10/-
 Plastic Cover 15/- extra.
GOLDRING GL69 fitted Goldring G800 cartridge complete with de luxe base and cover. Total list price £50.16.0.
OUR PRICE £39. Carr. 20/-

Variable Voltage TRANSFORMERS
 Brand new, guaranteed and carriage paid. High quality construction. Input 230 v. 50-60 cycles. Output full variable from 0-260 volts. Bulk quantities available.
 1 amp.—£5/10/-; 2.5 amp.—£6/15/-; 5 amp.—£9/15/-;
 8 amp.—£14/10/-; 10 amp.—£18/10/-; 12 amp.—£21; 20 amp.—£37

RTC 249 4-TRACK TAPE DECK
 British made. Speeds 1 1/2 in., 9 1/2 in., 7 1/2 in. p.s. Marriot heads. 7 in. reel size. Push button controls, fully interlocking. Size 13 in. x 10 in. x 1 1/2 in. above unit plate, 4 1/2 in. below. Full instructions. £13.19.8. Carr. 7/6.



MULTIMETERS for EVERY purpose!

TE-900 20,000 OHM/VOLT GIANT MULTIMETER
 Mirror scale and overload protection. Sim. full view meter. 3 colour scale. 0/2.5/10/250/1,000/5,000 v. A.C. 0/25/12.5/10/50/250/1,000/5,000 v. D.C. 0/50uA/110/1v./500mA/10 amp. D.C. 0/2K/200K/2M/300M Ohm. £15/-+. P. & P. 5/-.

MODEL AS-100D. 100K Ohm/Volt. Sim. mirror scale. Built-in meter protection 0/3/12/60/120/300/600/1,200 v. D.C. 0/6/30/120/300/600 v. A.C. 0/10uA/60/600/300mA/12 Amp. 0/2K/200K/2M/300M Ohm. —20 to +17dB. £19/10/-+. P. & P. 3/6.

MODEL TE-200 20,000 O.P.V. Mirror scale, overload protection. 0/5/25/125/1,000 V.D.C. 0/10/50/250/1,000 V.A.C. 0/50 uA/250 MA. 0/60K/6 meg. —20 to +62 db. 75/-+. P. & P. 2/6.

MODEL TE-300 30,000 O.P.V. Mirror scale, overload protection 0/6/30/150/300/1,200 V.D.C. 0/6/30/120/300/1,200 V.A.C. 0/30uA/60mA/600mA/300mA/600mA. 0/8K/80K/800K/8 meg. —20 to +63 db. £5.19.6. P. & P. 3/-.

MODEL TE-12. 30,000 O.P.V. 0/0.6/6/30/120/300/1,200 v. 3,000/6,000 v. D.C. 0/6/30/120/600/1,200 v. A.C. 0/80uA/60/600mA. 0/6K/600K/6Meg. 60 Meg. 0.50 Pf. 2 MF 25/19/6. P. & P. 3/6.

MODEL TE-5L NEW 20,000 OHM/VOLT MULTIMETER, with overload protection and mirror scale, 0/6/60/120. 1,200 v. A.C. 0/3/30/60/300/600/3,000v. D.C. 0/60uA/12/1300mA D.C. 0/60K/6 meg. ohm. 92/6. P. & P. 2/6.

MODEL PT-34. 1,000 O.P.V. 0/10/50/150/250/1,000V. a.c. and d.c. 0/1/100/500 mA. d.c. 0/100 K Ohm 39/6. P. & P. 1/6.

LAFAYETTE 57 Range Super 50K Ohm/V. Multimeter. D.C. volts 15v-1000v. A.C. volts 1.5v-1000v. D.C. Current 25uA-10 Amp. Ohms 0-10 Meg Ohm. D.B.—20 to +81 db. Overload protection. £12/10/-. P. & P. 3/6.

TE-5L NEW 20,000 OHM/VOLT MULTIMETER, with overload protection and mirror scale, 0/6/60/120. 1,200 v. A.C. 0/3/30/60/300/600/3,000v. D.C. 0/60uA/12/1300mA D.C. 0/60K/6 meg. ohm. 92/6. P. & P. 2/6.

SAVE UP TO 33% ON HI-FI EQUIPMENT
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AVO CT471A MULTIMETER
 Battery operated, fully transistorised. Sensitivity 100 MΩ/v. Measures A.C./D.C. voltages 12mV to 1,200V. A.C./D.C. current 12uA to 1.2 Amp. Resistance 12 ohm to 120 mΩ H.F., V.E.F., U.H.F. voltage with multiplier 4V. to 400V. up to 50 Mc/s, 40mV to 4V. up to 1,000 Mc/s. Offered in perfect condition. £25 each. Carr. 10/-.

SINCLAIR EQUIPMENT
Project 60. Package Offers
 2 x Z30 amplifier, stereo 60 pre-amp. P25 power supply. £19.0.0. Carr. 7/6. Or with P26 power supply, £21.0.0. Carr. 7/6. 2 x Z50 amplifier, stereo 60 pre-amp. P28 power supply. £21.10.0. Carr. 7/6. Transformer 4 P28, 59/6 extra. Add to any of the above £4.17/6 for active filter unit and £16.0.0 for a pair of Q16 speakers. All other Sinclair products in stock: 9,000 amplifier, £23.0.0. Carr. 7/6. Nesteric amplifier £46.0.0. Carr. 7/6.


ECHO HS-606 STEREO HEADPHONES
 Wonderfully comfortable. Lightweight adjustable vinyl headband, 6ft. cable and stereo jack plug, 25-17,000 cps., 8Ω imp. 67/6. P. & P. 2/6.



B.C. 221 FREQUENCY METERS
 Latest release 125 KHz-20 MHz. Excellent condition. Fully tested and checked and complete with calibrator charts. £27.10.0 each. Carr. 10/-.

270° 500 MICROAMP METER
 Incorporated in Radio Altitude Indicator ID-14APN. Ideal for rev. counter etc. 15/6. P. & P. 3/-.


HOSIDEN DH-025 STEREO HEADPHONES
 Wonderful value and excellent performance combined. Adjustable headband, 8 ohm impedance. 20-12,000 cps. Complete with lead and stereo jack plug. ONLY 47/6 P. & P. 2/6.



TRANSISTORISED TWO-WAY TELEPHONE INTERCOM
 Operative over amazingly long distances. Separate call and press to talk buttons. 2-wire connection. 1000's of applications. Beautifully finished in ebony. Supplied complete with batteries and wall brackets. £6/19/6 pair. P. & P. 3/6.



TE111 DECADE RESISTANCE ATTENUATOR
 Variable range 0-111 db. Connections: Unbalanced T and Bridge T. Impedance 600 ohms. Range (0.1 db x 10) + (1 db x 10) + 10 + 20 + 30 + 40 db. Frequency: DO to 200 KHz (—3db). Accuracy: 0.05 db. + indication db x 0.01. Maximum input less than 4 watts (50 volts). Built in 600 Ω load resistance with internal/external switch. Brand new £27/10/-. P. & P. 5/-.



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 Cosmocon 1 track heads: Post extra.
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 Record/Playback, high Imp..... 65/-
 Erase, low Imp..... 20/-

AMERICAN RECORDING TAPES

First grade quality American tapes.	3in. 225ft. L.P. Acetate	3/8
	3 1/2in. 600ft. T.P. Mylar	10/-
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Brand new and guaranteed.	3in. 1,200ft. D.P. Mylar	15/-
	5 1/2in. 1,200ft. L.P. acetate	12/6
	5 1/2in. 1,800ft. L.P. Mylar	19/-
	5 1/2in. 1,800ft. D.P. Mylar	22/6
Discounts for quantities.	7in. 1,200ft. Std. acetate	39/6
	7in. 1,800ft. L.P. acetate	15/-
Postage 2/-.	7in. 1,800ft. L.P. Mylar	24/-
Over £3 paid.	7in. 2,400ft. D.P. Mylar	25/-
	7in. 3,600 ft. T.P. Mylar	45/-

TAPE CASSETTES
 Top quality in plastic library boxes.
 C60—60 min. 8/6; 3 for 24/6.
 C90—90 min. 12/6; 3 for 36/6.
 O120—120 min. 15/-; 3 for 43/6.
 Cassette Head Cleaner 11/3 All Post Extra.

G.W.SMITH & CO. (RADIO) LTD
 3, LISLE STREET, LONDON, W.C.2 Tel: 01-437 8204
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ELECTRONIC BROKERS LTD

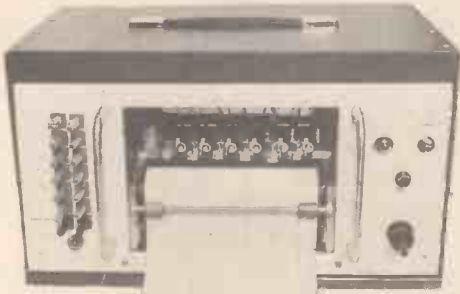
NEW 6-CHANNEL TIME AND EVENT RECORDER

A self-contained instrument, specifically for recording events without the need for a combined recorder.

There is a separate and independent paper drive, with a monitor lamp indicating when it is in operation. The pens are displaced 1/16", activated by a close contact system. Each of the 6 channels works independently of each other, with the pens writing at 72 hours per filling at a maximum speed of 10 pulses per second.

The recorder is supplied either in a portable cabinet or with rack mounting adaptions and the size is 15" x 9" x 9 1/2" deep. It weighs 10 lb. and is available in 220-240 volt A.C. (50 cycles) or 110-115 volt A.C. (60 cycles). The 6-channel time and event recorder is available at the following speeds: 30, 20, 10, 5, 1 per minute. 18, 12, 9, 6 per hour. Width of paper roll is 6", maximum diameter of roll is 3", length on standard 3" diameter paper roll is 2 00'. Price of the event marker is £79-10-0, plus £5-0-0 for the special vinyl-treated portable case.

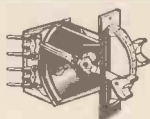
The instrument is guaranteed for one year, and is available with a complete range of accessories, including teledots paper, graphic paper, plain paper, pens, pen containers and time bases. Prices of these items are available on application.



HIGH GRADE COMPONENTS

DOUBLE AUDIO FADERS IW

1000 plus 1000 ohms. Each resistive dimmer is adjustable and independent of each other. Ex-equipment but in an almost new condition. Price £3/19/6. P. & P. 7/6.



AVO TRANSISTOR ANALYSER CT 446

A portable direct-reading instrument capable of giving accurate transistor measurements in the grounded emitter configuration. Battery power unit 1.5V to 10.5V in 5 steps. Base current 0-1 mA, 1-40 mA. Collector current 250 mA. Size: 1 1/2 x 9 1/2 x 5 in. Weight with batteries: 15 lbs. Price £42-10-0. Carriage extra.



MINIRACK MULTICHANNEL OSCILLOGRAPH. MUR 12

The multichannel oscillograph is a 12 ch. oscilloscope with recording facilities. The instrument consists of two units. The trolley mounted recording unit comprising 12 chs. with their respective controls and a 120 mm. continuous feed camera. The electronic console contains the appropriate amplifiers, time marker, time base, and associated power supplies. Price and full details on application.



OSCILLOSCOPE CAMERAS

Coscor. Model 1431 and Model 1428. Complete with motor auto transformer and capacitor unit. Price £49-10-0 plus carriage. Langham Thompson 200 Type B. Price £55-0-0 plus carriage. New Telford Polaroid. Type 'A'. Price £95-10-0 plus carriage. Viewing head to suite Type 'A' camera. Price £25-10-0 plus carriage.

VOLSTATS

Type	I/P	Freq.	O/P	Load	Price
CV 25E	190/260	50	6	25 W.	£3-10-0
MT 161E	190/260	50	6	50 W.	£5-10-0
MT 161F	190/260	50	12	50 W.	£6-10-0
MT 161A	190/260	50	30	50 W.	£7-10-0
CV 500/27	95/130	50	85	4 Amp	£15-0-0
CV 50J	190/260	50	230	50 W.	£4-0-0
CV 150/98	110/220	50	230	150 W.	£8-10-0
MT 267A	190/260	50	230	250 W.	£10-10-0
MT 161ADA	190/260	40	230	50 W.	£4-0-0
MT 140A	190/260	50	230	150 W.	£7-0-0
MT 262XA	190/260	50	230	500 W.	£25-0-0
MT 140	190/260	50	230	150 W.	£8-10-0
MT 262A	190/260	50	230	500 W.	£25-0-0
30MB790	210/250	50	230	2.61 Amps	£25-0-0
CVE 60A	190/260	50	240	60 W.	£10-10-0
CV 50D	95/130	50	240	50 W.	£3-10-0
CV 100BA	190/260	50	240	1000 W.	£35-10-0
OVN 500H	190/260	50	220	500 W.	£35-0-0

GALVANOMETERS (PENCIL TYPE) SPECIFICATIONS

Adaptors available to suit all types of recorders.

Type No.	Natural Frequency Response ± 5% c/s	Terminal Resistance in ohms	Galvanometer sensitivity for a 35cm optical path. MA/cm	Price
EB/25	20	85	0.4 Micro A/cm	£33
EB/30	35	75	0.67 Micro A/cm	£33
EB/40	40	95	0.43 Micro A/cm	£33
EB/40c	40	45	2.1 Micro A/cm	£33
EB/60	60	90	0.7 Micro A/cm	£33
EB/100c	100	60	9.1 Micro A/cm	£33
EB/100	100	75	2.7 Micro A/cm	£33
EB/160	160	70	5 Micro A/cm	£33
EB/200	200	70	21 Micro A/cm	£33
EB/300	300	120	25 Micro A/cm	£33
EB/450	450	120	50 Micro A/cm	£33

High Frequency Types	Price
EB/1,000	1,000
EB/1,400	1,400
EB/1,600	1,600
EB/2,200	2,200
EB/2,500	2,500
EB/3,300	2,300
EB/4,000	4,000
EB/5,000	5,000
EB/8,000	8,000
EB/10,000	10,000
EB/20,000	20,000

GENERATORS

AVO SIGNAL GENERATOR CT 378

2-225 M Hz in 7 ranges on Fundamentals up to 450 M Hz on Harmonics. Scale calibration accuracy ± 1%. Output 1 micro volt to 25 mV continuously variable into 75 ohm using fixed attenuator pad. Modulation facilities. A/F o/p facility. O/p level meter. Force o/p facility. Size 1 1/2 in. x 9 1/2 in. x 1 1/4 in. Weight 25 lbs. Price £45. Carriage extra.



OSCILLATORS & SIGNAL GENERATORS

I 1 CRYSTAL CONTROLLED OSCILLATOR STC. 16-LXU-52A Mk II. 0-20 M Hz. Sweep facilities. O/p attenuation 0-70db. Complete with power supply unit 14-LXU-52B. Price £25
I 104 NEW AUTOMATIC CYCLING OSCILLATOR. ACOS 1. P.YE. Range 5Hz-5K Hz. Sweep mode 1 Clr/min. O/p. 0-10V. Mains Supply. Price £99-10
I 108 LOW FREQUENCY DECADE OSCILLATOR D-638-A MUIRHEAD. Range 0.1 Hz-2.12 K Hz. O/p 0-50V. Mains supply. Max O/p 1W in 600 Ohm at 30 Hz. Price £45
I 109 DECADE OSCILLATOR D-850-B. Range 1 Hz-111K Hz. Max O/p 2 W into 8 K Ohm above 20 Hz. O/p 0-150V. Price £45
I 110 L.F. OSCILLATOR G 420 FURZEHILL. Range 1.4 Hz-15 K Hz. Viewing CRT. Price £15
I 113 R.C. OSCILLATOR & AUTOMATIC FREQUENCY MONITOR-SMITHS. Oscillator range 10 Hz-100 K Hz. Price £75
I 130 AUDIO FREQUENCY OSCILLATOR-PYE. Range 20 Hz. O/p. 0-20V. Mains operated. Price £15
I 49 GAUGE OSCILLATOR M 700L SOUTHERN INSTRUMENTS. Price £15

I 18 SIGNAL GENERATOR CT218. Range 85-30 M Hz. O/p. Facilities include crystal calibrator, modulation. Price £25
I 15. AUDIO FREQUENCY GENERATOR. Type J2. ADVANCE. Range 15Hz-50 K Hz. O/p. 0-40V. Price £25
I 83. SIGNAL GENERATOR. CT 480 SANDERS. Range 7 K Hz-12 K Hz. O/p. 0-±50V. Attenuation range -10 to -4. 100 db. Price £25
I 79 WOBULATOR GM 2877/02 PHILLIPS. Price £25
I 42 NOISE GENERATOR CT 410 WAYNE KEER. Frequency. Range. 15 Hz-160 M Hz. Timer 0-8 mins. Diode Current 0 db at 5mA to +13db at 100 mA. Price £50
FM/AM SIGNAL GENERATOR. Type SG. 63D. ADVANCE. Range 4M Hz-100 M Hz. O/p 1 micro V-100 mV. Sweep facility and line FM deviation ± 100 K Hz. Price £55
I 105 SIGNAL GENERATOR Mod. 68A TAYLOR. Range 100 K Hz-240 M Hz. O/p 0-10V R.F. O/p and attenuation 0 to -80 db in 4 steps. Price £15

MOTORS

HIGH TORQUE INDUCTION MOTOR

3-30 oz/inch. Available in the following speeds only 240V 50 Hz 1 r.p.m., 1 r.p.m., 2 r.p.m. 120 V 50 Hz. 20 r.p.m. 30/- each. P. & P. 3/-.

HIGH PRECISION MAINS MOTOR 3 Phase-1 Phase

3000 r.p.m. Made by Croydon Engineering. Model KA 60 JPB. Suitable for capstan motor. Size 3 in. long, 4 1/2 in. diameter with 6 in. diameter flange and 4 fitting holes. £4/10 each. P. & P. 25/-.



LOW TORQUE HYSTERESIS MOTOR MA23

Ideal for instrument chart drives. Extremely quiet, useful in areas where ambient noise levels are low. High starting torque enable relative high inertia loads to be driven up to 0-02 in. Available in the following speeds and ranges: 240V 50 Hz 4 r.p.m., 1/2 r.p.m., 1 r.p.m., 1/3 r.p.m., 1/3 r.p.m., 1/5 r.p.m., 1/10 r.p.m., 1/12 r.p.m., 1/20 r.p.m., 1/40 r.p.m., 1/60 r.p.m., 1/75 r.p.m., 1/120 r.p.m., 1/180 r.p.m., 1/720 r.p.m., 1/280 r.p.m., 1/45 r.p.m.; 120V 50 Hz 1/6 r.p.m., 1/15 r.p.m., 1/18 r.p.m., 1/20 r.p.m., 1/24 r.p.m., 1/30 r.p.m., 1/60 r.p.m., 1/120 r.p.m., 1/240 r.p.m., 1/300 r.p.m., 1/720 r.p.m., 1/440 r.p.m. 25/- each. P. & P. 3/-.

HYSTERESIS REVERSIBLE MOTOR

Incorporating two coils. Each coil when energised will produce opposite rotation of output shaft. 240V 50 Hz. 1/2 r.p.m., 1/3 r.p.m., 1/6 r.p.m., 120V 60 Hz, 1/10 r.p.m., 30/- each. P. & P. 3/-.

SYNCHRONOUS MOTORS

Model S 71 r.p.h. and 1/60 r.p.h. Self starting complete with gearing shaft 1/2 in. dia. in. long. 200/250V 50 Hz. New condition Ex-Equipment. 40/- P. & P. 3/-.

DATA TRANSMISSION-SYNCHROS

Type	Maker	Voltage	Hz	Price
Torque Receiver	11TR4a	Sperry	90/115v	400
Torque Receiver	ACN 1550C	Smith	26,12.3	400
Torque Receiver	11TR4a	Pullin	90/115v	400
Control Transformer	11CT4A	Muirhead	90v	400
Control Transformer	09CT4	Muirhead	26v	400
Control Transformer	11CT4a	Sperry	90v	400
Control Transformer	11CX4a	Pullin	26v	400
Control Transformer	11CX4	Ketay	115/90v	400
Torque Transmitter	AC8/AE	Smith	115/90v	400
Torque Transmitter	11MD3	Muirhead	26v	400
Torque Transmitter	15M1B1	Muirhead	115/90v	400

A.C. MOTOR GENERATOR

Type G1005 Motor Spec. 6000 r.p.m. Torque 25gm/cm. Control winding 26v., 400Hz. Ref. Winding 26v., 400Hz. generator Spec. Ref. Winding 26v., 400Hz. O/P 0.4v/1000 r.p.m. Length 2 in., dia. 1 in. Price £7/10/0 p. & p. 5/-.

D.C. TACHOGENERATOR

Type 8c/106 16v. at 1000 r.p.m. Drive shaft dia. 3/16 in., 3/8 in. long. Price £16/10/0.



SYNCHRONOUS MOTOR WITH GEARBOX

Motor 11M83 gearbox type 11H21. This unit is an 8000 r.p.m., 115v., 400Hz motor fitted with concentric cyclo gear reduction gearbox of 9.92/1. Motor torque 6 oz./in. length o/w gearbox 2 5/8 in. x 1 in. diameter.

RAGONOT MOTOR

220V 3-phase 50Hz 1/20 HP. 1500 R.P.M. Precision EX-OILY RUBBER TAPE DRIVES. Motor moves 1 in. axially on "Switch on" to take up drive and on "Switch off" is spring returned to disengage drive. 45/- each. P. & P. 10/-.



FRACMO

230v. 1/50 h.p., 50Hz. 1500 r.p.m. shaft dia. 1/8 in. Price 45/- P. & P. 10/-.



EVERSHED & VIGNOLES SPLIT FIELD SERVO MOTOR

Type FB6A-A1/B 1 in. keyed shaft. Price £12/10/0 each.

MEASURING INSTRUMENTS AND RECORDERS

PORTABLE AC/DC PEN RECORDER

A most versatile pen recorder. Produces a trace on a curvi-linear 3 1/2 in. strip chart. Two speeds 1 in. and 6 in./hr. Limiting contacts to give alarm, and limits the current when it exceeds the high and/or low preset values. Range: 0 - 1MA D.C. Meter Resistance 400 ohms; 0 - 1MA A.C. Meter Resistance 1800 at 50 Hz; -10 to +5 dB into 600 ohm Impedance Source. Chart speed: 1 in. and 6 in./hr. Chart width: 3 1/2 in. curvi-linear. Power supply: 230V 50 Hz driving Synchronous Motor. Price: £52-10-0. P. & P. £15-0.



49-53 PANCRAS ROAD, LONDON, N.W.1. Tel: 01-837 7781/2. Cables: SELELECTRO

STRIP-CHART INDICATING RECORDER

Chart width 9½ in. 10 mV. Sensitivity ±0.17 of full scale. Source impedance 100 ohms. Speed of operation 33 sec. for full-scale travel. Chart speed ¼ in., 3 in., 6 in. per hour. Single point. £49.10.0. P. & P. 30%. 12 Multi-point recorder available.



PORTABLE D.C. 3 inch SINGLE PEN RECORDER (Panel Mounting)

Made to G.P.O. specification, this is a very compact and accurate instrument. Available 0-1mA and 0-500 micro amp. Fitted with alarm circuit which operates when current exceeds preset values. Specifications: Chart width 3 in. Chart speed 1 in. and 6 in./hr. Other speeds available by changing gears. Resistance 400 ohm (1mA range). Resistance 1.53 K ohms. (500 micro amp range). Power Supply 190/250V. 50Hz for synchronous drive motor. Dimensions: 9½x4 6 in., Height 7½ in. Depth 9 in. Weight 22 lb. Price 0-1mA £49/10/0; 0-500 micro-amp £55.



PEN RECORDER

Portable 1, 2 and 4 channel pen recorders by Kelvin Hughes. General purpose recorders providing clear instantaneous and permanent records of phenomena with comparatively high rates of change. The torsion-strip suspension of the moving-coil renders the instrument immune to the effects of vibration and acceleration.



Six possible chart speeds, chart width 55 mm., length 150 ft., linearity 8 v. at 3 mA. response D.C. to 100 c/s. Single pen with amplifier £99; 2 pen recorder £85, 4 pen with amplifier £149. Also 5 pen recorder complete with amplifiers, specification as above but housed in cabinet £225. P. & P. extra.

POTENTIOMETRIC 6 POINT STRIP CHART RECORDER BRAND NEW

For use with thermocouples, pyrometers and other e.m.f. sources. 6 point. Range (-100) - (+100) mV; (-1,800 deg. C. 6 in. chart width; 1 pen speed 8 secs. Accuracy ±0.5%. 10 chart speeds 20-720 mm/hr. Tropicalised. Including tools and spares. Listed at over £200. Our price £79.10.0. Also available 0-100 mW F.S.D. £89.10.0.



SERVORITER Model FWS

By well-known American manufacturer. Power supply 120 v 50 Hz. Response time 24 secs. Resistance source 10 K ohms max. Chart width 11 in. This is a slow-speed recorder that can be used for measuring any quantity with a comparatively slow rate of change such as temperature, humidity etc. Supplied with electrovolt controller that enables the sensitivity, reset, proportional band and rate to be adjusted. This unit enables the demanded temperature to be controlled and the actual temperature recorded. Size: 16½ in. wide, 17½ in. high, 13½ in. deep. Price £175. Carriage extra.



METERS

A.C.-D.C. CONVERTERS TYPE 2140/AI-BI and 2140/A3-B3

A flexible modular system for use with a DVM for accurate mean (RMS) or true (RMS) Voltage measurements. Module AI LF Amplifier X 0.1 to X 1000. Module A3 LF Amplifier X 0.1 to X 100. 2140/AI-BI 1000 V True RMS Converter. Price £175. 2140/A3-B3 200 V Mean (RMS CALIBRATED) Converter. Price £150.

DIGITAL VOLTMETERS

Type LM902-2. 4 digit £75. LM902-2R. 4 digit £75. LM1010. 4 digit £75. All the above units have been calibrated. DM2006. An all solid state D.V.M. having a wide application. Scale 9999. D.C. accuracy 0.0177%.s.d. with a D.C. range of 10µV to 1kV. Input impedance 10000MΩ. C.M.R. 154dB. Outputs parallel B.C.D. £245. Carriage free. DM2010. Scale 109999. D.C. Accuracy 0.001 per cent. D.C. Range 10 micro volts to 1.1 kV. I/P Z greater than 25000 Megohms. Outputs Parallel BCD. Price £500. DM2001. Scale 19995 DC. Accuracy 0.025% FSD. DC RANGE 50 microvolt to 2 KV. I/P Impedance greater than 10,000 M ohm Parallel BCD Output or Decimal (not isolated). Price £235.

