Wireless World

ELECTRONICS, RADIO, TELEVISION

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Stereophony from Discs

FOR some time work has been going on behind the scenes in most of the major gramophone recording companies of the world on the development of discs in which sounds from two separate sources are recorded in the same groove. These recordings can be extracted by a special pickup, with two degrees of freedom, and reproduced through separate amplifiers and loudspeakers to synthesize a sound field which, to the listener, has directional properties similar to those of the original.

The foundations of stereophonic recording on disc were firmly laid by A. D. Blumlein of E.M.I. in a British patent (394,325) granted in 1933. He showed that modulations of the groove at right angles to each other could be vertical and horizontal or both at 45° to the surface of the disc, and that one system could be converted to the other by taking the sum and difference of the electrical outputs from the two channels. Shellac records at 78 r.p.m. made by the Columbia Graphophone Company on this principle in 1933, were demonstrated recently by H. A. M. Clark at the Institution of Electrical Engineers as a prelude to examples of the latest experimental recordings by E.M.I. We have also been privileged to hear the Decca records which made a profound impression when they were demonstrated recently in America. Both these demonstrations left little doubt that the problems of cutting a groove with dual modulation and extracting the signals without noticeable distortion or crosstalk have been successfully solved by the use of modern techniques of recording with feedback cutters, and reproduction with lightweight pickup movements. The results from discs are practically indistinguishable from the master dual-track magnetic tapes from which they are transcribed.

The record manufacturers have been alive to the necessity for standardization before stereo discs are marketed on a large scale. We understand that agreement has been reached, independently by groups of companies in Europe and in America, on the same basic standards which, subject to confirmation, will be as follows: (1) Modulations to be mutually at right angles and inclined at 45°/45° to the surface of the record; (2) Playback to be with a stylus tip of 0.0005in radius; (3) Relative channel polarity to give predominantly lateral movement of the stylus when the inputs are approximately in phase; (4) Modulation of the outer groove wall to correspond with the right-hand sound channel, i.e. if the axis of the right-hand modulation is extended it cuts the axis of rotation above the record; (5) Frequency response to I.E.C. fine-groove playback standard (B.S. 1928: 1955).

There are fundamental differences in the processes of tracing lateral and vertical modulations of the groove, and the 45°/45° system has been chosen because it gives better symmetry in this respect between the two channels. The smaller stylus radius is necessary because with dual modulation the groove will at times be narrow and shallow, but it is also of advantage in giving a reduction of tracing distortion. Distortion is also reduced by the relative channel recording polarity which has been chosen.

The qualities of stereophonic sound reproduction as exemplified by H.M.V. "Stereosonic" magnetic tape records have made many converts, even among those with full knowledge of the very realistic results which have been achieved with multi-microphone and other studio techniques on single-channel l.p. records. Quite apart from the obvious spatial effects, there is, in the best stereophonic orchestral recordings, a clarity and definition which is immediately appreciated by musicians. We say "the best" advisedly for pseudo-stereophony can also introduce ludicrous incongruities such as levitations and expansions and contractions in the apparent size of musical instruments according to the registers in which they are playing! Much will depend on the skill of the studio managers and recording engineers, and what between them they put on the record. The qualities of some ordinary l.p. records seem to shine through all kinds of distortion in indifferent reproducers, and it is to be hoped that similar foolproof qualities will emerge from the stereo discs which are offered to the general public. The crude effects of marching bands, railway sounds, and even antiphonal choral singing can be safely left to look after themselves, but it remains to be seen whether the more subtle qualities will survive the vagaries of general usage. The purely spatial effects are likely soon to lose their novelty, and stereophony will displace the single-channel high-quality reproducing system only if it shows a gain in realism on all kinds of programme material which is commensurate with the extra cost of the equipment.

Transistor Television Circuits

By J. N. BARRY*, M.Sc.
and G. W. SECKER*

I—Synchronizing Separators and Timebase Oscillators

CONSIDERABLE progress has been made recently in the design of junction transistors in two directions. These are, first, that devices have been produced which are capable of operating at much higher frequencies than hitherto, and secondly, that considerable steps have been made to increase the power handling capacity of transistors. Even now no transistors are available which are capable of giving performances equivalent to valves in the r.f. and i.f. circuits of a television receiver, but the improved high frequency performance of recent devices such as the surface barrier and diffusion type transistors has enabled circuits to be designed capable of giving acceptable video amplifier characteristics.