MICOVAC ELECTRONIC TEST METER

By E.I. Ltd. Model 22B this is a precision portable instrument with a wide range of facilities. D.C. volts. 0-2.4, 4.8, 24, 48, 240, 480, volts FSD with facility for centre zero measurement. A.C. volts, similar range to D.C. with frequency coverage from 20 Hz-20 M Hz. Probe increases range from 10K Hz-200 M Hz. Resistance Ranges 0-1 K, 10 K, 100 K, 1 M ohm and 10 M ohms. Fitted with mains F.S.U. adaptor. Metal case. Price £40. Carriage extra.

I 90 VALVE VOLTMETER Type 6 MARCONI. Range 0-150V. Mains operated. Price £25.10
I 50 A.C./D.C. Meter Model 44 E.I.L. Ranges. Voltages 0-200 V. A.C./D.C. Resistance 0-1000 MΩ Current 1mA-10A. Power 1mW-4W: -10 to + 19db. Price £15
I 43 VERNIER POTENTIOMETER-CAMBRIDGE. Accuracy 0.0001V. Standard Cell voltage selection. Price £55

I 517 VIBRON ELECTROMETER. Mod 33B. Electronic Inst. Range 0-10V. 0/p ± 1mA into 1.5 KΩ. Price £85
I 514 pE METER. CAMBRIDGE. Price £12.10
I 506 A.C./D.C. Voltmeter. WINSTON ELECTRONIC. Voltage range -7.5 to 15V. Price £12.10
I 508 FLUX METER Type 15A/AP. T.L.G. ELECTRIC. Range 96-12 gauge. In wooden case. Price £10
I 504 VERNIER POTENTIOMETER. Type 4363. A. TINSLEY. Accuracy x .00001. Price £75
I 513 WATTMETER. S 67. SANGAMO WESTON. Range 0-15W: 150-300V: 0.25-0.5A. Price £29.10
I 117 WIDEBAND MILLIVOLTMETER. TF 1371 MARCONI. Range 3mV-300mV: -10 to + 3 dB. complete with probe. Flat response 30 Hz-30 M Hz. Reading in mV. dB. Price £20
I 121 PORTABLE POTENTIOMETER. Type LI92826 CAMBRIDGE. Fitted with standard cell and thermometer. Price £45
I 122 POTENTIOMETER & GALVO. Type P.3.-CROYDON PRECISION. Accuracy .0001V. Price £35
I 123 SLIDE WIRE POTENTIOMETER. CAMBRIDGE. Voltage range 0.01:0.1-1:10: Fitted with Galvo Key. Absolute Voltage 0-1.7V in 18 steps. Price £35
I 132 DECADE INDUCTOMETER. Type 230A. DAWE. Range 1 micro H to 100 mH. in 40 steps. Price £25
I 114 MILLIVOLTMETER. Type 264. AIRMEC. Range 0-300 mV. Complete with amplifiers and 75Ω probe. Price £20
I 111 VALVE VOLTMETER. Type 712. AIRMEC. Range A.C. 0-150V D.C. 0-500V. Price £25
I 119 ABSORPTION WATTMETER. A.P. No. 1 MB 4. Power Ranges. 200 micro W-6W. Scaled in watts and dB. Impedance 2.5Ω-20 KΩ. Price £30
I 112 STANDARD FREQUENCY CHANGER. Type 203. AIRMEC. Range Volts 0-2.0V. Filters 100 K Hz: 500 K Hz: 1.1 M Hz. Freq. 1 M Hz-30 M Hz. Price £25
I 94 DYNOMETER. Type 3206. TINSLEY. Price £45
I 95 A.C./D.C. VOLTMETER Mod. 32. TURNER. Range Voltage 0-300V. 250/0 Volt. 5 in. moving coil with mirror scales, in wooden carrying case. Price £15
I 98 PHASE METER. Type K159. SOUTHERN INST. 0-100° with invert and direct switching. Price £35
I 92 PHASE METER. Type IT. 1-3. MEMICHAEL RADIO. 0-90° with reverse 0/p switching. Price £20
I 66 MICROAMMETER. CA 138. Range 0-60 microA. Price £10
I 81 FREQUENCY METER 1176-A. GENERAL CAMBRIDGE RADIO. Range 200 Hz-60 KHz. Input 25-150V. Price £30
I 90 A.C./D.C. VOLTMETER. 872.18. SANGAMO WESTON. Range Voltage 0-300V. Price £29.10
I 69 FREQUENCY METER. ENGLISH ELECTRIC. Range 350-410 Hz. Input Voltage. 115 and 208V. Price £5
I 72 TUNING FORK FRQ. METER. 4 volts. 279. 3877. SMITHS. Fitted with clock 1-12 hrs. Freq. 50 cycles. Price £25
I 51 MILLIAMMETER. CAMBRIDGE. Range 0-200 mA. Freq. error less than 0.5%. 64 mirror scale. Price £10
I 519 PRECISION PHASEMETER. Model 901-MAXSON. Facilities include, phase lag, phase lead; fine, medium and coarse reference; balance and multiplier; meters. Price £85
I 8 DYNAMOMETER. M.I.P. Voltage range 0 ± 4V: 0-200V. 54 mirror scale. FSD 220V at 400 Hz in wooden case with carrying handle. Price £35
I 12 B & Q METER. Type 299 XTE. SMITHS. Reference and quadrant reading, also readings in radians: 0-360° head/lag phase readings I/p 0-15V. Price £115

SPECTRUM ANALYSERS

Marconi OA. 109A. Spectrum Analysers. 3 to 30 M Hz. optional low frequency extension unit 100 Hz-3 M Hz. Display continuously variable up to 30 K Hz. Spectrum scan time variable from 0.1 to 30 secs. Long persistence CR tube. Complete with trolley and power supplies. Price £750.



FENLOW LOW FREQUENCY ANALYSER

0.3 Hz to 1 K Hz. Power density 0-10. Bandwidth switching range. .06: 0.3: 1.5: 7.5: 37.5 Hz. Price £275.

EVERSHED & VIGNOLES

2 Channel Mk1 Pen recorder. F.S.D. ± 10mV. These instruments were originally designed for testing synchros, but can be modified to produce a continuous 3 channel moving coil recorder. Price £22.10

INKWELL OPERATION

20 and 40 channel Multipen (Projecting Pattern) Recorder. Driven from a 24V supply. Chart width 9 in. Electromagnet pens. Voltage range 6-125V. Price £65.



VIBRATION EQUIPMENT

Goodmans Vibration Control Amplifier E501. Price £85
Goodmans Vibration Phase Shifter. E 566. Price £89
Goodmans Power Oscillator 6V.A. Price £59.10
Savage 'G' Amplifiers. Price £45
Savage Acceleration Control Unit. 8G01. 12Hz-10K Hz. Input impedance 1MΩ. Output impedance 600Ω. Price £45
Pye Ling. Power Amplifier. 50V.A. Price £30

ENVIRONMENTAL TEST GEAR

Thermostatically controlled ovens by GALLENKAMP. Mains supply 250V 50 Hz. Price £45

IMHOF CABINETS

Various sizes available, ranging in price from £12.10.

AUTOMATIC CRYSTAL THICKNESS SORTING MACHINE

W/W July '69. Price £490
Pulse Amplifier Analyser. Price £250

PLATINUM RESISTANCE THERMOMETER PROBES

SOLARTRON Type NT 1198/c and NT 1687. Accuracy ±1°C. Probes in stainless steel case. 4 in. diameter. Temp. range NT 1198/C-50°C to + 250°C. Price £12.10 each. p. & p. 3/6.

BOURNS KNOB POT

New 10-turn precision potentiometers consisting of potentiometer, knob and readout dial in one extremely compact assembly. A very attractive unit finished in black plastic with white dial. Available in 100K, 20K, 5K, 1K, 1/4W. Resistance tolerance 5%. Accuracy correlation of dial reading to 0/P 0.5%. Weight 0.6 oz., overall length 1 1/16 in., diameter 4 in. New price £7.15/0 each. Our price £4/10/0. P. & P. 2/6.



NUMICATORS

Cold cathode gas-filled, in-line 0-9 digital display tubes. Long life expectancy. Minimum striking voltage 180v. Side reading type XN 13 and XN3 amber filter. Price 18/6 each. P. & P. 2/6.

MERCURY WETTED RELAYS

Type HG4B1007 relay is capable of an operating time as short as 5 mill-seconds. A BILLION OPERATIONS! Small chassis space required. Convenient mounting. Environment-free. Tamper-proof. High sensitivity.



Type	Coil Resistance	Control Rating	Contact
HG2B 1004	5000 ohm	5 amp.	2 PDT
HG2B 1006	1300 ohm	5 amp.	2 PDT
HG2B 1010	1300 ohm	5 amp.	2 PDT
HG4B 1005	1300 ohm	5 amp.	4 PDT
HG4B 1007	1300 ohm	5 amp.	4 PDT

Ex-equip. £1/10/0. P. & P. 5/-.

PHOTOMULTIPLIER VMP11/44 (CV 2317)

by 20th Century Electronics
Cathode sensitivity 40µA/L. Operating volts for 10 A/L 1100 volts. DARK current 0.004µA. £9/10/0. E.M.I. 6097 and 20th Century CV 2317 £9/10/0. P. & P. 5/-.

ANIMAL SONARAY

Type 1803B by Dawes
An instrument for measuring the thickness of fat on an animal by the use of ultrasonic sensing the pulse echo principle. The animal sonaray was specifically designed for the measure of back fat thickness for use under field conditions. Fully portable weighing only 35 lb. With handbook, price: £149/10/0.



CRYSTAL OVENS

Rediton Fitted Bi-Metal Strip 75°C 5°C. Octal Base Type A 4260 EDN" C" 6V AC and 12V AC OR DC. Price £4/10/0. P. & P. 2/6.
Type A 4260 EDN" A" 12V/24V AC/DC. Price £4/10/0. Marconi Type F 3006-01 £12/10/0. P. & P. 2/6.

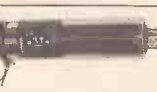


VARIABLE VOLTAGE TRANSFORMERS

Various types available, including single- and three-phase manual or motor drive. Contact us by phone or letter for stock appraisal and delivery.

SYNCHRONOUS CHOPPERS

Base B-9. Coil 6.3 v., 50-60 Hz. Proportion of time contacts are closed 45%. Also available 100 Hz and 400 Hz. Price £6/10/0. P. & P. 5/-.



NEW COMPLETE TELEPHONE DIAL ASSEMBLIES

Clear Perspex dials—no markings. 20/- each. P. & P. 5/-.



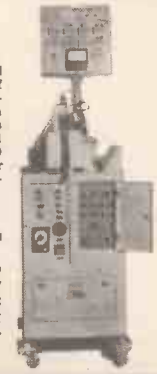
LINEAR THYRISTOR CONTROLLED LIGHT DIMMER

600w. module. Ideally suitable for photoflood or speed controller, etc. Will mount into standard socket boxes. Our price 69/8. P. & P. 8/-.



AUTOMATIC CRYSTAL THICKNESS SORTING MACHINE

Fully automatic dice gauging and sorting system, eliminates all manual operations. This instrument is of extreme interest to manufacturers of semiconductor. It is offered in good condition at a quarter of its original list price. It is suitable for the sorting of germanium and silicon dices. The unit can sort up to 2,400 pieces an hour. Our price £450. Further information available on request. Complete with manual and spares.



All orders accepted subject to our trading conditions a copy of which may be inspected at our premises during trading hours or will be sent on application through the post.

CURRENT RANGE OF BRAND NEW L.T. TRANSFORMERS. FULLY SHROUDED (*excepted) TERMINAL BLOCK CONNECTIONS. ALL PRIMARIES 220/240v

No.	Sec. Taps	Amps	Price	Carr.
1A	25-33-40-50	15	£10 10 0	12/6
1B	25-33-40-50	10	£7 12 6	9/6
1C	25-33-40-50	6	£6 15 0	9/6
1D	25-33-40-50	3	£4 0 0	7/6
2A	4-16-24-32	12	£7 2 6	8/6
2B	4-16-24-32	8	£5 7 6	8/6
2C	4-16-24-32	4	£3 12 6	7/6
2D	4-16-24-32	2	£2 7 6	5/-
3A*	25-30-35	40	£16 10 0	12/6
3B*	25-30-35	20	£10 5 0	10/6
3C	25-30-35	10	£7 5 0	8/6
3D	25-30-35	5	£4 2 6	7/6
3E	25-30-35	2	£2 2 6	7/6
4A*	12-20-24	30	£13 0 0	12/6
4B	12-20-24	20	£8 5 0	9/6
4C	12-20-24	10	£4 5 0	8/6
4D	12-20-24	5	£3 12 6	7/6
5A	3-12-18	30	£9 12 6	9/6
5B	3-12-18	20	£7 2 6	8/6
5C	3-12-18	10	£4 5 0	7/6
5D	3-12-18	5	£2 17 6	7/6
6A	48-56-60	2	£3 12 6	6/6
6B	48-56-60	1	£2 12 6	6/6
7A*	6-12	50	£10 7 6	10/6
7B	6-12	20	£6 2 6	8/6
7C	6-12	10	£3 17 6	7/6
7D	6-12	5	£2 15 0	6/6
8A	12-24	1	£1 12 6	6/6
9A	17-32	8	£6 5 0	8/6
10A*	9-15	2	£1 9 6	6/6
11A	6-3	15	£2 10 0	7/6
12A	30-25-0-25-30	2	£3 12 6	6/6

Notes: By using the intermediate taps many other voltages can be obtained.

Example: No. 1 7-8-10-15-17-25-33-40-50v.
 No. 2 4-8-12-16-20-24-32v.
 No. 5 3-6-9-12-15-18v.

AUTO TRANSFORMERS

240v.-110v. or 100v. Completely Shrouded fitted with Two-pin American Sockets or terminal blocks. Please state which type required.

Type	Watts	Approx. Weight	Price	Carr.
1	80	2 1/2 lb	£1 19 6	5/6
2	150	4 lb	£2 12 6	6/6
3	300	6 1/2 lb	£3 12 6	6/6
4	500	8 1/2 lb	£5 2 6	8/6
5	1000	15 lb	£7 2 6	9/6
6*	1500	25 lb	£9 15 0	10/6
7*	1750	28 lb	£14 15 0	12/6
8*	2250	30 lb	£17 17 6	15/-

* Completely enclosed in beautifully finished metal case fitted with two 2-pin American sockets, neon indicator, on/off switch, and carrying handle.

HEAVY DUTY L.T. TRANSFORMERS

Pri. 220-240v. Sec. 12v. 175 a. Open type flying leads. Size 8 x 8 x 7 ins. £26 carr. £2. 12v. 90a. Size 7 1/2 x 6 1/2 x 6 ins. £18.10.0 carr. 20/-.
 Pri. 220-240v. Sec. tapped 14-15-2-28-31v. 20a. Open type table top connections. £12.10.0 carr. 15/-.
 Pri. tapped 110-220-240v. Sec. 55v. 24a. 14v. 10a. 60v. 2a. All windings conservatively rated. Tropicallly finished. Terminal connections. Size 9 x 7 1/2 x 7 ins. Weight 65 lbs. £15 carr. 17/6.
 110 volt primary only. Sec. 46v. 29a. Very conservatively rated. Size 11 x 7 x 7 ins. Weight 75 lbs. By Partridge Transformer Co. £10 carr. 15/-.

Samson's

(ELECTRONICS) LTD.
 9 & 10 CHAPEL ST., LONDON, N.W.1
 01-723-7851 01-262-512

A.C. 220-240v. SHADED POLE MOTORS
 1,500 r.p.m. Double spindle. Length 0.9in. and 0.6in. Overall size 3 x 3 1/2 x 2 ins. New and Boxed. 10/6. P. & P. 3/6.

LONDEX PLUG-IN RELAYS
 Sealed type, 28v. D.C. Three heavy duty silver contacts. Size 2 x 2 x 1 in. Complete with base. 8/6. P. & P. 2/-.

W.D. TELEPHONE CABLE
 Single D.3. One-third of a mile drums. Ideal for outside telephone systems. Fraction of maker's price. 57/6. Carriage 10/-.

SMITH'S SYNCHRONOUS MOTORS
 A.C. 200-240v. 1 R.P.M. 3in. dia. Length of spindle 2 1/2 in. 22/6. P. & P. 2/6.

G.P.O. L.T. SUPPLY UNIT
 Type 19. A.C. input, tapped 200-250v., 100-120v. D.C. output, 12 or 24 volts, very conservatively rated at 3 amps. Can be connected to give 12 volts 6 amps. Built into strong metal case size 19 x 7 x 6 1/2 ins. With fitted fuses. On/off switch. Socket outlet. Circuit supplied, £7.19.6, carriage 15/-.

ZENITH DOUBLE-WOUND VARIABLE TRANSFORMERS
 Input 240v., output 0-80v., 15 amps or 0-40v. 30 amps. Open-type slider control. Size: length 2 ft. 8 ins. x 8 ins. x 7 ins. £17.10.0. Carriage 25/-.

OIL-FILLED BLOCK CAPACITORS
 T.C.C. 8 mfd. 2500v. wkg. at 70°C. 37/6. P. & P. 8/6. 0.5 mfd. 10,000v. wkg. at 70°C. 37/6. P. & P. 8/6. Dubilier 4 mfd. 2500v. wkg. at 70°C. 25/-. P. & P. 7/6. 2 mfd. 4000v. wkg. at 70°C. 25/-. P. & P. 7/6. 0.25 mfd. 7500v. wkg. 17/6. P. & P. 4/6. American Micamold 8 mfd. 600v. wkg. at 100°C. 10/6. P. & P. 2/-. 4 mfd. 600v. wkg. Tubular S-hole fixing. 6/6. P. & P. 2/-. T.C.C. Visconol tubular S-hole fixing. 1 mfd. 2500v. wkg. at 60°C. 12/6. P. & P. 2/6. 0.1 mfd. 8000v. wkg. at 60°C. 10/6. P. & P. 2/-. 0.1 mfd. 5000v. wkg. at 60°C. 7/6. P. & P. 2/-. 0.05 mfd. 10,000v. wkg. at 60°C. 8/6. P. & P. 2/-.

AMERICAN WILLARD MINIATURE LEAD ACID ACCUMULATORS. 6v. 1.2 a.h. Size 1 1/2 x 1 1/2 x 4 ins. Weight 4 ozs. 7/6. P. & P. 1/6.

SPECIAL OFFER OF PARMEKO NEPTUNE SERIES TRANSFORMERS ALL PRIMARIES TAPPED 115-230v.
 Sec. 6-3v. CT 5a. 6-3v. CT 3a. 6-3v. CT 2a. 37/6 P. & P. 5/-.
 Sec. 9-10v. 0-5a. 6-3v. 3-5a. 6-3v. 1-2a. 19/6 P. & P. 4/-.
 Sec. 400-0-400v. 150 m/a. 50/- P. & P. 7/6.
 Sec. 350-0-350v. 100 m/a. 3-8-12-18v. 5a. £3.19.6 P. & P. 8/6.
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 Sec. 6-3v. 1-8a. 6-3v. 1a. 6-3v. 1a. 17/6 P. & P. 3/6.
 Sec. 29.5-32.5v. 2a. 32/6 P. & P. 5/-.
 Sec. 4v. 0-5a. four times. 15/- P. & P. 3/6.
 Sec. 6-3v. CT 0-6a. 6-3v. 0-6a. 12/6 P. & P. 3/6.
 Sec. 250-0-250v. 50 m/a. 6-3v. 1a. 22/6 P. & P. 4/6.
 Pri. 200-240v. Sec. 250-0-250v. 60 m/a. 6-3v. 2a. 6-3v. 3a. 5v. 2-5a. 30/- P. & P. 7/6.

GARDNERS HT TRANSFORMERS ALL PRIMARIES TAPPED 200-250v.

Sec. 500-0-500v. 250 m/a. 6-3v. 4a. 6-3v. 4a. 6-3v. 3a. 5v. 3-5a. Fully shrouded. £6.10.0. Carr. 10/-.
 Sec. tapped 350-360-370-380-390-400v. 350 m/a. 15v. 2a. 6-3v. 3a. X 3. 6-3v. 2a. 6-3v. 1a. Fully shrouded. £4.19.6. Carr. 8/6.
 Sec. 350-0-350v. 60 m/a. 4-6-3v. 4a. 4-5v. 2-5a. Fully shrouded. 27/6. P. & P. 5/-.
 Sec. 500-0-500v. 80 m/a. 6-3v. 2a. 6-3v. 2a. 5v. 2a. Fully shrouded. 47/6. P. & P. 5/-.
 Sec. 63v. 1-6a. 24v. 0-8a. 6-3v. 1a. Open type. Table top connections. 65/- P. & P. 7/6.
 Sec. 12v. 1a. Twice open type T.T. connections. 17/6. P. & P. 3/6.
 Sec. 3-75v. 9a. 6-3v. 0-5a. Fully shrouded. 17/6. P. & P. 3/6.
 Sec. 7v. 5a. 6-4v. 4a. 6-4v. 2-2a. 6-4v. 2-2a. 5v. 2-8a. 4v. 1a. Oil-filled potted type. 50/- Carr. 8/6.
 Sec. 370-390-410v. 6 m/a. Open 'C' core type. 12/6. P. & P. 2/6.
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 Sec. 300v. 37-5 m/a. 4kv. D.C. wkg. Twice. 4v. 1a. 4v. 0-3a. 19/6. P. & P. 4/6.
 600 watts auto tapped 200-210-220-230-240-250v. Open type. T.T. connections. 45/- P. & P. 5/-.

H.T. TRANSFORMERS
 Parmeko Neptune. Pri. 115-230v. Sec. 2000v. 5 m/a. 4v. 1a. 47/6. P. & P. 5/-.
 Sec. 2250v. 22 m/a. 75/- P. & P. 7/6. Pri. 200-240v. Sec. 1650v. 25 m/a. 75/- P. & P. 7/6. Pri. 200-240v. Sec. tapped 3000-3300v. 10 m/a. 4-6-3v. 1-5a. 3kv. wkg. 2-4v. 2a. 3kv. wkg. £4.19.6. Carr. 10/-.

PARMEKO C CORE TRANSFORMERS
 Pri. tapped 110-200-240v. Sec. 1 250v. 197 m/a. Sec. 2 161v. 110 m/a. Sec. 3 152v. 76 m/a. Sec. 4 124v. 25 m/a. Sec. 5 28v. 0-4a. Sec. 6 6-4v. 6-2a. 6-3v. 3-25a. 6-3v. 1-4a. Table top connections. Size 5 x 4 x 4 ins. Brand new boxed. 35/- P. & P. 7/6. Special prices for qty.

ADVANCE C/V TRANSFORMERS
 Type CV 15/95. Input 95-130v., 190-260v. Output 4v. rms + or - 1%. 3 watts. Open frame type. 25/- P. & P. 5/-.
 Type MT140. Input 190-260v. Output 230v. 150w. £5.15.0. Carr. 10/-.
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Kinver for Components

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BC107	3/3	BD123	24/3	TIP32A	23/-	2N3055	15/9
BC108	3/-	BDY20	24/3	TIS44	1/9	2N3702	3/3
BC109	3/3	BF184	7/6	TIS49	2/6	2N3703	3/3
BC158	7/6	BF194	7/-	TIS60	3/9	2N3704	3/9
BC182L	3/-	BFX29	9/6	2N696	4/6	2N3705	3/4
BC183L	2/6	BFX84	6/8	2N697	5/-	2N3707	3/6
BC184L	3/-	BFX85	8/8	2N706	3/-	2N3708	2/5
BC212L	3/9	BFY50	4/6	2N1132	10/9	2N3819	7/9
BC213L	3/9	BFY51	4/2	2N2906	13/-	2N3820	15/9
BC214L	4/-	BFY52	5/-	2N2924	4/4	2N3826	5/11
8CY70	4/9	BSY95A	3/9	2N2925	5/3	2N4058	4/6
9CY71	8/6	MJ481	27/-	2N2926	2/6	2N4059	3/5
9CY72	4/0	MJ491	29/6	2N3053	6/8	2N5457	9/9
BD121	17/3	TIP31A	17/-				

1 WATT AMPLIFIER MODULE TYPE PCM1

This amplifier unit is a printed circuit module incorporating the popular and well-liked PA234 i.c. amplifier. The unit is a complete AUDIO AMPLIFIER and requires no external components, you simply connect an 18-volt power supply and a 15 or 16-ohm speaker or headphone, even the supply smoothing capacitor and the output capacitor are included! The overall dimensions, including capacitors are 2 1/4" x 3" x 3 1/2". The input for 1 watt output at 1 kHz is typically 300mV into 100 k/ohms. This unit is available at only 36/- net complete with descriptive leaflet or 70/- net per pair. Send for free leaflet.

ELECTRONIC COMPONENTS IN THE WEST MIDLANDS

A wide range of components are available from stock for CALLERS, including the following: RESISTORS (includes 5% 1/2 watt, High stabs at only 2d each in 100+ quantities of MIXED values of your choice in the E12 series from 10 ohm to 10 M/ohm), CAPACITORS (includes Polyesters, polystyrene, metallised film, miniature electrolytics).

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Mail order, 1/6 p. & p. per order Inland. Overseas at cost, min. 10/-, Open 9.00 a.m. to 12.50 p.m., 2.00 p.m. to 5.00 p.m. weekdays, 9.00 a.m. to 12.50 p.m. Saturdays, silver mica). SEMICONDUCTORS (includes integrated circuits, transistors, diodes, rectifiers). PLUS ALL the usual components such as plugs and sockets, pots, Veroboard, etc.

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SERVICE TRADING CO



INPUT 230 v. A.C. 50/60
OUTPUT VARIABLE 0/260 v. A.C.

BRAND NEW. Keenest prices in the country. All types (and spares) from 1/3 to 50 amp. available from stock.

- 0-260 v. at 1 amp..... £5 10 0
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- 0-260 v. at 5 amps..... £9 15 0
- 0-260 v. at 8 amps..... £14 10 0
- 0-260 v. at 10 amps.... £18 10 0
- 0-260 v. at 12 amps.... £21 0 0
- 0-260 v. at 15 amps.... £25 0 0
- 0-260 v. at 20 amps.... £37 0 0
- 0-260 v. at 37.5 amps... £72 0 0
- 0-260 v. at 50 amps.... £92 0 0

20 Different types available for immediate delivery.
OPEN TYPE (Panel mounting). 1/2 amp. £3.18.6
1 amp. £5.10. 2 1/2 amp. £6.12.6. P. & P. 7/6.

RING TRANSFORMER

Functional Versatile Educational

This multi-purpose Auto Transformer, with large centre aperture, can be used as a Double wound current Transformer, Auto Transformer, H.T. or L.T. Transformer, by simply hand winding the required number of turns through the centre opening. E.g. Using the RT.100 V.A. Model the output could be wound to give 8V. @ 12Amp., 4V. @ 25Amp. or 2V. @ 50Amp., etc. Price: RT.100VA 3.18 turns per volt, £2. 5 0 + 3/6 p. and p. RT.300VA 2.27 turns per volt, £4. 4 0 + 5/6 p. and p. RT.1KVA 1.82 turns per volt, £6 10 0 + 6/6 p. and p. RT.2KVA 1.5 turns per volt, £10 0 0 + 9/6 p. and p. RT.3KVA 1.5 turns per volt, £14 0 0 + 10/- p. & p.



L.T. TRANSFORMERS

Type No.	Sec. Taps	Price	Carr.
1	12 v. at 5A	£1 17 6	5/6
2	30, 32, 34, 36 v. at 5 amps.	£4 13 6	6/-
3	30, 40, 50 v. at 5 amps.	£6 17 6	6/6
4	10, 17, 18 v. at 10 amps.	£4 19 0	4/6
5	6, 12 v. at 20 amps.	£6 8 6	6/6
6	17, 18, 20 v. at 20 amps.	£7 5 6	6/6
7	6, 12, 20 v. at 20 amps.	£6 17 6	7/6
8	24 v. at 10 amps.	£5 4 6	5/6
9	4, 6, 24, 32 v. at 12 amps.	£7 3 0	6/6

AUTO TRANSFORMERS. Step up, step down. 110-200-220-240 v. Fully shrouded. New. 300 watt type £3/12/6 each, P. & P. 4/6. 500 watt type £5/2/6 each, P. & P. 6/6. 1,000 watt type £7/2/6 each, P. & P. 7/6.

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Kit of parts including ORP.12 Cadmium Sulphide Photocell, Relay Transistor and Circuit. Now supplied with new Siemens High Speed Relay for 6 or 12 volt operations. Price 25/-, plus 2/6 P. & P. ORP. 12 and Circuit 12/6 post paid.



220/240 A.C. MAINS MODEL

Incorporates mains transformer rectifier and special relay with 2 x 5 amp. mains c/o contacts. Price inc. circuit 47/6, plus 2/6 P. & P.

LIGHT SOURCE AND PHOTO CELL MOUNTING

Precision engineered light source with adjustable lens assembly and ventilated lamp housing to take MBC bulb. Separate photo cell mounting assembly for ORP.12 or similar cell with optic window. Both units are single hole fixing. Price per pair £2/15/0 plus 3/6 P. & P.



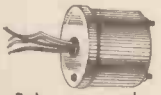
'AVO' MODEL 48A

Ex-Admiralty in good condition with instructions, leads, plus D.C. Shunts for 120 Amp. and 480 Amp. A.C. Transformer for 60 Amp. and 240 Amp. Multiplier for 3600 volt. Complete outfit in fitted case. £15/0/0, P. & P. 10/-



SOLID STATE INTERVAL TIMER

24-30v. D.C. operation. Stabilised uni-junction Timer and S.C.R. (30v. 1Amp.), encapsulated in metal core. Timing Interval adjustable from a fraction of a second to several minutes by means of external resistor or pot. By adding a 24v. Relay many other complex timing Functions are possible. Price: 16/6 incl. circuit, p. & p. 2/6. Suitable relay 9/6. P. & P. 1/6.



A.C. CONTACTOR

2 make and 2 break (or 2 c/o) 15 amp. contacts. 230/240 v. A.C. operation. Brand new. 22/6 plus 1/- P. & P.



INSULATION TESTERS (NEW)

Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work. Constant speed clutch. Size L8 in. W.4 in. H.6 in., weight 6lb., 500 VOLTS, 500 megohms £28 carriage paid. 1,000 VOLTS, 1 000 megohms, £24 carriage paid.



INSULATED TERMINALS

Available in black, red, white, yellow, blue and green. New 2/- each.



POWER RHEOSTATS

(NEW) Ceramic construction, winding embedded in Vitreous Enamel, heavy duty brush assembly designed for continuous duty. AVAILABLE FROM STOCK IN THE FOLLOWING VALUES:

100 WATT 1 ohm 10a., 5 ohm 4.7a., 10 ohm 3a., 25 ohm 2a., 50 ohm 1.4a., 100 ohm 1a., 250 ohm .7a., 500 ohm .45a., 1k ohm 280mA., 1.5k ohm 230mA., 2.5k ohm .2a., 5k ohm 140mA., Diameter 3 1/2 in. Shaft length 3 1/2 in. dia. 3/16 in., 27/6. P. & P. 1/6. 50 WATT 1/5/10/25/50/100/250/500/1K/1.5K/2.5K/5K ohm. All at 2 1/2-. P. & P. 1/6. 25 WATT 10/25/50/100/250/500/1K/1.5K/2.5K ohm. All at 14/6. P. & P. 1/6. Black Silver Skirted knob calibrated in Nos. 1-9. 1 1/2 in. dia. brass bush. Ideal for above Rheostats, 3/6 each.

RECHARGEABLE NICKEL CAD. BUTTON CELLS.

2 x 1.2 v. 250 MA/HR Nickel Cad. Cells, connected to give 2.4 v., at 25 milliamp/10 hour rate, complete with 200/250 v. A.C. charger. Unusd. Price 9/6 each plus 1/6 p. & p. or 2 units for £1 post paid.



MOTOROLA MAC1/6 PLASTIC TRIAC 400 PIV 8 AMP

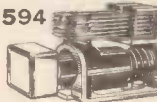
Now available EX STOCK supplied complete with full data and applications sheet. Price 21/- plus 1/6 P. & P.

T.M.C. ILLUMINATED

LATCHING PUSH BUTTON

KEY SWITCH No. S525594

LOCK 4 c/o



Complete with mounting bracket, Push Knob and Lenses (GREEN, AMBER, RED or CLEAR - state colour preference). PRICE 14/6 each excluding bulb, Post Paid. Discount for quantities of 200 or over.

STROBE! STROBE! STROBE!

- * THREE EASY TO BUILD KITS USING XENON WHITE LIGHT FLASH TUBES, SOLID STATE TIMING + TRIGGERING CIRCUITS. PROVISION FOR EXTERNAL TRIGGERING. 230-250v. A.C. OPERATION. The Strobe is one of the most useful and interesting instruments in the laboratory or workshop. It is invaluable for the study of movement and checking of speeds. Many uses can be found in the psychiatric and photographic fields, also in the entertainment business. It is used a great deal in the motor industry and is a real tool as well as an interesting scientific device.
- * EXPERIMENTERS "ECONOMY" KIT Adjustable 1 to 36 Flash per sec. All electronic components including Veroboard S.C.R. Unijunction Xenon Tube + instructions. £5.5.0 plus 5/- P. & P.
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2 metal carrying cases each containing 10 x 1.2 volt 7 AH (12v) batteries, also 10 x 1.2v 22 AH (12v) batteries (40 batteries in all). 1 Dual voltage, dual meter, thyristor controlled charging unit. Designed for charging the 7AH and 22AH batteries simultaneously. Input voltage can be adjusted between 100-250v A.C. Built to ministry specification. Ideal power supply for field work. Offered at fraction of makers price. 2 sets of batteries, 1 charging unit. The set £45 c. & p. 30/-.



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3 banks of 11 positions, plus homing bank. 40 ohm coil. 24-36 v. D.C. operation. Carefully removed from equipment and tested. 22/6, plus 2/6 P. & P.

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25 ohm coil, 24 v. D.C. operation. £5.17.6, plus 2/6 P. & P.

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NEW SIEMENS PLESSEY, etc. MINIATURE RELAYS AT A HIGHLY COMPETITIVE PRICE.

COIL	WORKING D.C. VOLT CONTACTS	PRICE
52	6-9 6M	12/6
170	9-12 4 c/o H.D.	14/6
170	9-12 3 c/o + 1 H.D. c/o	12/6
230	6-12 2 c/o	12/6
280	6-12 2 c/o incl. base	14/6
700	16-24 4M 2B incl. base	12/6
1250	36-45 6M	12/6
2500	36-45 6M	12/6
5800	80-85 4 c/o	12/6
9000	40-70 2 c/o incl. base	10/-

H.D. = Heavy Duty POST PAID



MINIATURE RELAYS

9-12 volt D.C. operation. 2 c/o 500 M.A. contacts. Size only lin. x 1/2 x 1/2 in. Price 11/6 Post paid. 30-36 v. D.C. operation. 2 c/o 500 M.A. contacts. 3,200 ohm coil. Size only 1 x 1/2 x 1/2 in. 8/6 post paid.

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TYPE A.G.C. 1M 1B 12v. A.C. 3 amp contacts. NEW 9/6 + 1/6 p. & p. or 3 for 30/- post paid.

230 VOLT AC RELAY LONDEX four c/o 3 amp contacts. 18/6, incl. base. Post Paid.



230 v. A.C. SOLENOID. Heavy duty type. Approx 3lb. pull. 17/6 plus 2/6 P. & P. 12 v. D.C. SOLENOID. Approx. 1lb. pull. 10/6, P. & P. 1/6.

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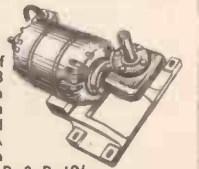
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7 adjustments, precision tool, speed adjustable 10 w.p.m. to as high as desired. Weight 2 1/2 lb. £4/12/6 post paid.



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230/240V 10 RPM MOTOR

(Non Reversible) Extremely powerful. Continuously rated. Offered at the low price of 35/- post paid.



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DRY REED RELAYS AND COILS FOR TRANSISTOR OPERATION

Stocks of these Relays and Coils are now available for use at voltages from 1-48v and at operate powers from 2.5 to 30mW. Their characteristics render them ideal for transistor operation. Details are as follows—deliveries are all ex stock.

Coil	Res	Typical Operate volts	Break volts	Coil only	Relay with		
					Number of reeds	2	3	4
37992D	190 ohms	2.3V	1.8V	4/-			9/-
37992Z	325 ohms	3.5V	2.5V	3/6			
37992J	2.2K	5.5V	2.5V	4/-	6/6	8/-	
37992B	4K	7.0V	3.0V	4/6	7/-		9/6
37992M	4.05K	4V	2.3V	4/6	7/-		
37992G	7K	14V	5V	4/6			9/6
37992E	200+4.2K	3.5V	2.5V	4/6			9/6
		6.5V	4.5V	4/6			
37992H	1.2K+9K	7.0V	4.0V	4/-			9/-
		23.0V	9.0V	4/6			
37992R	1.5K+4K	4.2V	3.2V	4/6			
		5V	3.5V	4/-			9/-
37992E	2.5K+4.2K	11V	4.5V	4/6			
		15V	5V	3/-			7/6
37992A	200W	2.5V	2.0V	3/-			
37991C	100W	0.5V	0.5V	5/-			
37991B	1.2K	2V	1V	5/-			
37991A	2.4K	2.7V	2.2V	4/6			
37822B	3.3K	4.5V	3.5V	5/-			

DRY REED INSERTS



Overall length 1.85" (Body length 1.1") Diameter 0.14" to switch up to 500 mA at up to 250V D.C. Gold clad contacts. 12/6d. per doz. 75/- per 100; £27.10.0 per 1,000; £250 per 10,000. All carriage paid.

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TANTALUM CAPACITORS We hold large stocks by S.T.C., T.C.C., Dubilier, Kemet, Plessey, G.E., etc., send for stock list with lowest prices for immediate delivery.

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SINE-COSINE POTENTIOMETERS Types SCPI, SCP4, SCP5, CLR96, CLR66 in stock.

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500mA MC 35/- 3A RF 25/-

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CAMBRIDGE DYNAMOMETER VOLTMETERS in as new condition. 10 ranges up to 150v. in as new condition £45 each (plus carriage).

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MARCONI VIDEO OSCILLATORS TF885A 50Hz-50MHz sine-square wave outputs 1mV-31.6V in 11 ranges metered output £35 (carriage 30/-) fully serviced.

MARCONI SIGNAL GENERATOR TF601A 10-300 MHz in 4 bands. £45 (carriage 30/-).

MARCONI SIGNAL GENERATOR TF144G £30. Brand new with spares (carriage 30/-).

MARCONI Q METER TF329G £60 (carriage 30/-).

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HIGH SPEED OSCILLOSCOPE TYPE CT90 P.O.A. AIRMEC SIGNAL GENERATOR TYPE 701 £35. (Carr. 30/-).

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LOW PRICED OSCILLOSCOPES for secondary school use or for production testing.

Cosor 1035 MK I DB £25 1049 MK IIIA DB £35

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All instruments are full serviced at our Croydon workshops before sale and customers are invited to attend by appointment final test and inspection. All oscilloscopes are checked on our Tektronix oscilloscope calibrator.

SANGAMO-WESTON PORTABLE sub-standard FREQUENCY METERS S105 1200-2,000 Hz 95-135V. £12.10.0. Post 7/6.

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COMPUTER TAPE CARRYING CASES 13 1/2" square 2 1/2" deep. 30/- (carriage paid).

R.F. VARIABLE INDUCTANCE UNITS comprising 96 turns silver clad wire on 2 1/2" dia. low loss former 1/2" drive shaft. 90/- (post paid).

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BRAND NEW and in original cases—A.C. mains input. 110V or 250V. Freq. in 6 bands 535 Kc/s-32 Mc/s. Output impedance 2.5-600 ohms. Complete with crystal filter, noise limiter, B.F.O., H.F. tone control, R.F. & A.F. variable controls. Price £87/10/- each, carr. £2.

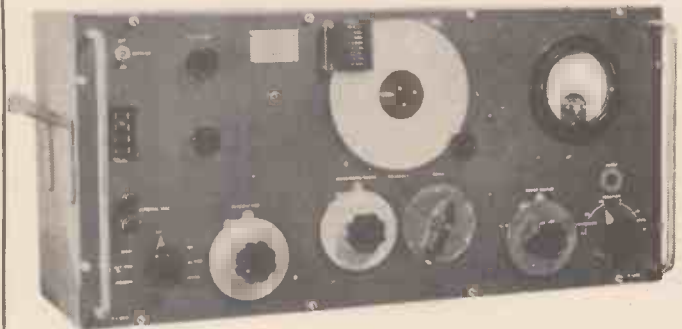
Same model as above in secondhand cond. (guaranteed working order), from £45 to £60, carr. £2.

***SET OF VALVES:** new, £3/10/- a set, post 7/6; **SPEAKERS:** new, £3 each, post 10/-; ***HEADPHONES:** new, £1/5/- a pair, 600 ohms impedance. Post 5/-.

AR88 SPARES. Antenna Coils L5 and 6 and L7 and 8. Oscillator coil L55. Price 10/- each, post 2/6. RF Coils 13 & 14; 17 & 18; 23 & 24; and 27 and 28. Price 12/6 each. 2/6 post. By-pass Capacitor K.98034-1, 3x0.05 mfd. and M.980344, 3x0.01 mfd., 3 for 10/-, post 2/6. Trimmers 95534-502, 2-20 p.f. Box of 3, 10/-, post 2/6. Block Condenser, 3x4 mfd., 600 v., £2 each, 4/- post. Output transformers 901666-501 27/6 each, 4/- post.

* Available with Receiver only.

If wishing to call at Stores, please telephone for appointment.



MARCONI SIGNAL GENERATOR TYPE TF-144G: Freq. 85 Kc/s-25Mc/s in 8 ranges. Incremental: ± 1% at 1Mc/s. Output: continuously variable 1 microvolt to 1 volt. Output Impedance: 1 microvolt to 100 millivolts, 10 ohms 100mV -1 volt - 52.5 ohms. Internal Modulation: 400c/s sinewave 75% depth. External Modulation: Direct or via internal amplifier. A.C. mains 200/250V, 40-100c/s. Consumption approx. 40 watts. Measurements 19 1/2 x 12 1/2 x 10 in. Secondhand condition. £25 each, carr. 30/-.

LAVOIE PORTABLE ABSORPTION FREQUENCY METER TYPE TS-127/U: Freq. 375-725Mc/s. Circuit: Piston-capacitor type tuning Resonator working direct into a 957 detector valve, R.C. coupled to a 2 stage amplifier (1S5 & 3S4): Microammeter Resonance Indicator: Time switch to select operating time up to 15 mins. Average 'Q'-3000: Power Requirements: 1.5V dry batteries and 45V. Price £20 each, 10/- post.

CT.49 ABSORPTION AUDIO FREQUENCY METER: Freq. range 450c/s-22Kc/s., directly calibrated. Power supply 1.5V-22V d.c. £12.10.0 each, 15/- carr.

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HRO RECEIVER. Model 5T. This is a famous American High Frequency superhet, suitable for CW, and MCW, reception crystal filter, with phasing control. AVC and signal strength meter. Complete HRO 5T SET (Receiver, Set of 5 Coils & Power Unit) for £27/10/-, carr. 30/-.

COMMAND RECEIVERS; Model 6-9 Mc/s., as new, price £5/10/- each, post 5/-.

COMMAND TRANSMITTERS, BC-458: 5.3-7 Mc/s., approx. 25W output, directly calibrated. Valves 2 x 1625 PA; 1 x 1626 osc.; 1 x 1629 Tuning Indicator; Crystal 6,200 Kc/s. New condition—£3/10/- each, 10/- post. (Conversion as per "Surplus Radio Conversion Manual, Vol. No. 2," by R. C. Evenson and O. R. Beach.)

AIRCRAFT RECEIVER ARR. 2: Valve line-up 7 x 9001; 3 x 6AK5; and 1 x 12A6. Switch tuned 234-258 Mc/s. Rec. only £3 each, 7/6 post; or Rec. with 24 v. power unit and mounting tray £3/10/- each, 10/- post.

RECEIVERS: Type BC-348, operates from 24 v D.C., freq. range 200-500 Kc/s, 1.5-18 Mc/s. (New) £35.0.0 each; (second hand) £20.0.0 each, good condition, carr. 15/- both types.

MARCONI RECEIVER 1475 type 88: 1.5-20 Mc/s, second-hand condition £10.0.0 each. New condition £25.0.0 each, carr. 15/-.

RACAL EQUIPMENT: Frequency Meter type SA20: £35 each, carr. £1. Frequency Counter type SA21: £65 each, carr. 30/-. Converter Frequency Electronic VHF Type S.A.80 (for use with the SA.20): 25 Mc/s-160 Mc/s, £40 each, carr. £1.

ROTARY CONVERTERS: Type 8a, 24 v D.C., 115 v A.C. @ 1.8 amps, 400 c/s 3 phase, £6/10/- each, 8/- post. 24 v D.C. input, 175 v D.C. @ 40mA output, 25/- each, post 2/-.

CONDENSERS: 150 mfd, 300 v A.C., £7/10/- each, carr. 15/- 40 mfd, 440 v A.C. wkg., £5 each, 10/- post. 30 mfd, 600 v wkg. D.C., £3/10/- each, post 10/- 15 mfd, 330 v A.C. wkg., 15/- each, post 5/- 10 mfd, 1000 v, 12/6 each, post 2/6. 10 mfd, 600 v, 8/6 each, post 5/- 8 mfd, 1200 v, 12/6 each, post 3/- 8 mfd, 600 v, 8/6 each, post 2/6. 4 mfd, 3000 v wkg., £3 each, post 7/6. 2 mfd, 3000 v wkg., £2 each, post 7/6. 0.25 mfd, 2Kv, 4/- each, 1/6 post. 0.01 mfd. MICA 2.5 Kv. Price £1 for 5. Post 2/6. Capacitor: 0.125 mfd, 27,000v wkg. £3.15.0 each, 10/- post.

OSCILLOSCOPE Type 13A, 100/250 v. A.C. Time base 2 c/s-750 Kc/s. Bandwidth up to 5 Mc/s. Calibration markers 100 Kc/s. and 1 Mc/s. Double Beam tube. Reliable general purpose scope, £22/10/- each, 30/- carr.

COSSOR 1035 OSCILLOSCOPE, £30 each, 30/- carr.

COSSOR 1049 Mk. 111, £45 each, 30/- carr.

RELAYS: GPO Type 600, 10 relays @ 300 ohms with 2M and 10 relays @ 50 ohms with 1M., £2 each, 6/- post. 12 Small American Relays, mixed types £2, post 4/-.

Many types of American Relays available, i.e., Sigma; Allied Controls; Leach; etc. Prices and further details on request 6d.

GEARED MOTORS: 24 v. D.C., current 150 mA, output 1 r.p.m., 30/- each, 4/- post. Assembly unit with Letcherbar Tuning Mechanism and potentiometer, 3 r.p.m., £2 each, 5/- post.

SYNCHROS: and other special purpose motors available. British and American ex stock. List available 6d.

TCS MODULATION TRANSFORMERS, 20 watts, pr. 6,000 C.T., sec. 6,000 ohms. Price 25/-, post 5/-.

SOLENOID UNIT: 230 v. A.C. input, 2 pole, 15 amp contacts, £2/10/- each post 6/-.

CONTROL PANEL: 230 v. A.C., 24 v. D.C. @ 2 amps., £2/10/- each, carr. 12/6.

OHMMITE VARIABLE RESISTOR: 5 ohms, 5½ amps; or 2.6 ohms at 4 amps. Price (either type) £2 each, 4/6 post each.

TX DRIVER UNIT: Freq. 100-156 Mc/s. Valves 3 x 3C24's; complete with filament transformer 230 v. A.C. Mounted in 19in. panel, £4/10/- each, 15/- carr.

POWER SUPPLY UNIT PN-12A: 230V a.c. input 50-60 c/s. 513V and 1025V @ 420 mA output. With 2 smoothing chokes 9H, 2 Capacitors, 10Mfd 1500V and 10Mfd 600V. Filament Transformer 230V a.c. input. 4 Rectifying Valves type 5Z3. 2 x 5V windings @ 3 Amps each, and 5V @ 6 Amp and 4V @ 0.25 Amp. Mounted on steel base 19"Wx11"Hx14"D. (All connections at the rear). Excellent condition £6.10.0 each, Carr. £1.

AUTO TRANSFORMER: 230-115V, 50-60c/s, 1000 watts. mounted in a strong steel case 5" x 6½" x 7". Bitumin Impregnated. £5 each, Carr. 12/6. 230-115V, 50-60c/s, 500 watts. 7" x 5" x 5". Mounted in steel ventilated case. £3 each, Carr. 10/-.

POWER UNIT: 110 v. or 230 v. input switched; 28 v. @ 45 amps. D.C. output. Wt. approx. 100 lbs., £17/10/- each, 30/- carr. SMOOTHING UNITS suitable for above £7/10/- each, 15/- carr.

CORPORAL ROCKET ELECTRONIC GUIDANCE EQUIPMENT: Beacon Radio DRN.7. Rec/Trans. Assembly MX.2048DPW-8. Electronic Control Amplifier AM1510/DJW3. Transmitter C-1493/MRQ.1. Power Units and miscellaneous spares available.

MODULATOR UNIT: 50 watt, part of BC-640, complete with 2 x 811 valves, microphone and modulator transformers etc. £7/10/- each, 15/- carr.

NIFE BATTERIES: 4 v. 160 amps, new, in cases, £20 each, £1 10/- carr.

FUEL INDICATOR Type 113R: 24 v. complete with 2 magnetic counters 0-9999, with locking and reset controls mounted in a 3in. diameter case. Price 30/- each, postage 5/-.

ALL GOODS OFFERED WHILST STOCKS LAST IN "AS IS" CONDITION UNLESS OTHERWISE STATED

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FREQUENCY METERS: BC-221, meter only £30 each, BC-221 complete with stabilised power supply £35 each, carr. 15/- LM13, 125-20,000 Kc/s., £25 each, carr. 15/- TS.175/U, £75 each, carr. £1.

CANADIAN HEADSET ASSEMBLY: Moving coil headphones 100Ω, with chamouis leather earmuffs. Small hand microphone complete with switch and moving coil insert. New condition. Price 35/- each, post 5/-.

AUDIO OSCILLATOR 382/F: Input 115 v. A.C., 50 c/s, 20-200,000 c/s per sec. in 4 ranges. Cont. wave. Output 0-10 v. in 7 ranges. Power output 100 mW. Output impedance 1,000Ω. £27/10/- each, £1 carr.

RACK CABINETS (totally enclosed) for std. 19in. panels. Size: 6ft. high x 21in. wide x 16in. deep. With rear door. £12 each, £2/10/- carr. OR 4ft. high x 23in. wide x 19in. deep. With rear door. £8/10/- each, £2 carr.

CATHODE RAY TUBE UNIT: With 3in. tube, Type 3EG1 (CV1526) colour green, medium persistence complete with nu-metal screen, £3/10/- each, post 7/6.

APNI ALTIMETER TRANS./REC., suitable for conversion 420 Mc/s., complete with all valves 28 v. D.C. 3 relays, 11 valves, price £3 each, carr. 10/-.

TEST EQUIPMENT

MARCONI	TF-1274	VHF Bridge Oscillator	.. ..	£75 each
	TF-1275	VHF Bridge Detector	.. ..	£75 each
	TF-1067/1	Heterodyne Frequency Meter	.. ..	£85 each
	TF-899	Valve Millivoltmeter	.. ..	£35 each
	TF-978	VHF Admittance Bridge	.. ..	£85 each
	TF-894A	Audio Tester	.. ..	£55 each
	TF-329G	Circuit Magnification Meter	.. ..	£45 each
	TF-428/2	Valve Voltmeter	.. ..	£12/10/- each
	TF-428/1	Valve Voltmeter	.. ..	£8/10/- each
	TF-726C	UHF Signal Generator	.. ..	£65 each
	TF-934	Deviation Test Meter	.. ..	£35 each
	6075A	Deviation Test Meter	.. ..	£65 each
TF-987/1	Noise Generator	.. ..	£20 each	
TF-956	(CT.44) A.F. Absorption Wattmeter	.. ..	£20 each	
FIRZ HILL	V.200	Sensitive Valve Voltmeter	.. ..	£35 each
	B.810	Incremental Inductance Bridge	.. ..	£75 each
SOLATRON	CD-513	Oscilloscope	.. ..	£45 each
	CD-513-2	Oscilloscope	£47/10/- each
	AW-553	Power Amplifier	£30 each
AIRMEC	Type 701	Signal Generator	£50 each
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DAWE	Type 402C	Megohm Meter	£12 each

APN-1 INDICATOR METER, 270° Movement. Ideal for making rev. counter. 25/- each, 5/- post.

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PRD Electronic Inc. Equipment: FREQUENCY METER: Type 587-A, 0.250-1.0 KMC/SEC. (New) £75 each, post 12/6. FIXED ATTENUATOR: Type 130c, 2.0-10.0 KMC/SEC. (New) £5 each, post 4/- . FIXED ATTENUATOR: Type 1157S-1, (new) £6 each, post 5/-.

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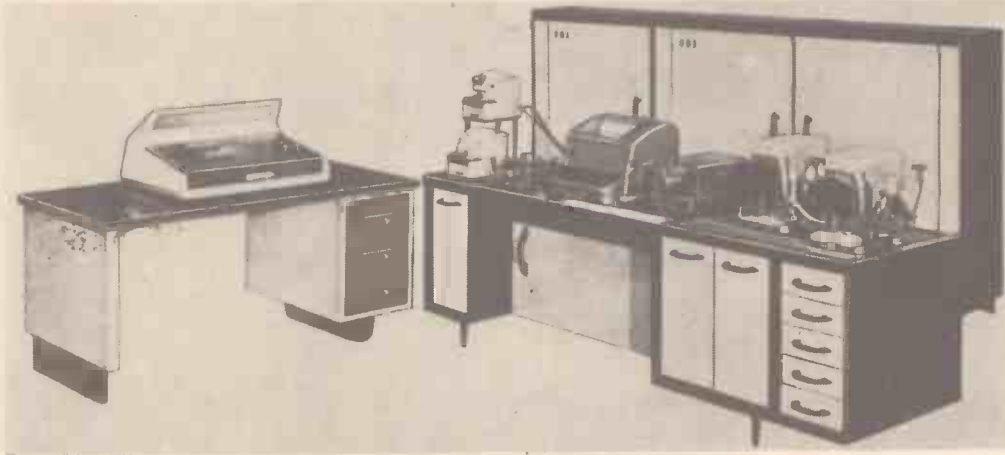
NPN SILICON PLANAR BC107/8/9, 2/- each, 50-99, 1/10, 100 up, 1/8 each,



COMPUTER SALES AND SERVICES

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(low cost computers and peripherals)



ELLIOTT 803 COMPUTER

Configuration Central Processor with 4096 Core Store.
Type 3 Paper Tape Station One Tape Reader 500 characters per sec. (Elliott TS/93).
 One Tape Punch 100 characters per sec. (Teletype BRPE E11).
 Keyboard console and associated Table. Creed Teleprinter. Automatic Floating Point Unit.

DATA DISK

The Mark IV Data Disk Handler is a self-contained magnetic disc memory unit designed for integration with small computers or other digital systems. The handler's salient features include: random access; high density contact recording; interchangeable disc cartridges; write lock-out; air filtration in critical areas. The mechanical assembly, alone, can be supplied for rack mounting or custom installation.



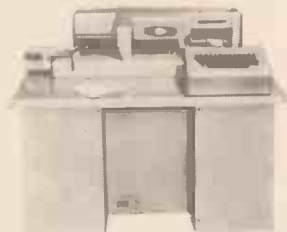
ELLIOTT TRM 250 PAPER TAPE READER

A medium speed input device for use in data processing and automation systems. Reads 5, 6, 7, or 8-hole perforated tape, at speeds up to 250 characters per second. Tape widths up to 1" can be read. Stopping time half a character. Tape read conforms to B.S.3880. Motor supplies 250v. 50cps. pinch roller solenoid 24v. D.C. at 1 amp current. Lamp supply 9.5v. D.C. 3 amps. (Lamp rated 12v. 36 watts.)



IBM 151 NUMERICAL VERIFIER

Has been designed for use on a table. It can be used in conjunction with the 011 Electrical Punch. Uses an electric keyboard, card being fed, and removed manually. A Skip Bar can be fitted to control skipping over card areas which need no verification. Alphabetic and special character information can be verified using a multiple punch procedure.



ICT HOLLERITH Type 029.80 column Punch

A well-proven electro-mechanical card punch, with duplicating, spacing, and skipping facilities. Two types of keyboard are available for this model Alpha/Numeric and, Alphabetic. The alphabetic largely resembles a typewriter keyboard, enables alpha punching by the operation of one key. Supplies 110v. D.C. mains for card feed motor. **FEATURES:** Motor cut-out switch for clearing card jams. Stop Lever for stopping card at the 80th column.



CREED MODEL 90
 Verifier set, consisting of keyboard comparator, tape reader 92, tape punch 25, 5-hole or 8-hole system.

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COMPUTER QUALITY
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 CERTIFIED 550 B.P.1.
 800 B.P.1. ON 2,400-ft. REELS. GUARANTEED
 REPLACEMENT IF FAULTED. £6.10.0



HAND PUNCHES—80 COLUMN The Punch

Is a table-mounted model punch. For the Serial Punching of alphanumeric Data, Alpha or Multi Hole Punching is made by depressing two or more keys simultaneously. **Function Keys** Release key for completing the left-hand movement of the card rack when punching ends before column 40. Space key for skipping single unused columns. Skip Key for skipping over unused areas of Card as demanded by the Format arranged by an interchangeable Skip Bar.



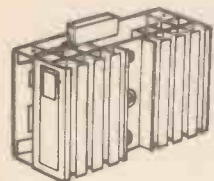
FRIDEN FLEXOWRITERS

Flexewriter programmatic automatic writing machine for automatic letter writing, Data preparation work, invoice format paper work, edge punching cards, cutting continuous cards, preparing unit cards, preparing stub cards, reading edge punched cards, reading/copying punched tape. **Choice of:** Single case, four bank, three bank, double case, keyboards for various uses. Punch tape output, punch and verify, 115v. or with transformer for 230v. operation. A variety of codes to order.

PART USED COMPUTERS AVAILABLE SHORTLY

ICL 1500; PDP 8F; IBM 1440; IBM 1401; SDS 930; ELLIOTT 803;
 EMIDEK 1100; HONEYWELL 200; NCR 400.

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LOOK AT THE SPECIFICATIONS! 25 WATT & 50 WATT RMS SILICON AMPLIFIERS

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★IC Stereo £24.0.0

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- Response—1dB 11 c/s to 100 kc/s.

PA 25 10 transistor all silicon differential input 400 mV sensitivity. 25 watts Rms into 8 ohms. Supplied with edge connector harness size 5" x 3" x 2".

PA 50 12 transistor version 50 watts Rms into 3 to 4 ohms. Size 5" x 3" x 4".

MU 442. Power supply for one or two PA 25 or one PA 50.
PA 25 £7.10.0. PA 50 £9.10.0. MU 442 £6

No soldering—just edge connectors!

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★Two Z30 Pz5 up 60 pre-amp (usually £23.10.0) £19 (or with Pz6 in place of Pz5 £21)

PORTABLE GEIGER COUNTERS £9.10.0. Carriage 15/-



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Complete system comprising Control Unit, 4 Tannoy loud hollers, microphone and headphones, etc., 12V D.C. operation. Low battery drain, 8 watts power output. The ideal system for mobile use, outdoor meetings, sports days, factories, garden fetes, etc. Speakers can be spaced effectively over hundreds of yards. Also has talk back facility. Guaranteed Brand New in sealed cartons. Original cost over £60.

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A must for the home constructor and professional engineer. **FREE** to schools, colleges and companies on written request.

COMPLETE STEREO SYSTEM (usually £50) Price £39.10.0

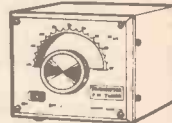
British made 5-5 amplifier input for ceramic cartridge tuner/aux etc. Full controls, output for 8 to 15 ohm speakers fitted headphone socket. Complete system uses above amplifier, Garrard model 50 or 3000 with 9TAH/C diam. Pair EM1 10 watt speakers with twin tweeters and cross over, Polished speaker, cabinets and plinth/cover.



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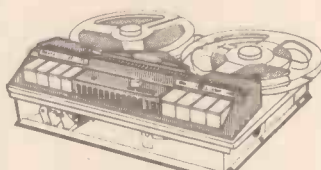


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British made, takes 7" spools, operates horizontally or vertically, piano key operation. Fitted three-speed Marriot XRPS17 and XES II heads. Size: 13 x 10 x 5 1/2 in. Price £13.19.6 p.p. 7/6

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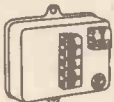
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Ideal for experimenters, educational projects as well as for practical uses. Delay adjustable 3-15 secs. Operates 9-12 volts. Heavy Duty Relay Contacts. Complete with suggested applications sheet. Price 35/-, or 3 for 90/-.



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Fire Detector Unit containing 931A photo multiplier and gold cathode tube. Shock and fire proof. Originally made for £74. Price complete with data sheet £6 Brand new.



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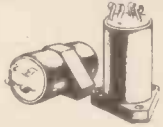
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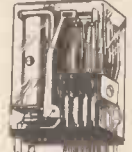
Electro-Tech Sales

MINIATURE "LATCH-MASTER" RELAY 6, 12, or 24V. D.C. operation. One make one break, contacts rated 5 amps, at 30v. Once current is applied, relay remains latched until input polarity is reversed. Manufactured for high acceleration requirements by Sperry Gyroscope Co. Size: Length $\frac{3}{4}$ " dia. $9/16$ " (including mount). Please state vertical or horizontal mount and voltage. £2.5.0 each. Carr. Paid.



SPECIAL OFFER. Enclosed Relay, complete with base. Brand New. Type MQ308 600 Ω 24v. 4 c/o. Size $1\frac{1}{2}$ " x $1\frac{1}{2}$ " x $\frac{3}{8}$ ". 12/- each.

Type MQ508 10,000 Ω 100v. 4 c/o. £5 per dozen. 12/- each.
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NEW "F.I.R.E." PLUG-IN RELAY.—115v. Coil 50/60 c.p.s. 3 heavy duty silver change-over contacts. Very robust. 17/6. Carr. Paid.



SCHRACK ROTARY STEPPING RELAY RT304 48v. coil (280 ohm). The relay has 48 basic segments shorted in step by the 4 sweep contacts to 4 pole-plates (banks of 12). There are 2 secondary switches: (1) one c/o H/Duty contact set which changes over and back with each step; (2) two H/Duty changeovers which change over on each 12th step and return on the following pulse. Size: Base $3\frac{1}{2}$ " x $1\frac{1}{2}$ " x $4\frac{1}{2}$ " high. New in maker's packing, also, as above, but 110v. (1,290 ohm coil), £4.15.0. each. Carriage paid.



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DIAMOND "H" SEALED RELAY Type. BR 115 C.I.T.—IC 26v. 150 Ω 4 P.D.T. Completely encapsulated in heavy gauge brass case, glass sealed terminals, very robust. 17/6 each. Carr. Paid

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THORN DIGITAL INDICATOR. A modular unit easily read through a wide angle of view even under bright lighting. 12 characters, 0 to 9, decimal point and minus sign. Characters 13/16" high on acrylic, edge-lit by 1 watt midge lamp. Front panel $4\frac{1}{2}$ " x $1\frac{1}{2}$ ", depth overall 1", matt black finish. Supplied with 12 lamps. Choice of the following ratings—6v. .1A. or 12-14v. .08A. £4.0.0 each, spare lamps 24/- per dozen. Carr. Paid.



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Also limited number only as above. Without spigot. Brand New. £12.10.0 each. P. & P. 10/-.

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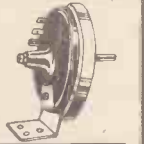
"TEDDINGTON" CONTROLS STAT TYPE T88.—Adjustable between 75° and 100°C. A further internal adjuster takes the maximum up to 120°C. Circuit cuts in again at 3° below cut-out setting. 42" capillary and sensor probe. The thermostat actuates a 15 amp. 250v. c/o switch. A second single pole on/off switch is incorporated in the adjustment mechanism. 17/6. Carr. Paid.



OMRON MICROSWITCH. Type VV—15—1A. Single c/o 10 amp. at 250v. $1\frac{1}{4}$ " x $\frac{1}{2}$ " x $\frac{3}{8}$ ". 30/- per dozen. Carr. Paid.

"HONEYWELL" MICROSWITCH.—Single and double bank, manual-push. Ideal for vending machines, etc. Each bank comprises a change-over rated 15 amps. 240v. A.C. The through-panel mounting assembly is in heavy polythene surmounted by black knob. Neck dia. $\frac{1}{8}$ ". Single 10/- each. Double 15/- each. Also few only 3 bank 20/- each. Carr. Paid.

"GOYEN" PRESSURE SWITCH.—Incorporating differential adjustment between 2" and 12" water gauge (a max. of approx. $\frac{1}{2}$ p.s.i.). A single pole change-over switch rated 15 amps. 250v. is actuated. Air inlet tube $\frac{3}{16}$ " dia. Projection $1\frac{1}{2}$ ". Overall size: dia. $3\frac{1}{2}$ ", depth 2" plus $\frac{1}{2}$ " (air tube). 25/- Carr. Paid.



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GARDNERS CASTLE SERIES. Isolation transformer type CAS 934. 240v. fused. Primary 24v. 4 $\frac{1}{2}$ amps. out. These units are constructed for outside use with fitted 5" mains lead and 3 socket outlet with plug supplied. Brand New. Makers price £7.18.6. Our price £4.15.0. P. & P. 15/-.

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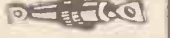
"DECCO" MAINS SOLENOID.—Compact and very powerful. 16 lb. pull. $\frac{1}{8}$ " travel which can be increased to 1" by removing captive-end-plate. Overall size 2" x 2 $\frac{1}{2}$ " x 2 $\frac{3}{4}$ " high. 27/6. P. & P. 5/-.



New "Magnetic Devices" solenoid 240v. A.C. Type 42117, 1 to 3 lb. pull, frame size $1\frac{1}{2}$ " x $1\frac{1}{2}$ " x 1". 20/- each. Carr. Paid.



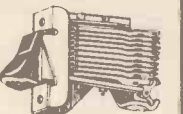
K.L.G. Sealed Terminals. Type TLSI AA, overall length 11/16", box of 100, 25s. Type TLSI BB, overall length 1", box of 100, 35s. Carr. Paid.



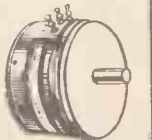
Welwyn high value Resistors Type GA 36501. Values between 9.4 and 10.9 kilo- Ω \pm 1%, glass encapsulated 15/- Carr. Paid.

WELWYN RESISTORS.—Type H12. One value only. 1 kilo- Ω \pm 20%. 5/- each. (Min. order 2.) Carr. Paid.

Torn 3 change-over Key-Switch. Locking or spring-return, as required determined by reversing fixing-plate. Attractive plastic prestle. Available red, green, grey, cream. Limited number only. 12/6 each. Carriage paid.



SERVO POTENTIOMETER By "Precision Line" U.S.A. Size 15. Continuous track with 2 platinum contact wipers set at 180° resistance 300 ohm \pm 5% LIN \pm 0.5%. ball bearing spindle column. These Potentiometers were purchased by the importer at a cost of approx. £25 each. Our price 75/- each. Carr. Paid.



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CA3000	39/6	MC724P	17/6	15/-	13/6	TAA241	32/6
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11	19/6	MC790P	27/6	24/6	23/-	268	15/6
12	19/6	MC792P	17/6	15/-	13/6	293	19/6
13	24/-	MC799P	17/6	15/-	13/6	300	35/-
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18A	25/-	MC708P	59/6	—	—	350	35/-
19	18/-	MC7490P	69/6	—	—	435	29/6
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20A	37/-	MC838P	130/-	115/-	79/6	522	72/-
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45	27/-						
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	18/-	17/6	17/6	17/6	17/6	17/6	17/6	17/6	17/6
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SN7402N	18/-	FJH141	17/6						
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TRANSISTORISED UHF TUNER UNITS NEW AND GUARANTEED FOR 3 MONTHS

Complete with Aerial Socket and wires for Radio and Allied TV sets but can be used for most makes.
Continuous Tuning, 90/-; Push Button, 100/-.

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TC8, GC2, GP59, CG8, DC284, Stereo 105, 106, 208, 2/- each (individually boxed); ST3/5, ST8/9, 9TA, 9TA/HC, CP91, 8/-, Diamond. Post and packing 5d. per item for orders under 24.

TAPES (Polyester PVC)

4 in. L.P., 8/6; 3 in. L.P., 5/6.
Standard play: 600 ft. 5 in., 8/6; 900 ft. 5 1/2 in., 10/6; 1,200 ft. 7 in., 12/6.
Long Play: 900 ft. 5 in., 11/-; 1,200 ft. 5 1/2 in., 13/-; 1,800 ft. 7 in., 18/-.
Double Play: 1,200 ft. 5 in., 16/-; 1,800 ft. 5 1/2 in., 19/-; 2,400 ft. 7 in., 28/-.
Philips type Cassettes (in plastic library pack): C60, 10/6; C90, 12/6; C120, 19/6.
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GP91-1—Medium output Mono Crystal, 21/- inc. P. Tax.
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AC FAN

Small but very powerful mains motor with 5 in. blades. Ideal for cooling equipment or as extractor. Silent but very efficient. 17/6, post 4/6. Mounts from back or front with 4BA screws.

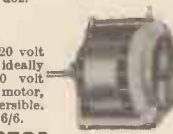


Double Leaf Contact

Very slight pressure closes both contacts. 1/3 each. 12/- doz. Plastic push-rod suitable for operating, 1/- each, 9/- doz.

PAPST MOTORS

Est. 1/20th h.p. Made for 110-120 volt working, but two of these work ideally together off our standard 240 volt mains. A really beautiful motor, extremely quiet running and reversible. 30/- each. Postage one 4/6, two 6/6.



E.M.I. MOTOR

230v. 50Hz. Capacitor start. Reversible. Normal construction. Size: 3/4 in. dia. x 2 in. deep. Approx. 1/40th h.p. 32/6 with Condenser, plus 4/6 post and insurance.

INSTRUMENT KNOS

1/4 in. dia. head with 3/16 in. shank for flatted 1/4 in. spindle, 9d. each, 8/- dozen. Ditto but with metal disc, 1/- each, 11/- dozen

MIDGET OUTPUT TRANSFORMER

Ratio 140 : 1. Size approx. 1 1/2 in. x 1/2 in. x 1/2 in., primary impedance 450 Ohm. Connection by flying leads. 4/6 each. 48/- doz.

MIDGET OUTPUT TRANSFORMER

Ratio 60 : 1. Size approx. 1 1/2 in. x 1/2 in. x 1/2 in. Primary impedance 132 Ohm. Printed circuit board connection. 5/6 each. 48/- doz.

THE 5 x 5 WATT STEREO AMPLIFIER

Made by one of our most famous makers for a deluxe player. This amplifier has a quality of reproduction much better than average. Using a total 16 transistors and a generously sized mains power pack. Controls include bass, treble, balance and volume. Suitable for 8-16 ohms impedance speakers with crossovers for tweeter mid-range and bass thus giving option of 1, 2 or 3 speakers per channel. Offered at about one-third of its original price, only 29.19.6 plus 8/6 post and insurance.

CHART RECORDER MOTOR

Small (2 1/2 in. diameter approx.) instrument motor with fixing flange and spindle (1/4 in. long, 1/4 in. diameter); integral gear-box gives 1 rev. per 24 hours. 19/6.

IGNITION (E.H.T.) TRANSFORMER

Made by Parmeko Ltd. Primary 240v. 50 c.p.s. Secondary 5kV at 23mA. Size approx. 4 1/2 in. x 3 1/2 in. x 2 1/2 in. thick. Price 29/6 + 4/6.

12-VOLT EXTRACTOR FAN BY DELCO

Ideal for ventilation in caravan, car or boat. 6-bladed 5 in. diameter fan inside heavy duty cylinder with 3-point fixing flange. 3/4 in. diameter fixing hole. Length approx. 8 1/2 in. Exceptional bargain. 27/6 plus 8/6 post and insurance.

4-PUSH SWITCH

Ideal to control fan heater, etc. 3 on switches and 1 off. Contacts rated at 15 amp on all switches. Price 4/6 each. 48/- doz.

MAINS TRANSISTOR POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PPI, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer rectifier, smoothing and load resistor, condensers and instructions. Real snip at only 16/6, plus 3/6 postage.

3 DIGIT COUNTER

For Tape Recorder or other application, re-settable by depressing button. Price 5/6.

ISOLATION SWITCH

20 Amp D.P. 250 Volts. Ideal to control Water Heater or any other appliance. Neon indicator shows when current is on. 4/6; 48/- per dozen.

LIGHT CELL

Almost zero resistant in sunlight increases to 10 K. Ohms in dark or dull light, epoxy resin sealed. Size approx. 1 in. dia. by 1/2 in. thick. Rated at 500 MW. wire ended. 8/6. Suit most circuits.

5A 3-PIN SWITCHED SOCKETS

An excellent opportunity to make that bench dis board you have needed or to stock up for future jobs. This month we offer 6 British made (Hioraft) bakelite flush mounting shuttered switch sockets for only 10/- plus 3/6 post and insurance. (20 boxes post free.)

MOTOR WITH GEARBOX

Very powerful 7 r.p.m., operates from standard A.C. mains. 29/6, plus 3/6 P. & P.

230 VOLT SOLENOID

1/2 in. stroke. Size 2 1/2 in. x 2 in. x 1 1/2 in., 14/6, postage 2/6.

TRANSDUCER

Made by Acos, reference No. L.D.1001. For measuring vibration, etc., to be used in conjunction with "G" Meter. Regular price £5. Our price 49/6. Brand new and unused.

SCREWS

100 assorted 4BA and 6BA, various lengths, 4/6. 100 assorted self-tappers, 5/6. Screw users please send for our list.

PRINCESS AUTO CHANGER FINAL OFFER AT 49/6

The most amazing bargain ever! A brand new Auto change record player for less than the price of a single player... due to a frustrated export order we are able to offer the Balfour Princess 4 speed Autochanger—a really fine machine at about one-third of its regular price.



The Balfour has two unique features (1) A patented brush system which automatically cleans stylus after each record playing and (2) at shut off the pick-up locks itself into its recess—other features include pick-up height and stylus pressure adjustments, and motor suitable for our 230/240 or for 115v. continental mains.

Beautifully styled—this is a high class expensive instrument but you can purchase one this month for only 49/6 plus 8/6 post and packing. One point, these changers have been to France and back and the vibrations of the journey, etc., may have loosened screws or otherwise put them out of adjustment. However, with each we supply a 16 page service manual and fault finding chart which is so detailed that if necessary you could completely re-build the changer. So this is truly a bargain that you will not want to miss so order today, offer closes August 30th.

1 HOUR MINUTE TIMER

Made by famous Smiths company, these have a large clear dial, size 4 1/2 in. x 3 1/2 in., which can be set in minutes up to 1 hour. After preset period the bell rings. Ideal for processing, a memory jogger or, by adding simple lever, would operate micro-switch. 22/6.

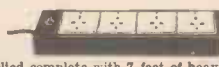


VARIAC CONTROLLERS

With these you can vary the voltage applied to your circuit from zero to full mains without generating undue heat. One obvious application therefore is to dim lighting. We offer a range of these, ex-equipment but little used and in every way as good as new. Any not so, will be exchanged or cash refunded. 2 amp 24.19.6. 4 amp 26.19.6. 8 amp 28.10.0. 7 amp 212.19.6. Carriage extra.

DISTRIBUTION PANELS

Just what you need for work bench or lab. 4 x 13 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 7 feet of heavy cable. Wired up ready to work. 39/6 less plug; 45/- with fitted 13 amp plug; 47/6 with fitted 15 amp plug, plus 4/6 P. & I.



STANDARD WAFER SWITCHES

Standard size 1 1/2 wafer—silver-plated 5-amp contact, standard 1/2 spindle 2" long—with locking washer and nut.

Table with columns: No. of Poles, 2 way, 3 way, 4 way, 5 way, 6 way, 8 way, 9 way, 10 way, 12 way. Rows: 1 pole, 2 poles, 3 poles, 4 poles, 6 poles, 7 poles, 8 poles, 9 poles, 10 poles, 11 poles, 12 poles.

24 HOUR TIME SWITCH

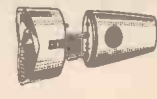
Mains operated. Adjustable Contacts give on/off per 24 hours. Contacts rated 15 amps, repeating mechanism so ideal for shop window control or to switch hall lights (anti-burglar precaution) while you are on holiday. Made by the famous Smiths Company. This month only 39/6 complete with perspex cover, new and unused, plus 8/6 postage and insurance, a real snip which should not be missed.

INTEGRATED CIRCUITS

A parcel of integrated circuits made by the famous Plessey Company. A once in a lifetime offer of Micro-electronic devices well below cost of manufacture. The parcel contains 5 ICs all new and perfect, first grade device definitely not sub-standard or seconds. The ICs are all single silicon chip General Purpose Amplifiers. Regular price of which is well over £1 each. Full circuit details of the ICs are included and in addition you will receive a list of 50 different ICs available at bargain prices 5s. upwards with circuits and technical data of each. Complete parcel only 41/- post paid or List and all technical data.

RE-CHARGEABLE TORCH

Neat flat torch, fits unobtrusively in your pocket, contains 2 NiCad cells and built-in charger. Plugs into shaver adaptor and charges from our standard 200/240 volt mains. American made, sold originally at over 4 dollars. Our price only 19/6 each.



VARYLITE

Will dim incandescent lighting up to 600 watt from full brilliance to out. Fitted on M.K. flush plate, same size and fixing as standard wall switch so may be fitted in place of this, or mount on surface. Price complete in heavy plastic box with control knob 23.19.6.

BARGAIN OF THE YEAR

MICROSONIC RADIOS 7 transistor Key chain Radio in very pretty case, size 2 1/2 x 2 1/2 x 1 1/2 in.—complete with soft leather zippered bag. Specification: Circuit: 7 transistors superheterodyne Frequency range: 530 to 1600 Kc/s. Sensitivity: 5 mv/m. Intermediate frequency: 465 Kc/s, or 455 Kc/s. Power output: 40mW. Antenna: ferrite rod. Loudspeaker: Permanent magnet type. In transit from the East, these sets suffered slight corrosion as the batteries were left in, but when this corrosion is cleared away they should work perfectly—offered without guarantee except that they are new. 24/6 plus 3/6 post and insurance. Less batteries. Six for 27, post free.



1 WATT AMPLIFIER & PRE-AMP

5 transistors—highly efficient made for use with tape-head G4 but equally suitable for microphone or pick up. Limited quantity 29/6. Full circuit diag. also shows tape controls 5/-.



OUT OF SEASON BARGAIN

TANGENTIAL HEATER UNIT This heater unit is the very latest type, most efficient, and quiet running. Is as fitted in Hoover and blower heaters costing £15 and more. We have a few only. Comprises motor, impeller, 2kW. element and 1kW. element allowing switching 1, 2 and 3kW. and with thermal safety cut-out. Can be fitted into any metal line case or cabinet. Only need control switch. 59/6. 2kW. Model as above except 2 kilowatts 39/6. Postage and insurance 6/6. Don't miss this.



Where postage is not stated then orders over £5 are post free. Below £5 add 2/9. Semi-conductors add 1/- post. Over £1 post free. S.A.E. with enquiries please.

TOGGLE SWITCH

3 amp 250v. with fixing ring. 1/8 each 15/- doz.



MICRO SWITCH

5 amp. changeover contacts. 1/9 each 18/- doz. 15 amp model 2/- ea. or 21/- doz.

MINIATURE EAR PIECE

As used with imported pocket radios. 1/6 each 15/- doz.

15/20 AMP CONNECTORS

Polythene insulated 12-way strip. 2/8 each 24/- doz.

13 AMP FUSED SWITCH

Made by G.E.C. For connecting water heater etc., into 13 amp ring main. Flush type 3/6 each 30/- doz. Metal boxes for surface mounting 1/6 each 15/- doz.

13 AMP SPUR UNIT

By G.E.C. for connecting clock, etc., to ring main. Pull-out fuse. Flush mounting. Cream. 2/6 each; 24/- doz.

SUPPRESSOR CONDENSER TCC

1 mfd. 250v. A.C. working metal case with fixing lug. 1/9 each 18/- doz.

REED RELAY

Glass encapsulated reed switch in 24-volt solenoid, neatly enclosed in neat metal case, size 2 1/2 in. x 1 1/2 in. x 3/8 in. Operates from 24 volts D.C. or from A.C. mains using rectifier, resistor and condenser (3/6 extra).

SHEET PAXOLIN

Ideal for transistor projects, panels 12 in. x 6 in., 1/9 each 15/- per dozen.

G.E.C. MULTIPLE SWITCHES

Metal boxes (with cable knockouts) sprayed silver with cover and switch mounting grid. For 8, 10 and 12 switches 8/-, 6 switches 5/-.

G.E.C. Clipper switches

For the above boxes, 5 amp, A.C. rating, one-way 1/6 2-way 2/-, bell push 2/-, intermediate 2/6, secret 2/6, 15 amp one-way 2/6.

THERMOSTAT

Continuously variable 30°-90°C. Has sensor bulb connected by 3/16 in. of flexible tubing. On operation a 15 amp 250 volt switch is opened and in addition a plunger moves through approx. 1/4 in. This could be used to open valve on ventilator etc. 29/6 plus 4/6 p. & ins.

HI FI BARGAIN

FULL F1 12-INCH LOUDSPEAKER. This is undoubtedly one of the finest loudspeakers that we have ever offered, produced by one of the country's most famous makers. It has a die-cast metal frame and is strongly recommended for Hi-Fi load and Rhythm Guitar and public address. Flux Density 11,000 gauss—Total Flux 44,000 Maxwell—Power Handling 15 watts B.M.S.—Cone moulded fibre—Freq. response 30-10,000 c.p.s.—specify 3 or 15 ohms—Main resonance 60 c.p.s.—Chassis Diam. 12 in.—121 over mounting lugs—Baffle hole 1 1/2 in. diam.—Mounting holes 4, holes—1/4 in. diam. on pitch circle, 1 1/2 in. diam.—Overall height 1 1/2 in. A 25 speaker offered for only 23.19.6 plus 7/6 p. & p. Don't miss this offer. 15 in. 25 watt 27.19.6. 18 in. 100 watt 219.10.0. Carriage, etc., 30/-.



CONTROL DRILL SPEEDS

Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions 19/6, plus 2/6 post and insurance. Made up model also available 37/6 plus 2/6 p. & p.

MAINS MOTOR

Precision made—as used in record decks and tape recorders—ideal also for extractor fans, blower, heater, etc. New and perfect. Snip at 9/6. Postage 3/- for first one then 1/- for each one ordered. 12 and over post free.

MINIATURE WAFER SWITCHES

2 pole, 2 way—4 pole, 2 way—3 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way—1 pole, 12 way. All at 3/6 each, 36/- dozen, your assortment.

MINIATURE SLIDE SWITCH

3 pole change-over. 3/- each 30/- doz.

ELECTRIC CLOCK WITH 25 AMP SWITCH

Made by Smith's, these units are as fitted to many top quality cookers to control the oven. The clock is mains driven and frequency controlled so it is extremely accurate. The two small dials enable switch on and off times to be accurately set. Ideal for switching on tape recorders. Offered at only a fraction of the regular price—new and unused only, 36/9 less than the value of the clock alone—post and insurance 2/9.



ELECTRONICS (CROYDON) LTD Dept. WW, 266 London Road, Croydon CRO-2TH Also 102/3 Tamworth Road, Croydon

L.S.T. ELECTRONIC COMPONENTS LTD

= BETTER QUALITY, SERVICE, PRICES & LARGEST STOCKS

A1617/3	40/-	AUY10	30/-	BF179	12/6	MPF105	8/-	NKT228	6/6	NKT12329	8/5	TIS34	17/6	2N743	4/6	2N3393	5/-	2N5029	9/6	BY100	5/-
AA30	1/7	BI181	10/-	BF180	6/6	NKT11	7/6	NKT229	3/11	NKT12429	10/6	TIS44	1/9	2N744	6/-	2N3394	4/9	2N5030	8/6	BY125	3/6
AAZ13	3/2	B2M	15/-	BF181	6/6	NKT12	5/8	NKT231	6/-	NKT13329	3/11	TIS45	3/3	2N911	10/-	2N3402	5/6	2N5172	3/6	BY127	4/-
AC107	7/7	B3M	15/-	BF184	7/7	NKT32	6/-	NKT232	6/-	NKT13429	3/11	TIS46	3/3	2N914	3/11	2N3403	5/6	2N5174	10/6	BY234	2/3
AC126	5/3	BI08	2/6	BF185	8/8	NKT42	6/-	NKT233	5/9	NKT16229	8/5	TIS47	3/3	2N918	8/5	2N3404	7/6	2N5175	10/6	BYX10	3/-
AC127	4/-	BA111	6/-	BF194	3/6	NKT43	6/-	NKT238	4/-	NKT20329	6/8	TIS48	3/3	2N929	5/3	2N3414	5/6	2N5176	9/-	BYX36/150	2/6
AC127Z	9/6	BAX13	1/6	BF200	10/6	NKT72	3/9	NKT239	4/-	NKT20339	6/4	TIP31A	12/4	2N930	6/-	2N3415	6/-	2N5232	5/6	BYX36/300	2/10
AC128	4/-	BC107	2/9	BF274	3/7	NKT73	3/7	NKT240	3/10	NKT25219	15/9	TIP32A	14/10	2N1131	6/11	2N3416	7/6	2N5249	13/6	BYX36/600	3/9
AC176	5/-	BC108	2/9	BFX13	5/11	NKT101	6/-	NKT241	3/9	OC19	5/-	V205	20/-	2N1132	7/9	2N3438	15/-	2N5249A	13/6	BYZ21	25/-
AC187	12/-	BC109	2/9	BFX25	6/2	NKT102	6/-	NKT242	2/11	OC20	19/8	V405A	9/3	2N1302	3/7	2N3525	21/9	2N5305	7/6	BYZ23	26/3
AC188	12/-	BC113	8/8	BFX44	8/8	NKT103	6/-	NKT243	12/-	OC22	8/-	40250	10/9	2N1303	3/7	2N3528	19/-	2N5306	8/-	BYZ25	31/9
ACY17	5/9	BC116	8/8	BFX84	5/2	NKT104	6/-	NKT244	3/1	OC23	8/-	40309	6/6	2N1304	4/11	2N3606	5/6	2N5309	12/6	BYZ142	3/9
ACY18	4/-	BC118	5/8	BFX85	6/9	NKT105	6/-	NKT245	3/2	OC24	8/-	40310	6/6	2N1305	4/11	2N3607	4/6	2N5354	5/6	BYZ10	9/-
ACY19	4/-	BC125	11/-	BFX86	4/11	NKT106	6/-	NKT246	4/3	OC25	7/6	40311	6/6	2N1306	6/-	2N3702	2/6	2N5355	3/6	BYZ12	6/-
ACY20	3/10	BC126	11/-	BFX87	5/11	NKT107	6/-	NKT262	4/3	OC26	6/6	40312	9/6	2N1307	6/-	2N3703	2/5	2N5356	10/6	BYZ13	5/-
ACY21	3/10	BC134	5/-	BFX88	8/3	NKT108	6/-	NKT263	4/8	OC28	12/-	40314	7/3	2N1308	6/-	2N3704	3/2	25001	10/-	CG6E	4/-
ACY22	3/9	BC135	6/-	BFY18	15/-	NKT109	6/-	NKT264	4/3	OC29	15/-	40315	7/3	2N1309	6/3	2N3705	2/8	25002	12/6	CG63	2/-
ACY27	3/6	BC136	8/-	BFY50	4/6	NKT121	10/6	NKT265	5/6	OC35	9/-	40316	6/-	2N1613	4/8	2N3706	2/3	25003	12/6	EA403	3/6
ACY28	3/8	BC137	8/6	BFY51	3/9	NKT122	10/-	NKT270	6/-	OC36	12/6	40317	7/3	2N1711	5/1	2N3707	2/10	25004	15/-	EC401	5/8
ACY29	7/6	BC138	12/-	BFY52	4/6	NKT123	9/6	NKT271	2/10	OC41	4/6	40319	10/9	2N2147	16/3	2N3708	1/10	25005	15/-	EC402	4/8
ACY30	7/6	BC140	13/3	BFY53	3/2	NKT124	6/8	NKT272	2/10	OC42	4/6	40320	7/3	2N2148	12/6	2N3709	2/-	25006	13/6	EB383	3/6
ACY31	4/7	BC147	2/9	BFY90	24/6	NKT125	4/6	NKT273	3/8	OC43	4/6	40323	6/6	2N2160	14/8	2N3710	2/3	25017	13/-	GEK45/1	4/-
ACY34	3/6	BC148	3/3	BFW57	6/7	NKT126	4/4	NKT274	2/10	OC44	3/-	40324	4/3	2N2217	5/3	2N3711	2/6	25018	17/6	GJ3M	4/-
ACY35	3/6	BC149	3/3	BFW58	5/6	NKT127	10/6	NKT275	3/4	OC45	3/-	40326	4/3	2N2218	11/4	2N3789	5/9	25019	19/6	OA5	3/8
ACY36	3/9	BC154	12/-	BFW59	5/6	NKT128	10/-	NKT276	3/6	OC70	2/6	40329	2/9	2N2218	6/8	2N3819	7/-	25020	20/-	OA10	6/-
ACY39	12/-	BC167	3/6	BFW60	4/6	NKT129	8/6	NKT279A	2/6	OC71	3/-	40344	8/3	2N2218A	8/4	2N3820	18/9	25104	12/6	OA47	1/8
ACY40	3/4	BC168	3/9	BLY47	31/3	NKT135	6/1	NKT281	5/-	OC72	4/6	40347	7/6	2N2219	7/2	2N3826	6/-	25301	8/6	OA70	1/8
ACY41	3/4	BC169	10/-	BS05	10/-	NKT137	6/1	NKT301	11/-	OC74	8/-	40348	10/3	2N2219A	10/-	2N3854	5/6	25302	7/6	OA73	1/8
ACY44	8/-	BC171	2/-	BSX19	3/3	NKT141	10/6	NKT302	12/5	OC75	4/6	40361	8/6	2N2369	3/4	2N3854A	5/6	25303	10/-	OA79	1/8
AD140	11/-	BC182L	2/3	BSX20	3/3	NKT142	10/-	NKT303	17/6	OC76	2/6	40360	9/6	2N2369A	3/11	2N3855	5/6	25304	12/6	OA81	1/8
AD149	11/6	BC183L	1/10	BSX21	7/6	NKT143	9/6	NKT304	9/10	OC77	5/6	40362	11/6	2N2613	7/6	2N3855A	6/-	25306	15/-	OA85	1/8
AD161	6/-	BC184L	3/-	BSX60	12/7	NKT144	8/-	NKT351	10/-	OC81	4/6	40370	6/-	2N2614	4/-	2N3856	6/-	25320	9/-	OA90	1/8
AD162	6/-	BC121L	3/4	BSX61	7/11	NKT151	6/8	NKT404	17/6	OC82	7/6	40406	11/6	2N2616	6/6	2N3856A	6/-	25321	10/-	OA92	1/8
ADT140	10/-	BC185	3/4	BSX76	6/1	NKT153	6/1	NKT361	20/-	OC82B	3/-	40408	10/3	2N2904	8/10	2N3858	5/-	25322	8/-	OA95	1/8
ADZ11	32/-	BCY12	12/-	BSX77	4/-	NKT154	6/-	NKT362	20/-	OC82D	3/-	40462	11/3	2N2904A	9/9	2N3858A	5/-	25323	10/-	OA200	2/8
ADZ12	32/10	BCY30	5/-	BSX78	6/6	NKT161	6/-	NKT401	14/6	OC83	4/6	40467	16/6	2N2905	12/11	2N3859	5/6	25701	8/6	OA201	2/8
AF102	12/6	BCY31	5/6	BSY27	4/6	NKT162	6/-	NKT402	15/-	OC84	5/6	40468A	7/-	2N2905A	15/1	2N3859A	6/3	25702	11/4	OA211	8/-
AF106	7/6	BCY32	10/-	BSY29	5/8	NKT163	6/-	NKT403	14/9	OC123	7/6	40602	30/-	2N2906	8/10	2N3860	6/-	25703	12/6	OA224	10/-
AF118	8/8	BCY33	4/8	BSY32	5/8	NKT164	6/8	NKT404	11/6	OC139	8/-	40607	11/3	2N2906A	10/10	2N3866	25/-	25704	12/6	OA234	10/-
AF119	8/8	BCY34	5/-	BSY36	5/8	NKT165	6/-	NKT405	11/-	OC140	7/-	40608	10/3	2N2923	4/-	2N3877	9/-	25712	34/6	OA247	10/-
AF116	5/8	BCY38	6/-	BSY98	3/2	NKT201	6/-	NKT406	9/11	OC170	5/-	40610	5/-	2N2924	4/-	2N3877A	9/6	25720	25/-	TD716	12/-
AF117	3/8	BCY40	10/-	BSY95A	2/11	NKT202	6/-	NKT420	28/11	OC171	6/6	40610	5/-	2N2925	3/6	2N3900	10/6	25732	28/-	IN34A	4/-
AF118	8/10	BCY42	4/-	BYZ14	33/3	NKT204	6/-	NKT451	9/11	OC200	6/3	40611	5/1	2N2926	2N3900A	11/6	25733	5/11	IN66	4/-	
AF121	6/-	BCY43	4/-	BYZ15	33/3	NKT205	6/-	NKT452	9/6	OC201	8/8	40612	5/1	2N2926	2N3900A	11/6	25733	5/11	IN66	4/-	
AF124	4/2	BCY54	7/6	CI11	18/6	NKT206	6/-	NKT453	8/6	OC202	8/8	40613	2/9	2N2926	2N3900A	11/6	25733	5/11	IN66	4/-	
AF125	4/2	BCY70	3/10	CI11E	12/-	NKT208	6/2	NKT603F	4/8	OC203	7/6	2G339A	5/-	Yellow	2/-	2N3905	7/6	3N128	13/9	IN82A	9/6
AF126	3/6	BCY71	7/8	C426	8/3	NKT210	4/2	NKT613F	5/2	OC204	8/-	2G337	3/5	Orange	2/-	2N3906	7/6	3N140	13/9	IN191	5/6
AF127	3/6	BCY72	3/2	CRI-051C	8/-	NKT211	3/9	NKT654F	4/2	OC205	10/6	2G371B	3/-	Orange	2/-	2N4037	15/-	3N141	14/9	IN194	1/6
AF178	9/6	BCY87	86/9	CRI-401C	10/-	NKT212	3/9	NKT675	6/8	OC206	10/6	2G374	5/-	2N2926	2N4038	3/4	3N142	10/6	IN401	1/6	
AF179	11/6	BCZ11	7/6	D1371	10/-	NKT213	4/7	NKT676	5/8	OC207	7/6	2G38	5/3	Brown	4/3	2N4039	5/3	3N143	10/6	IN402	1/6
AF180	12/6	BD112	18/6	GET3/BAF	10/-	NKT214	4/8	NKT677	3/10	OC271	19/6	2N1174	16/-	2N3011	12/6	2N4060	5/-	3N152	17/3	IN403	2/6
AF181	8/6	BD121	18/6	GET16	12/6	NKT215	3/7	NKT703	8/-	ORP12	9/-	2N385A	2N3036	39/-	2N4061	4/-	5D6	3/-	IN4004	2/9	
AF186W	9/-	BD123	21/6	GET102	6/-	NKT216	7/6	NKT713	3/10	ORP60	8/-	2N388A	15/-	2N3053	4/5	2N4062	4/6	AA119	2/-	IN4005	3/6
AF186G	9/-	BD124	21/6	GET103	5/-	NKT217	9/-	NKT717	5/10	ORP61	8/-	2N404	4/6	2N3054	12/6	2N4284	3/-	AA112	6/-	IN4006	3/6
AF239	7/6	BDY20	20/8	GET113	4/-	NKT218	6/-	NKT734	4/11	ORP63	9/-	2N696	3/7	2N3055	15/-	2N4287	3/-	AA212	6/-	IN4007	3/9
AFY19	22/6	BF115	3/4	MJ480	20/6	NKT219	4/7	NKT736	6/2	P346A	9/-	2N697	3/10	2N3133	6/-	2N4288	6/9	AA211	6/-	IN4148	1/9
AFZ11	8/6	BF122	13/6	MJ481	27/-	NKT221	7/-	NKT773	3/7	RAS310AF	6/-	2N698	6/-	2N3135	6/-	2N4289	3/-	BA110	6/-	IS44	1/9
AM006	10/-	BF154	9/-	MJ490	22/6	NKT222	5/-	NKT774	6/-	RAS508AF	15/-	2N706	2/4	2N3136	6/-	2N4290	3/-	BA111	6/-	IS103	4/3
AS226	4/8	BF159	5/-	MJ491	29/6	NKT223	5/-	NKT0013	6/6	S1M	19/-	2N706A	2/6	2N3235	28/6	2N4291	3/-	BA112	18/-	IS113	4/6
AS227	6/-	BF163	5/-	MPF102	8/6	NKT224	3/7	NKT10419	3/10	S4M	33/6	2N708	3/3	2N3234	27/6	2N4292	3/-	BA115	1/6	IS130	2/-
AS228	4/5	BF167	9/-	MPF103	7/6	NKT225	3/6	NKT10519	4/3	S72	9/8	2N709	8/6	2N3242	7/9	2N4293	6/9	BA130	1/6	IS171	2/6
AS229	6/-	BF173	6/-	MPF																	

BRAND NEW SEMICONDUCTORS & COMPONENTS GUARANTEED

TRANSISTORS Brand new and fully guaranteed. PLEASE NOTE—A large number of our transistors have now been reduced in price. Many more semi-conductors in stock. Please enquire for types not listed.

2G301	4/-	2N3402	4/6	3N143	17/6	BC159	4/-	BFY90	13/6	NKT261	4/-
2G302	4/-	2N3403	4/6	3N152	22/6	BC160	12/6	BFW58	5/6	NKT264	6/-
2G303	4/-	2N3404	7/6	R.C.A.:		BC167	3/-	BFW59	5/-	NKT264	6/-
2G308	8/6	2N3405	9/-	40050	13/6	BC168B	2/9	BFW60	5/-	NKT271	4/-
2G308	10/6	2N3414	5/6	40250	13/6	BC168C	3/6	BFY25	3/6	NKT272	4/-
2G309	6/-	2N3415	5/6	40251	19/6	BC169B	2/9	BFX29	36/-	NKT274	4/-
2G371	3/-	2N3416	7/6	40309	8/-	BC169C	3/-	BPY10	29/-	NKT275	5/-
2G374	4/-	2N3417	7/6	40310	11/6	BC170	3/6	BSX19	3/6	NKT281	4/-
2G381	4/6	2N3439	26/-	40311	9/6	BC171	7/6	BSX20	3/6	NKT401	17/6
2N388A	12/6	2N3440	19/6	40312	12/6	BC172	3/6	BSX21	3/6	NKT402	18/-
2N404	2/6	2N3570	17/6	40316	9/6	BC175	5/6	BSX22	9/-	NKT403	15/-
2N696	4/-	2N3572	17/6	40315	9/6	BC182	4/6	BSX27	9/6	NKT404	12/6
2N697	4/-	2N3605	5/6	40316	12/6	BC183	4/6	BSX28	6/6	NKT405	15/6
2N698	5/-	2N3606	5/6	40317	9/6	BC184	4/6	BSX60	16/6	NKT406	12/6
2N699	5/-	2N3607	4/6	40319	13/6	BC182L	4/-	BSX61	12/6	NKT451	12/6
2N705	2/6	2N3662	7/6	40320	10/6	BC183L	3/6	BSX76	5/6	NKT452	12/6
2N706A	2/6	2N3663	7/6	40323	9/6	BC184L	4/-	BSX77	5/6	NKT453	9/6
2N708	3/6	2N3702	3/6	40324	11/6	BC212L	4/6	BSX78	5/6	NKT603F	6/6
2N709	12/6	2N3703	4/6	40326	19/6	BCY10	5/6	BSY10	5/6	NKT613F	6/6
2N718	5/-	2N3704	4/6	40329	7/-	BCY12	5/6	BSY11	5/6	NKT674F	6/6
2N718A	6/-	2N3705	4/-	40344	7/-	BCY30	5/6	BSY24	3/-	NKT677F	6/6
2N720	6/-	2N3706	4/-	40345	9/6	BCY31	19/6	D1971	7/6	NKT713	10/6
2N727	6/-	2N3707	4/-	40348	12/6	BCY32	7/6	BSY26	3/6	NKT717	8/6
2N914	3/6	2N3708	3/6	40360	11/-	BCY33	4/-	BSY27	3/6	NKT734	5/6
2N916	3/6	2N3709	3/6	40361	12/6	BCY34	4/6	BSY28	3/6	NKT736	7/-
2N918	3/6	2N3710	4/-	40362	13/6	BCY38	4/6	BSY29	3/6	NKT773	5/-
2N929	4/6	2N3711	4/-	40370	7/6	BCY39	8/6	BSY32	5/-	NKT781	6/-
2N930	4/6	2N3713	30/6	40406	16/6	BCY40	7/6	BSY33	5/-	NKT8339	6/-
2N987	10/6	2N3714	35/-	40408	12/6	BCY42	3/-	BSY37	5/-	NKT10419	6/-
2N1131	5/6	2N3819	7/-	40467	16/6	BCY43	3/-	BSY38	4/6	NKT10439	7/6
2N1132	6/6	2N3823	22/6	40467A	14/6	BCY54	6/6	BSY39	4/6	NKT10519	6/6
2N1302	3/6	2N3854	5/6	40468A	14/6	BCY58	4/6	BSY40	6/6	NKT20329	9/6
2N1303	3/6	2N3854A	5/6	AF107	6/-	BF159	4/-	BSY51	6/6	NKT20329	9/6
2N1304	4/6	2N3855	4/6	AC126	4/6	BCY60	19/6	BSY52	6/6	NKT80110	15/6
2N1305	4/6	2N3855A	6/-	AC127	5/6	BCY70	4/-	BSY53	7/6	NKT80112	19/6
2N1306	5/-	2N3856	6/-	AC128	4/6	BCY71	8/6	BSY54	8/-	NKT80113	22/6
2N1307	5/-	2N3856A	7/-	AC154	4/6	BCY72	3/6	BSY56	18/-	NKT80211	18/6
2N1308	6/-	2N3858	5/-	AC176	5/6	BCZ10	5/6	BSY78	9/6	NKT80212	18/6
2N1309	6/6	2N3858A	5/6	AF187	11/6	BD117	7/6	BSY79	9/-	NKT80213	18/6
2N1507	5/6	2N3859	5/6	AC188	7/6	BD116	22/6	BSY82	10/6	NKT80214	18/6
2N1613	5/6	2N3859A	6/6	AC177	5/6	BD121	13/-	BSY90	11/6	NKT80215	18/6
2N1631	8/6	2N3860	6/-	AC118	5/6	BD123	16/6	BSY95A	2/6	NKT80216	18/6
2N1632	8/6	2N3866	30/-	AC119	5/-	BD124	12/-	BSW41	8/6	OC20	15/-
2N1637	8/6	2N3877	8/-	AC120	5/-	BD131	19/6	BSW70	5/6	OC22	10/-
2N1638	8/6	2N3877A	8/-	AC121	5/-	BD132	19/6	BSW71	5/6	OC23	10/-
2N1639	7/6	2N3900	7/6	AC122	4/-	BDY10	27/6	D16P2	8/-	OC24	11/6
2N1701	32/6	2N3900A	8/-	AC128	4/-	BDY11	37/6	D16P3	7/6	OC25	10/-
2N1711	5/-	2N3901	19/6	AC140	4/-	BDY17	37/6	D16P4	8/-	OC26	6/6
2N1889	6/6	2N3903	7/-	AC141	5/-	BDY18	49/6	GET102	6/6	OC28	12/6
2N1893	5/6	2N3904	8/6	AC142	8/6	BDY19	62/6	GET113	4/6	OC29	12/6
2N2147	14/6	2N3905	7/6	AD140	8/6	BDY20	22/6	GET114	4/6	OC35	18/-
2N2148	12/6	2N3906	7/6	AD149	11/6	BDY38	19/6	GET118	4/6	OC36	12/6
2N2160	11/6	2N4058	5/6	AD150	12/6	BDY60	36/-	GET119	4/6	OC41	4/6
2N2193	9/6	2N4059	5/-	AD161	7/6	BDY61	36/-	GET120	10/6	OC42	5/-
2N2193A	10/6	2N4060	5/-	AD162	7/6	BDY62	27/6	GET873	2/6	OC44	4/-
2N2194	6/6	2N4061	4/6	AF115	5/6	BF117	9/6	GET880	6/6	OC45	2/6
2N2217	5/6	2N4062	4/6	AF116	5/6	BF117	9/6	GET887	4/6	OC46	2/6
2N2218	6/6	2N4244	6/6	AF115	5/6	BF163	7/6	GET889	4/6	OC70	2/6
2N2219	6/6	2N4245	8/6	AF116	5/6	BF167	5/6	GET890	4/6	OC71	2/6
2N2220	5/6	2N4254	8/6	AF117	5/6	BF173	6/6	GET896	4/6	OC72	2/6
2N2221	5/6	2N4255	8/6	AF118	12/6	BF177	6/6	GET897	4/6	OC74	2/6
2N2222	5/6	2N4256	8/6	AF119	12/6	BF178	6/6	GET898	4/6	OC76	2/6
2N2227	21/6	2N4285	3/6	AF124	4/6	BF179	14/6	MAT100	6/-	OC76	6/6
2N2297	6/-	2N4286	3/6	AF125	4/6	BF180	7/-	MAT101	6/-	OC77	6/6
2N2368	3/6	2N4287	3/6	AF126	4/6	BF181	6/6	MAT120	6/-	OC81	4/6
2N2369	3/6	2N4288	3/6	AF127	3/6	BF184	6/6	MAT121	6/-	OC81D	4/6
2N2369A	3/6	2N4289	3/6	AF128	3/6	BF185	8/6	M1400	21/6	OC83	5/6
2N2410	8/6	2N4290	3/6	AF178	7/6	BF186	8/6	M1401	22/6	OC84	5/6
2N2483	5/6	2N4291	3/6	AF179	14/6	BF195	5/6	M1421	22/6	OC139	6/6
2N2484	4/6	2N4292	2/6	AF180	10/6	BF196	8/6	M1430	20/6	OC140	6/6
2N2539	6/6	2N5027	10/6	AF181	8/6	BF197	8/6	M1440	19/-	OC170	6/-
2N2540	4/6	2N5028	8/6	AF239	8/6	BF198	8/6	M1480	19/-	OC171	6/6
2N2569A	6/6	2N5029	9/6	AF239	9/6	BF200	10/6	M1481	25/6	OC200	6/6
2N2614	6/6	2N5030	8/6	AF280	12/6	BF209	6/6	M1490	20/6	OC201	6/6
2N2646	11/6	2N5172	3/-	AFZ11	6/6	BF225	6/-	M1491	27/6	OC202	12/6
2N2696	6/6	2N5174	10/6	ASV26	5/6	BF237	6/6	M1800	43/6	OC203	8/6
2N2711	6/6	2N5175	10/6	ASV27	7/6	BF238	6/6	M1E340	12/6	OC204	8/6
2N2712	6/6	2N5176	9/-	ASV28	5/6	BFX12	4/6	MIE520	17/6	OC205	8/6
2N2713	5/6	2N5241A	5/6	ASV29	5/6	BFX13	4/6	MIE521	17/6	OC207	12/6
2N2714	6/-	2N5245	12/6	ASV36	5/-	BFX13	4/6	MPF102	8/6	OC208	12/6
2N2865	12/6	2N5246	12/6	ASV50	5/-	BFX29	7/6	MPF103	7/6	OC209	12/6
2N2904	7/-	2N5249	13/6	ASV51	6/6	BFX43	7/6	MPF105	7/6	ORP62	10/6
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2N2905A	6/6	2N5266	6/6	ASV62	5/6	BFX84	13/6	NKT0013	9/6	TIS34	12/6
2N2906	6/6	2N5267	52/6	ASV63	3/6	BFX85	7/6	NKT124	8/6	TIS43	8/6
2N2906A	6/6	2N5305	7/6	ASV72	5/6	BFX86	6/6	NKT125	5/6	TIS44	2/6
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2N2924	3/6	2N5308	7/6	ASV87	6/6	BFX89	12/6	NKT135	5/6	TIS47	3/6
2N2925	3/6	2N5309	12/6	ASZ21	8/6	BFY10	8/6	NKT137	6/6	TIS48	3/6
2N2926	3/6	2N5310	8/6	AUY10	30/-	BFY11	4/6	NKT210	6/-	TIS49	3/6
Green	2/9	2N5354	5/6	BC107	3/6	BFY17	4/6	NKT211	6/-	TISSO	4/6
Yellow	2/6	2N5355	5/6	BC108	3/6	BFY18	6/6	NKT212	6/-	TISS1	3/6
Orange	3/6	2N5356	5/6	BC109	3/6	BFY19	6/6	NKT213	6/-	TISS2	3/6
2N3011	6/6	2N5365	9/6	BC113	5/6	BFY20	6/6	NKT214	4/6	TIS53	6/6
2N3014	6/6	2N5366	6/6	BC114	7/6	BFY21	8/6	NKT215	4/6	TIS60	6/-
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2N3085	15/-	2N5035	18/-	BC116A	7/6	BFY26	5/-	NKT219	6/6	TIP30A	15/-
2N3133	6/6	2N5020	37/6	BC118	6/6	BFY29	4/6	NKT223	5/6	TIP30B	16/6
2N3134	6/6	2N5102	6/6	BC121	4/6	BFY30	10/6	NKT224	5/6	TIP32A	19/6
2N3135	5/6	2N5103	6/6	BC122	4/6	BFY41	10/6	NKT225	4/6	ZTX107	3/6
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Complete Stereo System £41

WITH VISCOUNT F.E.T. FIELD EFFECT TRANSISTORS AMPLIFIER



This superb stereo system is a real price breakthrough. It comprises the VISCOUNT F.E.T. Mk I amplifier on which full details are given below, the famous Garrard SP 25 Mk II (including teak veneer base and transparent cover) with diamond cartridge or 2025 TC and the very successful DUO type 2 speakers.

Measuring 17½" X 10¾" X 6¾", the Duo type 2 speakers are beautifully finished in teak veneer with matching vnaic grills. They incorporate a 10½" X 6¼" drive unit and high frequency speaker, both of which are of 3 ohms impedance. The Duo speaker system is also available separately at £6.6.0, each plus 15/- P & P. Complete stereo system £41 plus £2.10 P & P.

The Viscount F.E.T. Mk I £14.5s. plus 7/6 P. & P.

High fidelity transistor stereo amplifier employing field effect transistors. With this feature & accompanying guaranteed specifications below, the Viscount F.E.T. vastly surpasses amplifiers costing far more.

Specification: Output per channel 10 watts r.m.s. Frequency bandwidth 20 Hz to 20 kHz ± 1 dB @ 1 watt.
Total distortion: @ 1 kHz @ 9 watts 0.5%.
Input sensitivities: CER, P.U., 100mV into 3 meg ohms. Tuner 100mV into 100K ohms. Tape 100mV into 100K ohms.

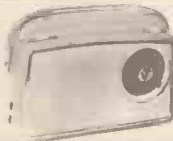
Overload Factor: Better than 26 dB.
Signal to noise ratio: 70 dB on all inputs (with vol. max).
Controls: 6 position selector switch (3 pos. stereo & 3 pos. mono). Separate Vol. controls for left & right channels. Bass ± 14 dB @ 60 Hz. Treble (with D.P.S. on/off) ± 12 dB @ 10 kHz. Tape Recording output sockets on each channel.

Size: 12½" X 6" X 2¼" in teak-finished case. **BUILT & TESTED.**

Mk II (MAG. P.U.) £15.15.0 plus 10/- p & p
 Specification same as Mk. I, but with the following inputs. Mag. P.U. CER. P.U. Tuner. Spec. on Mag. P.U. 3mV @ 1 kHz input impedance 47K. Fully equalised to within ± 1 dB RIAA. Signal to noise ratio—65 dB (vol. max).



Elegant Seven Mk 3 (350mW)
 7 transistor fully-tunable M.W.-L.W. superhet portable Set of parts. Complete with all components. Including ready etched and drilled printed circuit board—back printed for foolproof construction. **MAINS POWER PACK KIT:** 9/6 extra. **Price £5.5.0 plus 7/6 P. & P.** Circuit 2/6 FREE WITH PARTS



The Dorset (600 mW)
 7-transistor fully tunable M.W.-L.W. superhet portable—with baby alarm facility. Set of parts. The latest modulated and pre-alignment techniques makes this simple to build. Sizes: 12 x 8 x 3in. **MAINS POWER PACK KIT:** 9/6 extra. **Price £5.5.0 plus 7/6 P. & P.** Circuit 2/6 FREE WITH PARTS

50 WATT AMPLIFIER



AC MAINS 200-250V
£28 10s.
 plus 20/- p. & p.

An extremely reliable general purpose valve amplifier. Its rugged construction yet space age styling and design makes it by far the best value for money.

TECHNICAL SPECIFICATIONS

3 electronically mixed channels with 2 inputs per channel, enables the use of 6 separate instruments at the same time. The volume controls for each channel are located directly above the corresponding input sockets. **SENSITIVITIES AND INPUT IMPEDANCES:** Channels 1 & 2 4mV at 470K. These 2 channels (4 inputs) are suitable for microphone or guitars. Channels 3 & 4 300mV at 1M. Suitable for most high output instruments (gram. tuner, organ, etc.). Input sensitivity relative to 10w output. **TONE CONTROLS ARE COMMON TO ALL INPUTS.** Bass Boost + 12dB at 80 Hz. Bass Cut—13dB at 80 Hz. Treble Boost + 14dB at 15 kHz. Treble Cut — 12dB at 15 kHz. With bass and treble controls central — 3dB points are 30 Hz and 20 kHz. **POWER OUTPUT:** For speech and music 50 watts rms. 100 watts peak. For sustained music 45 watts rms. 90 watts peak. For sine wave 38.5 watts rms. Nearly 80 watts peak. Total distortion at rated output 3.2% at 1kHz. Total distortion at 20 watts 0.15% at 1kHz. **NEGATIVE FEEDBACK** 20dB at 1 kHz. **SIGNAL TO NOISE RATIO** 60dB. **MAINS VOLTAGES** adjustable from 200-250V. A.C. 50-80 Hz. A protective fuse is located at the rear of unit. Output impedance 3.8 and 15 ohms.

LIQUIDATED STOCK DANSETTE TOURISTE MK3 CAR RADIO

Beautifully designed to blend with the interiors of all cars. Permeability tuning and long wave loading coils ensures excellent tracking, sensitivity and selectivity on both wave bands. R.F. sensitivity at 1 MHz is better than 8 micro volts. Power output into 3 ohm speaker is 3



ALL TRANSISTOR

watts. Pre-aligned I.F. module and tuner together with comprehensive instructions guarantees success first time. 12 volts negative or positive earth. Size 7" x 2" x 4½" deep.

ORIGINALLY SOLD COMPLETE FOR £15.4.6.

SET OF PARTS £6.6.0.

Speaker, baffle and fixing kit 25/- extra plus 4/- P. & P. (Postage free when ordered with parts.)

Circuit diagram 2/6. Free with parts. Plus 7/6 P. & P.



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ZENER DIODES

- BZY88 series, from 3.3V to 8.1V ± 5% 400mW 3/6 each
- BZY94 series, from 10.0V to 12.0V ± 5% 400mW 4/1 each
- D814 series, from 7.5V to 13.0V ± 10% 340mW 3/- each
- D815 series, from 4.7V to 18.0V ± 10% 8 Watts 7/6 each
- D816 series, from 22V to 47V ± 10% 5 Watts 7/6 each
- D817 series, from 56V to 100V ± 10% 5 Watts 7/6 each

Outlines: BZY series—miniature—wire ended
 B814—Top Hat type
 D815-D817—stud mounted, supplied complete with hardware
 Please state voltage required—nearest standard voltage will be supplied.

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10 mc/s passband, triggered sweep from 1 μ sec. to 3 milli-sec. Free running time base from 20 c/s to 200 kc/s. Built-in time marker and amplitude calibrator, 3-in. cathode ray tube with telescopic viewing hood. £39.00

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69D7	6/8	12AX4GT	18/8	30FL37	15/8	32A	8/8	CBL1	17/-	E186F	24/-	EOL111	8/8	EN56	8/8	K768	8/8
69E7	6/8	12AX4GT	18/8	30FL38	15/8	32A	8/8	CBL1	17/-	E186F	24/-	EOL112	8/8	EN57	8/8	K769	8/8
69F7	6/8	12AX4GT	18/8	30FL39	15/8	32A	8/8	CBL1									

APPOINTMENTS VACANT

DISPLAYED SITUATIONS VACANT AND WANTED: £7 per single col. inch.

LINE advertisements (run-on): 8/- per line (approx. 7 words), minimum two lines.

Where an advertisement includes a box number (count as 2 words) there is an additional charge of 5/-.

SERIES DISCOUNT: 15% is allowed on orders for twelve monthly insertions provided a contract is placed in advance.

BOX NUMBERS: Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.
No responsibility accepted for errors.

Advertisements accepted up to
THURSDAY, 12 p.m., 6th AUG.
for the **SEPTEMBER** issue,
subject to space being available.

BROADCAST RELAY ENGINEERS

are required for the
ISLAND OF MASIRAH
(Off the coast of Muscat and Oman)

Applications for contract employment for a one year unaccompanied tour of duty are invited from engineers with experience of the operation and maintenance of high power radio transmitters and who are of third year City and Guilds Telecommunications Technicians Certificate or equivalent standard.

Salary £4,000 per annum plus a tax free allowance of £350 per annum for single, or £865 for married unaccompanied officers.

Free furnished accommodation and passages are provided.

Further details and application forms can be obtained from:

**The Personnel Officer,
Diplomatic Wireless Service
Foreign & Commonwealth Office,
Hanslope Park,
Wolverton, BUCKS.**

535



TEST ENGINEER

Aveley Electric Ltd., who are one of the leading manufacturers and suppliers of language laboratories and educational aids, now offer, due to continued expansion, an opportunity for an experienced Test Engineer to join the educational aids division of this company. Applicants should be in the age range 20-35 and fully conversant with the techniques of test and quality assurance.

Apply:

**MANAGING DIRECTOR
AVELEY ELECTRIC LTD.
SOUTH OCKENDON, ESSEX
TEL. SOUTH OCKENDON 3444**

UNIVERSITY OF BRISTOL Audio-Visual Aids Unit

The Unit provides a central service in Film and Television and other new media production for the teaching service of the University. Facilities include 4 plumbicon cameras, television studio, Ampex 1" V.T.R.s, 16mm telerecording, 16mm and 35mm film shooting, editing, dubbing and telecine.

The two new posts in an expanding environment will provide experience over the whole spectrum of Broadcast Engineering.

SENIOR TECHNICIAN

Preferably with experience with a broadcasting authority. To undertake operation, maintenance and development of television equipment.

Salary: £1,248-£1,556, plus £30/80 for approved higher qualifications.

TECHNICIAN

Operation of videotape and sound recording equipment, issuing and checking equipment and film and tape. Day release for further relevant education will be considered.

Salary: £905-£1,273, plus £30/80 supplement for recognised qualifications.

Applications, including the names and addresses of two referees, to be sent to the undermentioned by 31st July, 1970.

Both posts become tenable on 1st August, 1970.

**A.P.W. Makepeace, Director,
Audio-Visual Aids Unit,
University of Bristol, 29 Park Row,
BRISTOL BS1 5LT.**

645

GEC-Marconi Electronics

TECHNICIANS AND ENGINEERS FOR ST. ALBANS AND LUTON QUALIFIED OR NOT!

VACANCIES exist for work on testing and calibrating valve and solid-state electronic measuring equipments embracing all frequencies up to u.h.f. in Production, Service and Calibration departments.

APPLICATIONS are invited from people of all ages with experience or formal training in electronics and from ex-Armed Services technicians.

HIGHLY COMPETITIVE SALARIES, negotiable and backed by valuable fringe benefits.

RE-LOCATION EXPENSES available in many instances. **CONDITIONS** excellent; free life assurance, pension schemes, canteen, social club.

37½-hour, 5-day, office-hours week.

WRITE or phone Personnel Department stating age, details of previous employment, training, qualifications, approximate salary required, quoting WW6



MARCONI INSTRUMENTS LIMITED,
Longacres, St. Albans, Herts.
Tel: St. Albans 59292
Luton Airport, Luton, Beds.
Tel: Luton 31441.

A GEC-Marconi Electronics Company



FLIGHT SIMULATOR SERVICE ENGINEERS

Redifon Flight Simulator Division are designers and manufacturers of highly sophisticated simulators of current civil and military aircraft and linked products for use in the U.K. and world wide export markets.

We need skilled Service Engineers to keep this complex and hard worked equipment in continuous first class condition.

You should have a minimum of O.N.C. or City and Guilds Certificate, theoretical and practical experience of digital computing, hardware, software and computer peripherals. Knowledge of analogue computing and hydraulics would be advantageous. We will train those who have good experience in transistorised and integrated circuits.

The job is varied and interesting and in an expanding business. Promotion prospects are good. But you must expect to travel anywhere in U.K. and overseas at short notice, perhaps for extended periods.

Excellent welfare benefits include contributory pension and free life assurance. Our Sussex factory is only 25 miles from Brighton.

Send brief details or ring now :
H. C. Hall, Personnel Manager,
REDIFON LIMITED
Flight Simulator Division
Gatwick Road, Crawley, Sussex
Tel: Crawley 28811



REDIFON

A Member Company of the Rediffusion Organisation



If you're a telecommunications man and match up to the qualifications below cut yourself into a slice of Britain's future



Become a

Radio Technician

in the fast-growing world of
Air Traffic Control

Please send me an application form and details of how I can join the fascinating world of Air Traffic Control Telecommunications.

Name

Address

Not applicable to residents outside the United Kingdom

wwt/£1

To: A J Edwards, C Eng, MIEE,
The Adelphi, Room 705, John Adam Street, London WC2
marking your envelope 'Recruitment'

Sending this coupon could be your first step to a job that's growing in importance every year.

The National Air Traffic Control Service needs Radio Technicians to install and maintain the vital electronic aids that help control Britain's ever-increasing air traffic.

This is the kind of work that requires not only highly specialised technical skills but also a well developed sense of responsibility, and candidates must be prepared to undergo a rigorous selection process. Those who succeed are assured a steadily developing career of unusual interest and challenge. Starting salary varies from £1044 (at 19) to £1373 (at 25 or over) : scale maximum £1590 (higher rates at Heathrow). There is a good annual leave allowance and a non-contributory pension for established staff.

You must be 19 or over, with at least one year's practical experience in telecommunications, ('ONC' or 'C and G' qualifications preferred).

NATCS

National Air Traffic Control Service

HIGHER TECHNICAL OFFICERS

SWAZILAND

- * Salary £1,450 – £2,277 according to experience
- * Low taxation
- * 25% gratuity
- * Contract 24-36 months
- * Subsidised accommodation
- * Education allowances

Required by the Department of Posts and Telecommunications to assist in the development and maintenance of the national trunk circuit network.

Candidates, 25-45, should preferably possess City and Guilds Certificates in Radio and Line Transmission and must have had at least five years experience in the installation of multi-channel carrier and voice frequency telegraph systems. A knowledge of VHF radio systems would be an added advantage.

Apply to CROWN AGENTS, 'M' Division, 4 Millbank, London, S.W.1, for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference number M2K/700375/WF

659

RANK WHARFEDALE LIMITED
require

tester/ troubleshooters

The Company, who are leading producers of quality Hi-Fi equipment, require suitably qualified staff for production line testing of transistorised electronic equipment.

Applicants should preferably possess either a formal qualification in radio servicing or testing, or have obtained equivalent experience in similar work.

Location—Bradford, Yorkshire.

The positions carry staff status, and good salaries will be paid to the successful candidates.

There is a contributory pension scheme and free life assurance benefit. Assistance with removal expenses will be paid if applicable.

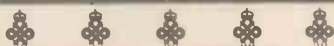
Applications to:

**The Personnel Manager,
Rank Wharfedale Limited,
Bradford Road,
Idle, Bradford BD10 8SQ,
Yorkshire.
Tel: Bradford 612552.**



**AUDIO
VISUAL
DIVISION**

The Rank Organisation
The man with the gong — a man of many skills



Laboratory Equipment ENGINEER

Rediffusion require a first class engineer. His job will be to administer and maintain a laboratory concerned with television distribution systems. This includes both laboratory and field test equipment. Qualifications required are either H.N.C. or equivalent C&G exams. He must be familiar with H.F. measuring techniques, oscilloscopes and sweep oscillators.

Salary up to £1,700 per annum, depending on age and experience. Three weeks' annual holiday after the completion of twelve months' service. Five day week, 9-5.30.

Applications in writing should be addressed to: D. E. Street, Head of Operational Services Dept., Rediffusion Engineering Ltd., 187 Coombe Lane West, Kingston-on-Thames, Surrey.



REDIFFUSION

632

Worthwhile Vacancies



There are vacancies for Electro-Mechanical and Electronic Equipment Servicing Technicians in West London.

The duties are for corrective and preventive maintenance of remote control equipment in substations and generating stations. The work includes on-site testing of equipment involving Post Office type relays, uniselectors and solid state switching logic. Also workshop testing, adjustments and repair of relays and electronic equipment associated with remote control equipment.

Salary £1,523 10s. 0d. Valuable free travel facilities, sick pay and superannuation.

Suitably qualified applicants should apply to

The Superintendent of Recruitment,
London Transport, 280 Old Marylebone Road,
London N.W. 1.

stating qualifications and experience.

640

RADIO OPERATORS

There will be a number of vacancies in the Composite Signals Organisation for experienced Radio Operators in 1971 and in subsequent years.

Specialist training courses lasting approximately nine months, according to the trainee's progress, are held at intervals. Applications are now invited for the course starting in January, 1971.

During training a salary will be paid on the following scale:

Age 21	£848 per annum
" 22	£906 "
" 23	£943 "
" 24	£981 "
" 25 and over	£1,023 "

Free accommodation will be provided at the Training School.

After successful completion of the course, operators will be paid on the Grade 1 scale:

Age 21	£1,023 per annum
" 22	£1,087 "
" 23	£1,150 "
" 24	£1,214 "
" 25 (highest age point)	£1,288 "

then by six annual increases to a maximum of £1,749 per annum.

Excellent conditions and good prospects of promotion. Opportunities for service abroad.

Applicants must normally be under 35 years of age at start of training course and must have at least two years' operating experience. Preference given to those who also have GCE or PMG qualifications.

Interviews will be arranged throughout 1970.

Application forms and further particulars from: Recruitment Officer, Government Communications Headquarters, Oakley, Priors Road, CHELTENHAM, Glos., GL52 5AJ Telephone No. Cheltenham 21491, Ext. 2270

92



ELECTRONIC TEST ENGINEER

Vacancies currently exist for engineers with experience of production test work who have a technical background equivalent to that of Inter City & Guilds (Telecoms) or radio and television servicing.

Interesting and varied work on U.H.F. V.H.F. and audio projects. Staff appointment. Free transport from approximately 13 mile radius.

Apply: Personnel Officer,

AIRTECH LIMITED,

HADDENHAM, Nr. AYLESBURY, BUCKS. Tel: Haddenham 422

674

RADIOLOGICAL PROTECTION SERVICE

(Department of Health and Social Security and Medical Research Council)
Clifton Avenue, Belmont, Sutton, Surrey

Junior Technical Officers/ Technical Officers

required for work in the design and development of instruments and systems concerned with radiation measurements. Experience on systems, digital and pulse techniques desirable.

Qualifications: HNC or equivalent.

**Salary range: J.T.O. £669-1418 plus London Weighting
T.O. £1499-2192 plus London Weighting**

(If this post is filled by a J.T.O. there are excellent prospects for eventual promotion to the T.O. grade.)

Applications with the names and addresses of two referees to the Administrative Officer at the above address, quoting reference 70/2/16. Closing date: August 7th.

629

UNIVERSITY COLLEGE CARDIFF Departments of Physics and Music TECHNICIAN

Applications are invited for a post of technician to assist with the inter-disciplinary Music/Physics project. The technician will be based in the Physics Department and most of his time will be spent in building and maintaining an electronic music studio. A basic practical knowledge of electronics is required and an interest in one or more of the following would be an advantage:

- Contemporary music,
- Computer sound synthesis and control,
- Sound recording and reproduction.

Salary will be within the scale £905-£1273 and the starting point will depend on qualifications, experience and age and additional allowances are payable for approved qualifications.

Applicants who should be over 21 should write to the Registrar, University College, P.O. Box 78, Cardiff, not later than the 31st August, and quoting Reference No. REG. 8251, giving (1) age (2) full details of any qualifications (3) full details of previous experience (4) the names and addresses of two persons (one of whom should have first-hand knowledge of work or training) to whom reference may be made.

633

RADIO ENGINEERS

CIVIL AVIATION-ZAMBIA

- * Salary £2310 to £2590 according to experience.
- * Low Taxation.
- * Contract of 36 months.
- * 25% Tax-free Gratuity.
- * Educational Allowances.
- * Subsidised Housing

Duties will involve the maintenance, overhaul and installation of ground terminal radio communication equipment and navigational aid at Airports and Flight Information Centres.

The equipment includes radar systems, H.F. and V.H.F. transmitters and receivers, I.L.S. and D.F. systems and tape recorders. Candidates, who should be under 55 years of age, should have practical experience and a knowledge of theoretical principles within this field.

In addition they should have attained one of the following:—

- i) completion of a 5 year apprenticeship,
- ii) a service trade certificate,
- iii) an I.C.A.O. certificate,
- or iv) equivalent

Apply to CROWN AGENTS, 'M' Division, 4, Millbank, London, S.W.1., for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference No. M2Z/690315/wf

664

Work as a RADIO TECHNICIAN attached to Scotland Yard

You'd be based at one of the Metropolitan Police Wireless Stations. Your job would be to maintain the portable VHF 2-way radios, tape recorders, radio transmitters and other electronic equipment, which the Metropolitan Police must use to do their work efficiently.

We require a technical qualification such as the City & Guilds Intermediate (telecommunications) or equivalent.

Salary scale: £1,161 (age 21), rising by increases to £1,590 plus a London Weighting Allowance. Promotion to Telecommunication Technical Officer will bring you more.

For full details of this worthwhile and unusual job, write to: Metropolitan Police, Room 733 (RT), New Scotland Yard, Broadway, London, S.W.1.

656

Network ENGINEER

Barbados Rediffusion Services Limited, require the services of a Network Engineer to be responsible to their Chief Engineer for the construction and maintenance of a relay sound programme distribution system and the supervision of maintenance staff.

Applications for the position are invited from Barbadian Nationals who are in possession of the City and Guilds Technicians Certificate (Intermediate), or its equivalent, and who have at least five years experience of line transmission.

The salary will be commensurate with qualifications and experience.

Applications in writing stating age, experience and present salary should be addressed to:— D. E. Street Esq., Head of Operational Services Department, Rediffusion Engineering Limited, 187, Coombe Lane West, Kingston-upon-Thames, Surrey.

REDIFFUSION

648

SIGNALS ENGINEERING LABORATORY
Ministry of Defence (Air)
RAF Northolt

ELECTRONIC ENGINEERS

(Graded Experimental Officer/Assistant Experimental Officer) to undertake circuit design, laboratory measurements and field investigations concerning either:

- (a) Radar and Navigation Aids, Air Traffic Control and Blind Landing Systems; or
- (b) Telecommunications, Navigation Aids, Telemetry and Data Processing Systems.

Some short term duty at RAF Stations, both in this country and overseas, will be involved. An ability to establish and maintain good relations with Service personnel at all levels is necessary.

Qualifications: Degree, HNC or equivalent in an appropriate subject. In addition it is essential that candidates for post (a) have experience of microwave measurements and pulse techniques, and for post (b) a knowledge of digital techniques and experience of HF, VHF, UHF and line communications. Familiarity with integrated circuit techniques is desirable.

Candidates must be natural born British subjects.

Age: normally 26-30 AEO under 28.

Salary: (Outer London EO £1800-£2252; AEO £1095 (at 22)—£1386 (at 26 or over)—£1653.

Prospects of permanent pensionable appointments. Prospects of promotion to Senior Experimental Officer (salary rising to £3174).

APPLICATION FORMS from Head of Signals Engineering Laboratory, RAF Northolt, Ruislip, Middlesex.

Closing date 11th August 1970.

660

SENIOR TEST ENGINEERS

The leading U.K. Manufacturers of high grade T.V. monitors and ancillary T.V. studio equipment require a Senior Test Engineer for their rapidly expanding test department. Situated in the Berkshire town of MAIDENHEAD the company offers pleasant working conditions, good salaries, and a friendly environment.

Duties will cover the testing and troubleshooting of our complete range of equipment. Previous experience on television equipment is not essential but candidates must have a thorough knowledge of electronics and testing procedures.

Reply to:

PROWEST ELECTRONICS LTD.,

Boyn Valley Road, Maidenhead, Berks.

Telephone: Maidenhead 29612

684

BOARD OF TRADE

VACANCY FOR AN UNESTABLISHED INFORMATION OFFICER (TECHNICAL) IN THE COMMONWEALTH AIR TRANSPORT COUNCIL SECRETARIAT

The Commonwealth Air Transport Council normally meets every three years. Apart from the duties associated with the conduct of these major conferences the Secretariat provides a comprehensive information service for Commonwealth Governments and serves as a medium for exchange of information of general interest on any aspect of air transport or civil aviation. In particular the main functions of the Information Officer, between Council meetings, consist of writing the CATC Newsletter (an illustrated magazine on Civil Aviation topics, of approximately 35 pages) published quarterly. The work also involves obtaining suitable material and illustrations from Commonwealth Civil Aviation Departments, airlines, industry, exhibitions etc.; preparation of MSS and illustrations for printers and block makers and other detailed production work.

He will also assist in the preparation of CATC Electronic News which is published quarterly, particularly in the writing of the sections on new equipment, responsibility for the art work and a contribution of some ten per cent of the technical articles.

In addition the Information Officer will be responsible for the preparation of the Abstracts of Technical Publications which are published quarterly and involves obtaining reports, papers and journals for preparation and classification of abstract material by sub-editing of author's abstracts and occasionally writing original abstracts. He will also assist in publishing quarterly a Bibliography of Radio Technical Reports involving extraction of details from existing sources and obtaining additional ones.

Opportunity will be offered to the successful candidate to become an established officer at a later date.

Inner London salary scale according to age and experience is £2,107 rising by five annual increments to £2,517 per annum.

Applications forms can be obtained from the Board of Trade (Mr. J. P. Collins), Establishment Division, Room 137, 1 Victoria Street, London SW1 (tel: 01-222 7877, extension 3388) and returned to that address after completion quoting reference E 27206/G. Only persons selected for interview will be advised of the result.

646

UNIVERSITY of SURREY DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING Senior Technician for Electronic Servicing

A Senior Technician is required in the Department of Electronic and Electrical Engineering to service a range of electronic equipment and to build specialised electronic research apparatus. Applicants should have had sufficient experience in the electronics field to enable them to work with the minimum of supervision.

The successful applicant will be entitled to 3 weeks annual holiday (rising to 4 weeks after 5 years service) plus generous leave at Christmas and Easter. Every encouragement is given to further study and day release courses are available. The post is superannuated.

Salary scale £1,278-£1,586 per annum plus £50 Qualification Allowance.

Applications should be sent to:

The Staff Officer, University of Surrey,
Guildford, Surrey.

687

STIRLING & CLACKMANNAN POLICE FORCE

Application is invited for the post of wireless technician in the wireless workshops at Police Headquarters, Randolphfield, Stirling, to work on maintenance, installation of VHF/UHF fixed and mobile radio telephones, and other electronic equipment. Applicants should have completed a recognised apprenticeship and have some recent experience in radio telephone maintenance. Formal qualifications an advantage.

Salary scale will be N.J.I.C. Technical Grade IV -£1,130 per annum, rising by annual increments £1,300 (12½% increase pending). N.J.I.C. conditions of service will apply.

Applications detailing experience and qualifications, together with copies of recent references, should be lodged with the Chief Constable, Police Headquarters, Randolphfield, Stirling, not later than 3rd August, 1970.

671

VHF/UHF DESIGN AND DEVELOPMENT ENGINEERS

Vacancies exist for Senior and Junior Development Engineers.

Applicants should have suitable qualifications, and experience in the field of solid state VHF TX and RX for use in Marine and/or Land Based Equipments.

Successful applicants will be offered an excellent salary, holiday and pension. Pleasant location on the South Coast.

Apply in writing to

Chief Engineer
DERRITRON ELECTRONICS LIMITED
Sedlescombe Road North
Hastings, Sussex

668

CONTINUOUS EXPANSION

Standard Telephones & Cables, Microwave and Line Division based at Basildon are growing fast. In order to keep pace with this consistent growth rate we require the following

Installation Engineers Technicians & Testers

Ref. 25720

To test and commission Multiplex, Co-axial Line and Microwave Radio Systems.

Ideal candidates will be less than 45 years of age with practical experience on some of the above equipment. These challenging posts call for drive, initiative and common sense. It is necessary for applicants to be prepared to work anywhere in the U.K.

*Applications should be addressed to
The Personnel Officer,
STC Chester Hall Lane,
Basildon, Essex.*



Test Technicians

Ref. 27221

The diversity of products manufactured at the Basildon Plant demands experienced testing staff for work on complex transmission systems.

Candidates should hold an ONC in electrical engineering and be able to offer considerable practical experience in the field of testing and fault clearing all types of land-unit, pcm and microwave equipment.

STC

91

computer engineering

NCR requires additional ELECTRONIC, ELECTRO MECHANICAL ENGINEERS and TECHNICIANS to maintain medium to large scale digital computing systems in London and provincial towns.

Training courses will be arranged for successful applicants, 21 years of age and over, who have a good technical background to ONC/HNC level, City and Guilds or radio/radar experience in the Forces.

Starting salary will be in the range of £900/£1,350 per annum, plus bonus. Shift allowances are payable, after training, where applicable. Opportunities also exist for Trainees, not less than 19 years of age, with a good standard of education, an aptitude towards and an interest in, mechanics, electronics and computers.

*Excellent holiday, pension and sick pay arrangements. Please write for Application Form to Assistant Personnel Officer
NCR, 1,000 North Circular Road,
London, NW2
quoting publication and month of issue.*

Plan your future with

NCR

85

Senior Equipment ENGINEER

Rediffusion (Nigeria) Limited require the services of a Senior Equipment Engineer to be responsible to the Chief Engineer for the maintenance of equipment including high power amplifiers and F.M. and A.M. transmitters. A knowledge of Television receivers would be an asset.

Applicants who must hold a Final City and Guilds Technicians Certificate must be prepared to work a minimum contract of 18 months.

A car will be provided. A starting salary of not less than £N1,000 will be paid depending on age and experience.

All transportation costs of applicant's immediate family to Nigeria will be paid by the company.

Applications in writing stating age, experience and present salary should be addressed to: D. E. Street, Esq., Head of Operational Services Department, Rediffusion Engineering Limited, 187, Coombe Lane West, Kingston-upon-Thames, Surrey.

REDIFFUSION

649

REDIFFUSION

COLOUR TELEVISION FAULTFINDERS & TESTERS

We have a number of vacancies in our Production Test Departments for experienced faultfinders and testers.

Knowledge of transistor circuitry and experience with Colour Receivers together with R.T.E.B. Final Certificate or equivalent qualifications required.

These will be staff appointments with all the expected benefits.

Applications to:

**Works Manager,
Rediffusion Vision Service Ltd.,
Fullers Way South,
Chessington, Surrey (near Ace of Spades).
Phone: 01-397 5411**

93

West Sussex County Council INDUSTRIAL TRAINING CENTRE, CRAWLEY

Applications are invited for a **TRAINING INSTRUCTOR** qualified to instruct Electrical Craft and Technician Engineer apprentices during first two years of apprenticeship. Good qualifications and experience in electronics are essential.

Salary scale £1,362; £902—£2,052.

Further particulars and application form from Head of Centre, Industrial Training Centre, College Road, Crawley. Completed form to that address within 14 days of the appearance of this advertisement.

657

TELECOMMUNICATIONS ENGINEERS WEST AFRICA

Qualified Telecommunications Engineers are required for servicing and maintenance of radiotelephone equipment and associated items in tropical West Africa.

Qualifications: HNC or higher.

Contract: One year plus leave extensible.

Salary: According to age, experience and qualifications. Commencing at not less than equivalent £2000 sterling. Free accommodation and passages. Preference for bachelors with tropical experience but not essential.

Interested? Apply for application form to:

C.O.D.E.C.O.
2b - Sussex Road - New Malden - Surrey
635

Ministry of Defence (Air Force Department) require **CIVILIAN INSTRUCTORS (male)** in the following trades and at the Units stated:—

RADAR	RAF Newton, Nottingham RAF Sealand, Flintshire
COMMUNICATIONS	RAF Watton, Thetford, Norfolk
BOTH TRADES	RAF Cosford, Wolverhampton RAF Locking, Somerset

Candidates must be **BRITISH SUBJECTS**. Training in the appropriate subject, practical experience and ability to teach essential. Salary £1,061 rising to £1,634. Five-day week and 3 weeks and 3 days annual leave. Appointments unestablished but prospects of becoming pensionable. Write (preferably on postcard) for application forms to **Ministry of Defence CE3g(Air), London, W.C.1**, quoting (Civ Inst RC/B) and stating which trade. Completed application forms must be returned by 15 August, 1970.

681

TEST ENGINEERS

EKCO AVIONICS (A Division of Pye Telecommunications Ltd.) urgently require a number of Test Engineers for their expanding production lines.

They will be employed on the test and diagnosis of VHF equipment and a City and Guilds Radio and TV Servicing or Intermediate Telecommunications Certificate qualification would be preferred.

Salary commensurate with experience and qualifications. Excellent working conditions in very pleasant surroundings. Good fringe benefits and opportunities for promotion.

Write, Phone or Call: The Personnel Manager

EKCO AVIONICS

Prory Crescent, Southend-on-Sea. S52 6PW.

Tel: Southend-on-Sea 49491

638

University of Birmingham

Applications are invited for the post in biomedical electronics in the Department of Anatomy. The work involves the design of specialized instrumentation under the direction of experienced engineers, and will provide opportunities for gaining experience of a variety of modern electronic techniques. Candidates should be of approximately H.N.C. Standard with experience of transistor circuit design. Salary up to £1,586. Ref.: 401/5/418.

Apply: Assistant Secretary (Personnel), Personnel Office, University of Birmingham, P.O. Box 263, Birmingham, 15.

619

SENIOR TECHNICIAN (GRADE III)

with electrical and preferably some mechanical experience to maintain Cobalt and Caesium and Therapeutic X-ray equipment at the Royal Marsden Hospital, Fulham Road, London, S.W.3. The successful candidate will also have the opportunity to develop new equipment.

Minimum qualifications, O.N.C. in Electrical Engineering. Salary scale £1270-£1590 per annum.

Applications with details of experience and names of two referees to the Deputy Administrator, The Royal Marsden Hospital, Downs Road, Sutton, Surrey. Further details may be obtained from Mr. E. Hawkins, Chief Technician, telephone 01-642 6011, Ext. 278.

567

UNIVERSITY OF STIRLING Department of Psychology TECHNICIAN/SENIOR TECHNICIAN

Applicants should have completed a recognised apprenticeship, or other appropriate training, and have interests in A.F. techniques and instrumentation, including use of digital and linear integrated circuits. Formal qualifications an advantage, day release facilities if required. Salary: Technician £935-£1,303; Senior Technician £1,278-£1,586. Applications, with names of two referees, should be received by the Deputy Secretary (VW), University of Stirling, Stirling, by 10 August, 1970.

600

Electronics Maintenance Engineers

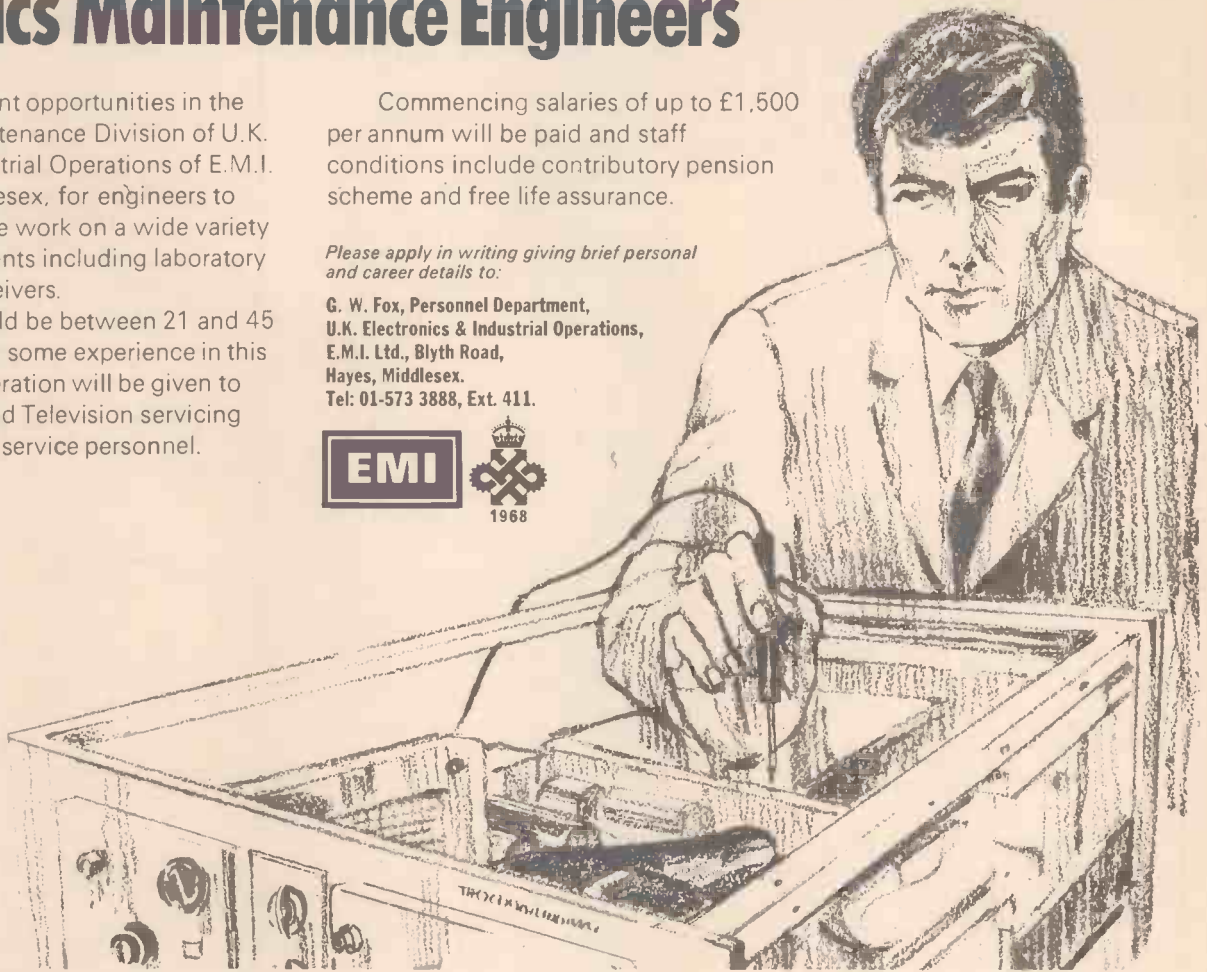
There are excellent opportunities in the Installation and Maintenance Division of U.K. Electronics and Industrial Operations of E.M.I. Ltd., at Hayes, Middlesex, for engineers to carry out maintenance work on a wide variety of electronic equipments including laboratory test gear and trans-mitters.

Candidates should be between 21 and 45 years of age and have some experience in this type of work. Consideration will be given to experienced Radio and Television servicing technicians and to ex service personnel.

Commencing salaries of up to £1,500 per annum will be paid and staff conditions include contributory pension scheme and free life assurance.

Please apply in writing giving brief personal and career details to:

G. W. Fox, Personnel Department,
U.K. Electronics & Industrial Operations,
E.M.I. Ltd., Blyth Road,
Hayes, Middlesex.
Tel: 01-573 3888, Ext. 411.



576

The University of Manchester Institute of Science and Technology SPECIAL RESEARCH ASSISTANT Department of Mechanical Engineering

The above vacant post is in the Thermodynamics and Fluid Mechanics Division of the Department and should appeal to the Mechanical Engineer or Physicist. The research programme is financed by an S.R.C. award for a minimum period of at least two years.

The successful applicant, who should hold an Honours degree and preferably have some previous experience in a related subject, will work on problems associated with research into heat transfer and heat release in internal combustion engines. Beside actual participation, the successful candidate should also have the necessary initiative and ability to co-ordinate and control the research programme.

Salary, in the range £1,500-£1,800 per annum, will be determined according to qualifications and experience.

Requests for application forms, quoting Reference Number ME/165/AG should be made to the Registrar, U.M.I.S.T., Sackville St., Manchester, M60 1QD. Closing date for return, 31st August, 1970.

652

ELECTRONIC TEST ENGINEERS

Required for work on Digital Measuring Equipment using Silicon Transistors and Microcircuits. Fully qualified applicants preferred, although proven experience in electronics would be considered. Prospects for advancement are good. Weekly staff status and salary commensurate with qualifications and experience. We would welcome applications from ex-service personnel or personnel about to leave the services. Please apply to: The Personnel Manager

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NEW MALDEN • SURREY • TEL: 01-942 2442

618

UNDERWATER AND COMMUNICATIONS DIVISION

Electronic Instrumentation Technicians

Vacancies exist in our Ilford Test Engineering Department for Electronic Technicians experienced in the use of electronic measuring instruments. The work involves simple design, construction and test of measuring equipment associated with advanced communication systems. There are opportunities for advancement for applicants with C. & G., O.N.C. or H.N.C. On the job training can be given to selected applicants. Realistic salaries will be negotiated and there are attractive staff benefits.

Apply giving brief details of experience and quoting Ref. ILF/63/E. to:—The Manpower Resources Manager, The Plessey Company Limited, Vicarage Lane, Ilford, Essex.

PLESSEY



663

DIPLOMATIC WIRELESS SERVICE requires TELECOMMUNICATIONS TECHNICIANS

Vacancies exist in LONDON and the HOME COUNTIES for men with experience in the following fields:—

- (a) Radio Communications transmitters and receivers.
- (b) High power radio broadcast relay transmitters and associated equipment.
- (c) A variety of telephone and teleprinter systems and associated electro-mechanical and electronic equipment.

Qualifications Required: City and Guilds Intermediate Telecommunications Technician Certificate or an equivalent or higher technical qualification.

Salary: £1,498 (at age 25) to £1,715 per annum in London. £1,373 to £1,590 per annum in Home Counties. Plus additional allowances for shift duties.

Prospects: of promotion and permanent pensionable employment.

The appointments carry a liability for overseas service.

Candidates and both parents must have been British subjects at all times since birth. Applications, giving details of qualifications and experience to:—

**The Personnel Officer,
Diplomatic Wireless Service,
Hanslope Park, Wolverton, BUCKS.**

631

AIR FORCE DEPARTMENT RADIO TECHNICIANS

Starting pay according to age, up to £1,373 p.a. (at age 25) rising to £1,590 p.a. with prospects of promotion.

**Vacancies at RAF Sealand, Near Chester
and RAF Henlow, Bedfordshire**

Interesting and vital work on RAF radar and radio equipment.

Minimum qualification, 3 years' training and practical experience in electronics.

5-day week—good holidays—help with further studies—opportunities for pensionable employment.

Write for further details to:—

**Ministry of Defence, CE3h(Air),
Sentinel House,
Southampton Row,
London, W.C.1.**

Applicants must be UK residents.

625

Electro-Medical Work

Young man required for interesting work in the medical field in connection with electrical recording of eye movements. Knowledge of electronics an advantage. Starting salary £990 per annum with annual increments to £1,250.

Please apply in writing to:

**Geoffrey A. Robinson, Secretary to the Board of Governors,
The National Hospital, Queen Square, W.C.1.**

680

WE KNOW YOU WANT A BETTER JOB

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WE WILL HELP YOU FIND IT.



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and we will help you.

Our placement service is professional, specialised and completely confidential. We are in consultation with over 800 companies on all aspects of electronics engineering. Phone or write at any time quoting WW101.

554

TECHNICAL OFFICER

required for the Electronics Department. Duties include design and construction of nucleonic equipment.

Qualifications, Degree, HND or HNC. Experience in the field of medical electronics desirable. Salary according to age and experience in the range of £879-£2192 plus London Weighting.

Please send applications to

**The Director, Medical Research
Council Neuropsychiatry Unit
Woodmansterne Road, Carshalton,
Surrey.** Please quote reference 262/4. 643

SITUATIONS VACANT

A FULL-TIME technical experienced salesman required for retail sales; write giving details of age, previous experience, salary required to—The Manager, Henry's Radio, Ltd., 303 Edgware Rd., London, W.2. [67]

ARE YOU INTERESTED IN HI FI? If so, and you have come experience of selling in the Retail Radio Trade, an excellent opportunity awaits you at Telesonic Ltd., 92 Tottenham Court Road, London, W.1. Tel. 01-387 7467/8. [21]

A SENIOR Transformer/Rectifier design Engineer is required for varied and interesting projects associated with equipment up to 150/kVA/KW. We are an expanding Company of Manufacturing Electrical Engineers located in South Herts. Box W.W. 97 Wireless World.

ASSISTANT LECTURER IN MARINE RADIO required by COLLEGE OF I.M.R. COMMNS., Brooks' Bar, MANCHESTER M16 TWT for Sept. 1970 or soonest thereafter. P.M.G. or M.P.T. Certificate and up-to-date knowledge of technical syllabus for same essential. B.O.T. Radar Cert. and Teaching experience an advantage. Placing on Burnham Scale £1,030-£1,720 per annum depends on qualifications, etc. Write Principal, giving in confidence full details of experience, education, present salary, etc. [678]

A YOUNG qualified electronic engineer required by a rapidly expanding company producing temperature control equipment to head up their servicing department in the London Area. Box No. 654

CIRCUIT details, service sheet, or manual wanted for the Elsec or Decco pulse induction metal detector. Types 684B and 693A. Box W.W. 677, Wireless World.

DEPARTMENT of Nuclear Physics, University of Oxford, has a vacancy at Technician or Senior Technician level for a steward to take charge of the day-to-day running of an undergraduate teaching laboratory. Background experience in electronics is needed, and a qualification in Physics or Electronics or Electrical Engineering would be an advantage. The successful candidate will be expected to learn to run a 1 MeV Van de Graaff generator. Salary within the range £797-£1,592 p.a. Day release may be available. Approximately six weeks' paid leave per year. Write as fully as possible to T. L. Green, Nuclear Physics Laboratory, Keble Road, Oxford, mentioning reference A131. [617]

DEPARTMENT OF NUCLEAR PHYSICS, University of Oxford, has a vacancy for a technician to work with a group engaged on development and maintenance of a dual computer system. Duties of the post are: (a) to assist with the development of circuits and systems for the computer, (b) to assist with the maintenance of an efficient service to the computer user. Experience of electronic or telephone exchange equipment would be an advantage. It is expected that the candidate would be working towards the HNC and day release is available. The appointment would be at either technician (£797-£1,310) or senior technician (£1,185-£1,592) level depending on age, qualifications and experience. Write to T. L. Green, Nuclear Physics Laboratory, Keble Road, Oxford, mentioning reference A132. [661]

ELECTRONICS ENGINEER, H.N.C. or equivalent, entirely self-reliant, to start from cold on the engineering (from existing bread-board diagrams) and few off assembly of miniaturised equipment; followed by a continuous increase in series of varied practical answers to fresh problems as they arise. Experience needed of development and assembly in radio or allied fields. Able to contribute to further developments in conjunction with user branch. Access available to latest components information. Attractive prospects with building up of really interesting specialist industry. £1,735-£2,394 according to age and ability with annual reviews and up to five weeks leave. Please write fully: H. R. Thomas, Level Developments, 7 and 10 Hildreth Mews, London, S.W.12. [690]

ELECTRONICS TECHNICIAN and JUNIOR TECHNICIAN (16-20) required for Psychology Department to assist in development, construction and maintenance of electronic equipment for use in teaching and research laboratories. Little routine work; good opportunities to exercise initiative; excellent holidays. Salary scales: Technician: £1,060-£1,480 + supplementary allowance for approved higher qualifications. Junior Technician: £581-£869 (with paid day release for further study). Apply, stating age, qualifications, experience and present salary, to Administrative Assistant (PI), Birkbeck College, Malet Street, London, WC1E 7HX. [630]

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B.Sc. General (Hons.)—
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Botany, Zoology, Statistics.

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(including Electronics).

These courses are suitable for
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cultural resort.

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Buckinghamshire Education Committee

SLOUGH COLLEGE OF TECHNOLOGY

Principal: W. Bosley, M.Sc., Ph.D., F.Inst.P.

DEPARTMENT OF ENGINEERING

LECTURER GRADE I IN ELECTRONIC ENGINEERING (EN/2/70)

To teach electronic subjects in Electrical Technicians and Radio, TV & Electronic Servicing Courses. Applicants should possess the H.N.C. or a suitable C. & G. Full Technological Certificate and must have recent TV development or servicing experience. Teaching experience desirable but not essential.

Salary on Burnham Technical Scale, viz.
Lecturer I £1,230-£2,075 plus additions for qualifications and training.

Removal expenses up to £100 may be paid in approved cases.

Further particulars and application forms (please quote reference number) can be obtained from the Vice-Principal, Slough College of Technology, William Street, Slough, Bucks, to whom completed forms should be returned within 14 days of the appearance of the advertisement.

624

Senior Electronics Engineer



Speytec, the expanding division of Burroughs Machines, require a Senior Electronics Engineer.

The Engineer we are looking for will be self propelled with at least three years' experience with a development team and holding a Degree, HND, or HNC with endorsements—probably in the age range 25-35. But the man is more important than the qualifications and the right mixture of practical and theoretical experience will influence us further. The work will cover a variety of fields involving linear integrated circuits and logic. We would be particularly interested in someone with experience in digital magnetics. In the future, the Engineer can expect to be involved in development work utilising large-scale integration in the computer field.

We can offer good prospects to those who join us now. What can you offer us?

Linda Scales, Speytec Ltd., Dept. WW/AUG.
512 Purley Way, Croydon, Surrey.
Telephone: 01-686 6431

Burroughs

Speytec Division

650

Contact Development

Plessey Telecommunications Ltd., located at Beeston, near Nottingham, have established the largest production capacity in Europe for the automated production of Reed Contacts for Telecommunications. A vacancy exists for a suitably qualified and/or experienced man to join a team working on Reed Contact Development.

We would expect a suitable applicant to be qualified to M.Sc. level or at least to B.Sc. level, plus a few years' relevant experience. He would be concerned with all aspects of development from initial concepts to advising on production techniques.

The successful candidate will be offered assistance in relocating his home.

Applications in writing stating age, qualifications and experience should be sent to D. R. Hilton, Senior Employment Officer, The Plessey Company Limited, Beeston, Nottingham.

PLESSEY



658

ELECTRONIC ENGINEERS

Service Engineers required for Offices, throughout the United Kingdom, of well-known Company manufacturing Electronic Desk Calculating Machines. Applicants should possess a sound knowledge of basic Electronics with experience in Electronics, Radar, Radio and T.V. or similar field. Position is permanent and pensionable. Comprehensive training on full pay will be given to successful applicants. Please send full details of experience to the Service Manager, Sumlock Comptometer Ltd., 102/103 Clerkenwell Road, London, E.C.1. 82

BRISTOL POLYTECHNIC

SENIOR TECHNICIAN

required in the Department of Navigation, Marine Radio & Radar, duties to commence 1 September, 1970. Applicants should be over 21 and hold Intermediate City and Guilds in Electronics or Radio Communications, or other appropriate qualifications. Duties include servicing and maintenance of electronic and electrical equipment as used in Merchant Ships and Civil Aircraft. 38-hour, 5-day week with generous holiday and sick pay schemes. Permanent post with superannuation under Local Government conditions of service. Salary Scale Senior Technician—£965-£1,130 (under review). Starting salary dependent upon age, qualifications and experience. An additional £50 or £30 will be paid to an applicant with appropriate National Certificate or C. & G. qualifications. Further particulars and application forms (to be returned within fourteen days of this advertisement) from Chief Administrative Officer, Bristol Polytechnic, Ashley Down, Bristol BS7 9BU. Please quote post reference number T66/82/2 in all communications. 627

Poole General Hospital Poole, Dorset

Applications are invited from qualified candidates for the following post in the Electronics Department at Poole General Hospital:

ELECTRONICS TECHNICIAN III

Qualifications: O.N.C., H.N.C., City & Guilds or equivalent
Salary: £1,180 x 8 increments to £1,500 p.a.
The Department will be primarily concerned with the Installation, testing and maintenance of an extensive range of diagnostic/therapeutic and allied electronic equipment, and ultimately with research and development of bio-medical equipment in consultation with medical staff. The position offers adequate scope for initiative and career progression, including the possibility of assistance with further training. Applications, giving full details, including qualifications, experience, and the names and addresses of two referees to the Hospital Secretary, POOLE GENERAL HOSPITAL, Poole. 623

Buckinghamshire County Council SLOUGH COLLEGE OF TECHNOLOGY CLOSED CIRCUIT TELEVISION

Applicants are sought for the operation and maintenance of equipment in the College television studio. Experience in television systems servicing is essential and an ability in graphical art would be an advantage. Basic 5-day week with adjustment for some evening and/or weekend work. Salary on scale £965-£1,130 (subject to revision).

Application forms and further details from the Vice Principal, Slough College of Technology, William Street, Slough, Bucks. 622

IMMEDIATE REQUIREMENT

for junior television engineer or television technician with test room or development experience in 625 line equipment. Telecine experience desirable. HNC or equivalent desired. Challenging new field with opportunities for foreign travel. Prestige offices in Central London. Pension Fund. Salary dependent on qualifications—£1,950 minimum. Please apply in writing to: The Technical Director, The EVR Partnership, Vogue House, 1 Hanover Square, London, W1R, 0JH. 620

UNIVERSITY OF STIRLING Department of Psychology TECHNICIAN/SENIOR TECHNICIAN

Applicants should have completed a recognised apprenticeship, or other appropriate training, and have interests in A.F. techniques and instrumentation, including use of digital and linear integrated facilities if required.

Salary: Technician £935-£1,303;
Senior Technician £1,278-£1,586.
Applications, with names of two referees should be received by the Deputy Secretary (W.W.), University of Stirling, Stirling, by 10 August, 1970. 621

University of Cambridge SCOTT POLAR RESEARCH INSTITUTE

There is a vacancy for a technical assistant to work on electronic instrumentation and to assist with field work in the Antarctic on tours of about four months duration. Salary on University Assistant scale, recently increased 21%. ONC would be suitable qualification. Apply in writing to, Director, Scott Polar Research Institute, Cambridge, stating date of birth, qualifications and experience. 642

INSTALLATION ENGINEER required for the servicing, testing and installation of audio, projection and lighting control equipment. An excellent opportunity for applicant with initiative and a sound knowledge of basic electronics. Starting salary £1,250. The post offers opportunities for travel in England and overseas. Apply to: The Personnel Director, Electrosonic Limited, 47 Old Woolwich Road, Greenwich, S.E.10. [683]

PROTOTYPE electronics wiremen required for a small but rapidly expanding company manufacturing "one off" systems to customers' specifications. The work covers the field of Analogue, Digital and Industrial electronics. Five years' experience on prototype wiring, including making the ancillary hardware, to sketches, is required. Ability to teach trainees would be useful. Salary up to £1,500 depending on experience. Applications in writing to: Parametric Ltd., Highfield Works, Canal Street, Runcorn, Cheshire. [669]

REDIFON LTD. require fully experienced TELECOMMUNICATIONS TEST ENGINEERS and ELECTRONICS INSPECTORS. Good commencing salaries. We would particularly welcome enquiries from ex-Service personnel or personnel about to leave the Services. Please write giving full details to—The Personnel Manager, Redifon Ltd., Broomhill Road, Wandsworth, S.W.18. [26]

SENIOR TECHNICIAN (Instrument/Electronics) required to assist in the running of a well-equipped electrical workshop. Duties include servicing and construction of modern electronic equipment. Knowledge of workshop and circuit wiring essential and candidate must have initiative and be able to work without supervision. HNC or equivalent qualification necessary. Salary in the range £1,403-£1,761 per annum according to age, qualifications and experience. Apply in writing to the Departmental Superintendent, Department of Chemistry, Imperial College, South Kensington, London, S.W.7. [644]

SENIOR technician/Technician required to work in a well-equipped modern workshop, designing, constructing and maintaining a wide variety of laboratory apparatus. Although primarily the work will concern electrical and electronic equipment, some experience in general workshop practice would be an advantage. Salary according to age, qualifications and experience in the Whitley Council scales for Medical Laboratory Technicians (Senior technician £1,448-£1,841, Technician £1,219-£1,533). Apply Secretary, Institute of Psychiatry, De Crespigny Park, London, S.E.5. (Ref. CR). [634]

TRANSFORMER DESIGNER urgently required for an expanding company. This is a progressive post for a keen and enthusiastic man. Replies in confidence to Managing Director, Belciere & Co. Ltd., 385/387 Cowley Road, Oxford. [628]

UNIVERSITY OF SHEFFIELD — TECHNICIAN or JUNIOR TECHNICIAN required in Department of Physics for Electronic Section dealing with designing, maintenance and production of electronic equipment for teaching and research purposes. Training given in workshop practice. Salary: Junior Technician £456 p.a. (age 16)—£704 p.a. (age 20). Technician £935-£1,303 p.a. with basic qualification. Supplement for approved higher qualification. Write to the Bursar (Ref. B.595), The University, Sheffield S10 2TN. [639]

SITUATIONS WANTED

YOUNG TV Engineer, studying for C.E.1. in spare time, requires interesting work compatible with educational standard. Manchester area. Box W.W. 641 Wireless World.

PRINCIPAL ENGINEER seeks appointment

to lead a team in signal processing in space and time domains using analogue and digital methods. The aim is to further the knowledge of radar resolution in a dense signal environment, and continuously to follow theoretical results with system engineering to prove principles where necessary.

Considerable experience in this and communications field and currently leading a team as outlined above. Now seeks salary compatible with results achieved. Southern England or overseas. BOX W.W. 670 WIRELESS WORLD

RADIO & TELEVISION SERVICING RADAR THEORY & MAINTENANCE

This private College provides efficient theoretical and practical training in the above subjects. One-year day courses are available for beginners and shortened courses for men who have had previous training.

Write for details to: The Secretary, London Electronics College, 20 Penywern Road, Earls Court, London, S.W.5. Tel.: 01-373 8721. 84



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**We still need you at
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The Company is engaged in the design and manufacture of a wide range of radio communications and allied equipment, from military pack-sets to broadcast transmitters, including communications receivers, M.F. Beacons, Teleprinter Terminals, complete Radio Office installations for the Merchant Navies of the world and mobile H.F. and S.S.B. Stations. If you have sound technical knowledge coupled with good practical experience in the alignment and test of H.F. and V.H.F. Communications equipment, we would invite you to visit us to talk about a position with Redifon which would offer excellent opportunities for you to broaden your experience in semi-conductors, S.S.B. and Frequency Synthesis. If you are the man we're looking for, you should be worth at least £24 a week to us and opportunities above this are readily available for the right men with prospects of monthly staff appointments at salaries commencing at

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Please phone or write to:
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Broomhill Road, Wandsworth, S.W.18.
Tel: 874 7281.

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Computicket is now implementing its entertainment seat-booking system. This service, which operates in real-time, will ultimately involve hundreds of on-line CRT Terminals, sited in a wide variety of public places.

Computicket is now recruiting Maintenance Technicians based in the London Area to perform a vital role in this exciting new service.

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Write for an application form to:-

**Colin Roberts, Chief Engineer,
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Northern Polytechnic

HOLLOWAY, LONDON, N.7

Department of Electronic and Communications Engineering

3-year Full-time courses.

(a) College Diploma in Electronic and Communications Engineering

with exemption from CEI pt. 1.

Students attending this course may sit for the CEI parts I and II exams to obtain the necessary educational requirements for the award of the title "Chartered Engineer" after a period of industrial experience. Entry requirements 2 "A" levels in Mathematics and Physics.

(b) Higher National Diploma in Electrical and Electronic Engineering

Successful students gain exemption from CEI pt. I and may sit for the CEI pt. II examinations after a further year's study. Entry requirements: 1 "A" level in Mathematics or Physics, ONC, OND or equivalent.

(c) Electrical and Electronic Technician's Certificate

The syllabus covers the requirements for the City and Guilds of London Institute Full Technological Certificate in Telecommunications Engineering and Final Certificate for Radio and Electronic Technicians.

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Computer Engineering Colour Television Engineering
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The Department has many well equipped Laboratories and a large anechoic chamber fully equipped with specialized measuring equipment.

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AMERICAN DYNAMOTOR input 27 volts output 285 volts at 75 M/A 27/6, p.p. 7/6. Aircraft Lamps 12/24 volts 239 Watts 4/- p.p. 1/6. G.P.O. Type 3000 Relays from 2 ohms to 50,000 ohms with any build up to suit your requirements. We hold huge stocks of relays. Miniature Motors 1-3 volts, r.p.m. at 2 volts 6,800-8,500 6/- each p.p. 1/6. Phillips Tape Cassette Recorder Motors 25/- p.p. 1/6. Assorted Wire-Wound Resistors (some short ends) 50 for 6/6 100 for 12/- Post free. Write, call or phone for details of other bargains. Elekton Enterprises, 12A Tottenham Street, London, W1P 9PQ. Telephone 01-580-7391. [688]

BRAND NEW ELECTROLYTICS, 15/16 volt, 0.5, 1, 2, 5, 8, 10, 20, 30, 40, 50 mfd. mids., 8/5d. Mullard 25 volt 6-4, 12-5, 25, 50, 80 mfd., 10d. 5% E.12 series resistors—Carbon Film 4 watt 10 ohms to 1 Megohm, 1/5d., Wirewound 5 watt 15 ohms to 15,000 ohms, 10d. Postage 1/- per order. The C.R. Supply Co., 127 Chesterfield Road, Sheffield, S8. [673]

BUILD IT IN A DEWBOX quality plastics cabinet. 2 in. X 24 in. X any length. D.E.W. Ltd. (W), Ringwood Rd., FERNDOWN, Dorset. S.A.E. for leaflet. Write now—Right now. [76]

FOR SALE, KO-Lectric coil winder with mardrive motor, clutch and pedal. Table mounted auto tensioning device winding spacing .001 to .020. Cost over £400. £70 o.n.o. Phone Welwyn Garden 24972. [689]

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MAGNETIC AMPLIFIER, demonstration unit, shows basic functions, permits measurement of gain characteristics of series and parallel connected amplifier. P.C.B. construction in wood frame with instructions, £12. Box W.W. 662, Wireless World

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NEW CATALOGUE No. 18, containing credit vouchers value 10/-, now available. Manufacturers' new and surplus electric and mechanical components, price 4/6, post free. Arthur Sallis Radio Control Ltd., 28 Gardner Street, Brighton, Sussex. [94]

S.S.B. Receiver HQ170 1.8-54 MHz, £90 o.n.o., 6 Calystane Hill, Edinburgh. 031-445-2608. [612]

250,000 bit storage capacity magnetic drum made by Nelson Laboratories. This unit has never been put into use and is in perfect condition. £300. Ring 01-340-7217 for details. [614]

UHF, COLOUR and TV SERVICE SPARES. Leading British makers' surplus Colour Frame and Line time base units incl. EHT transformer, £5, carriage 10/-. Integrated UHF/VHF 6 position push button tuner, 4 transistors, knobs, circuit data. Easily adjusted for use as 6 position UHF tuner, £4/10/-, P/P 4/6. MURPHY 600/700 series complete UHF conversion kits incl. tuner, drive assy, 625 IF amplifier, 7 valves, accessories, housed in special cabinet plinth assembly, £7/10/- or less tuner £2/18/6, P/P 10/-. SOBELL/GEC 405/625 switchable IF amplifier and output chassis, 32/6, P/P 4/6. Ultra 625 IF AMP chassis and circuit, 25/-, P/P 4/6. Philips 625 IF AMP panel and circuit 30/-, P/P 4/6. UHF tuners, transistorised, slow motion

drive assy, aerial panel, £5/10/-, P/P 4/6. New or manufacturer tested VHF tuners, AT7639 Peto Scott, Decca, Ekco, Ferranti, Coscor, 38/6, Cydon C 20/-, AB miniature with UHF injection 25/-, Ekco 283/330, Ferranti 1001/6 25/-, New fireball tuners, Ferguson, HMV, Marconi type 37/6, Plessey 4 position push button tuners with UHF injection, incl. valves, 58/6. Many others available. P/P all tuners 4/6. Large selection channel coils. Surplus Pye, Ultra, Murphy, 110° scan coils 30/-, Sobell 110° Frame O/P transformers 17/6, P/P 4/6. Transistorised time base panel for Ferguson portable 50/-, P/P 4/6. LOPTS, Scan Coils, FOPTs available for most popular makes. PYLE/LABGEAR transistorised booster units B1/B3 or UHF, battery operated 75/-, UHF Masthead £5/5/-, post free. COD despatch available. MANOR SUPPLIES, 172 WEST END LANE, LONDON, N.W.6 (No. 28 Bus or W. Hampstead Tube Station), MAIL ORDER: 64 GOLDBERG MANOR DRIVE, LONDON, N.W.11. Tel. 01-794 8751. Staff holidays August 17 to 31. [650]

60 kc/s Rugby & 75 kc/s HBG Neuchatel Radio Receivers. Signal and Audio outputs. Small compact units, £35. Toolex, 6 Warwick Close, Hertford (4856).

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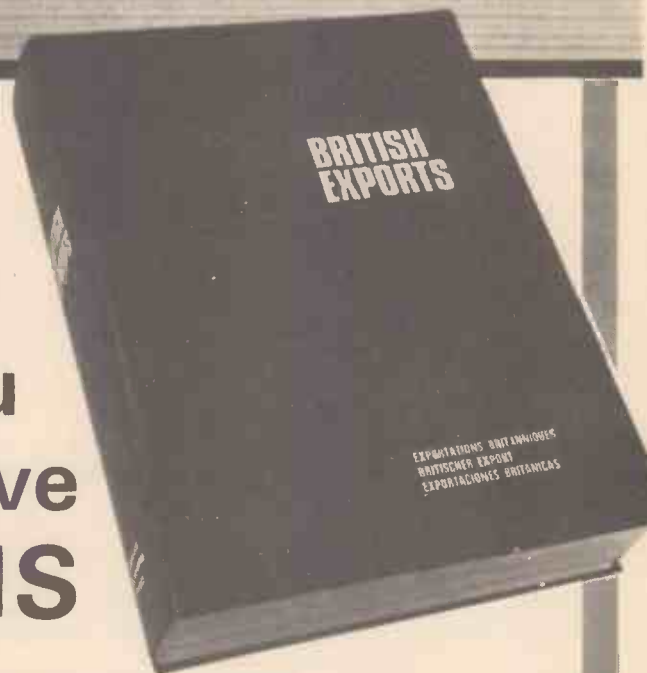
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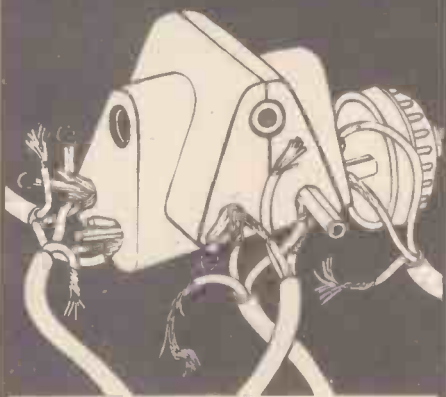
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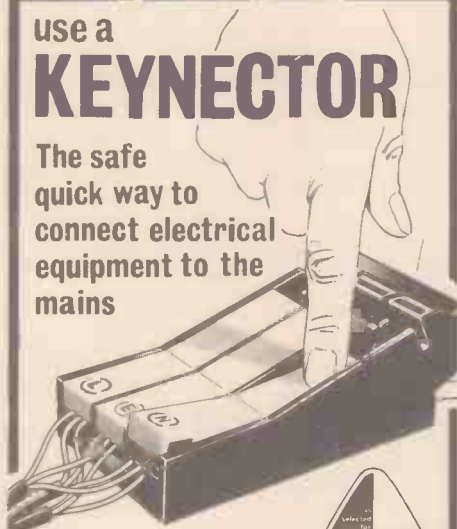
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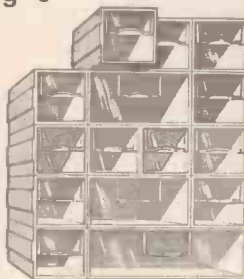
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AC19	BFX84	OC72	2N706	2N2907
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ACY21	BFX88	OC81	2N929	2N3391
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ACY29	NKT213	2G302	2N1613	2S103
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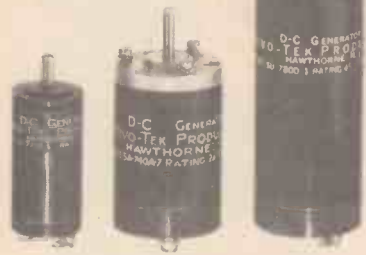
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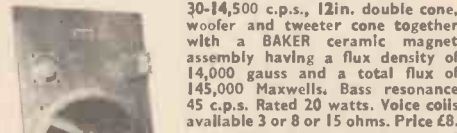
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6.3 v 1.5 a, 42/-; MT1 200 v 30 Ma, 6.3 v 1 a, 24/-; MT2 230 v
45 Ma, 6.3 v 1.5 a, 26/6.

MULTIVOLT TRANSFORMERS. Prim 200/240 v a.c. OMT4/1
One tapped sec. 5-20-30-40-50 v giving 3-10-15-20-25-30-35-40-
50-60, 10-0-10, 20-0-20, 30-0-30, 40-0-40, 1 amp, 45/-; ditto tran
2 amp OMT4/2, 67/6; OMT5/1 One tapped sec. 40-50-60-80-90-
100-110 v, giving 10-20-30-40-50-60-70-80-90-100-110, 10-0-10,
20-0-20, 30-0-30, 40-0-40, 50-0-50 v a.c. 1 amp. 67/6; OMT40/3
one sec 40 v CT 3 amp. 67/6.

DIVOLT TRANSFORMERS. Prim 200/240 v a.c. "D12V"
Sec 1, 12 v 4 a, Sec 2, 12 v 4 a, 71/6; "D25V" Sec 1, 10-20-25 v
2 a, Sec 2, 10-20-25 v 2 a, 71/6.

LT AUTO TRANSFORMERS. Prim 200/240 v a.c. output 24 v
a.c. 180 watt 90/-; 250 watt 135/-; for quartz iodine lamps.
HEATER TRANSFORMERS. Prim 200/240 v a.c. 6.3 v 1.5 a
16/6; 3 a 20/-; 6 a CT 34/-; 12 v 1.5 a 21/-; 3 a CT 34/-;
6 a CT 45/-; 18 v 1.5 a CT 26/6; 24 v 1.5 a CT 34/-; 3 a CT
58/6; 5 a 75/-; 8 a 112/6; 12 a 165/-.

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HIGH MELTING POINT

For service at high temperature, or service at very low temperatures. Outstanding creep strength. Melting range 296°C - 301°C (565°F - 574°F).

Applications

A useful application of H.M.P. is the soldering of joints close to each other in such a way that the connections made first are not re-melted while later joints are made, with for example, a standard 60/40 alloy, melting point 188°C. Essential for use where high operating temperatures are experienced, for instance, electrical motors, car radiators, high temperature lamps. H.M.P. is also ideal for equipment, which is being operated in low temperatures, as it reduces the chance of the joint becoming brittle.

Specification

Multicore H.M.P. alloy complies with BS.219 Grade 5S. Supplied in a form of Ersin Multicore 5 core solder wire on 11b. or 71b. reels, incorporating Ersin 362 rosin based flux. This non-corrosive flux-cored solder wire complies with BS.441 and is available from 10 to 26 s.w.g., and in Multicore Solder Preforms. Ask for Technical Bulletin No. 1369.

L.M.P.

LOW MELTING POINT

A low melting point solder for soldering silver plated and gold plated surfaces. Melting point 179°C (354°F).

Applications

L.M.P. reduces the absorption of silver or gold into the solder alloy whilst soldering, and therefore, preserving the silver or gold plated surfaces. Also reduces the chance of a brittle joint being made.

NOTE

- a) The solution of gold into tin rises rapidly with temperature and so the use of L.M.P. Low Melting Point Solder is preferable.
- b) The solution rate of gold into tin is also reduced because L.M.P. is a ternary alloy comprising tin, lead and silver.

Specifications

L.M.P. is normally supplied in the form of Ersin Multicore 5 core solder wire, incorporating Ersin 362 rosin based flux, which complies with Min. Tech. specification D.T.D.599A. It is available from 10 to 34 s.w.g. in 11b. or 71b. reels and Multicore Solder Preforms. Ask for Technical Bulletin 1469.

T.L.C.

EXTRA LOW MELTING POINT

Extra low melting point solder. Melting point 145°C (293°F).

Applications

T.L.C. alloy can be used whenever a soldered joint should be made with the minimum heat input. This would include heat sensitive transistors, flexible printed circuits and gold plated surfaces. The melting point of T.L.C. alloy is 38°C lower than any tin/lead alloy. Because of its low temperature application it is considered completely non-toxic in use unlike the high temperature cadmium-bearing brazing alloys.

Specification

T.L.C. alloy is normally supplied in the form of Ersin Multicore 5 core solder wire, incorporating Ersin 362 rosin based flux, which complies with Min. Tech. Specification D.T.D.599A. T.L.C. alloy can also be supplied in the form of Multicore precision made solid solder wire, Extrusol extruded solid solder bars for solderbaths and Multicore Solder Preforms. Available from 10 to 34 s.w.g. on 11b. or 71b. reels. Ask for Technical Bulletin No. 1569.

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