In conjunction with increased power ratings, recent improvements in manufacturing techniques have produced transistors whose current gains remain reasonably constant up to large values of emitter current, e.g. up to several amperes in some cases. In addition thermal resistance figures† as low as a few degrees centigrade per watt, when devices are used with a specified heat sink, are now quoted. These figures, in conjunction with maximum junction temperatures for germanium transistors of up to 75°C, permit dissipations of ten watts or more at normal operating temperatures. The advent of such transistors means that circuits can now be designed to perform such functions as timebase output amplification and e.h.t. generation, in addition to high-power audio output amplification.

In the case of low-power medium-frequency devices there has been a continual trend in the direction of higher operating voltages. Thus the maximum voltage rating, which a few years ago stood around 10 volts, is now of the order of 60 volts for several currently available types. Such an improvement aids the design of circuits performing the functions of sync separators and timebase oscillators.

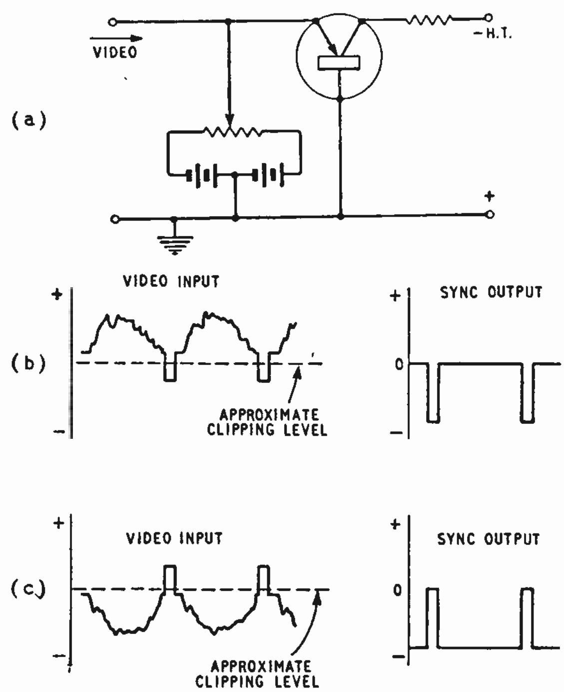
In the circuits which follow it will be seen that advantage has been taken in one way or another of all the recent improvements outlined above. The circuits are fairly economical in the number of ancillary components required, and could prove attractive should either the price of transistors drop appreciably or an interest develop in battery operated portable television sets.

Sync Separators.—A junction transistor may be used as a sync separator in any of the usual amplifier configurations, i.e. in the common-base, common-emitter or common-collector connections[1]. An example of the simplest form of common-base separator using a p-n-p type junction transistor is given in Fig. 1(a). The emitter may be given either (i) positive or (ii) negative bias.

Considering (i), the transistor is biased fully on and the collector will be nearly at earth (positive) potential. If a video signal of the form shown in Fig. 1(b) is applied to the separator the picture signal will be clipped, and amplified negative-going sync pulses will appear at the collector.

Considering (ii), the transistor is biased fully off, and the collector will be at approximately the full

Fig. 1. Simblest form of common-base sync separator (a). At (b) video input and sync output with transistor biased on. At (c) input and output with transistor biased off.



* Research Laboratories, General Electric Company.
† Thermal resistance, θ, is defined as the rise in collector junction temperature per unit power dissipation under specified conditions.
[1] "Transistorised Sync Separator Circuits for Television Receivers," by H. C. Goodrick, in "Transistors I" book (RCA Laboratories, 1956), p. 561.

h.t. negative potential less the voltage drop in the collector load due to the collector leakage current I_{co}. If a video signal of the form shown in Fig. 1(c) is applied to the input of the separator, amplified positive-going sync pulses appear at the collector as shown. This common-base type of separator may be adjusted to give clean rectangular sync pulses but possesses several disadvantages which include:

(1) The use of a fixed bias on such a separator means in practice that the greatest sync pulse output is obtained for a particular level of video input signal.

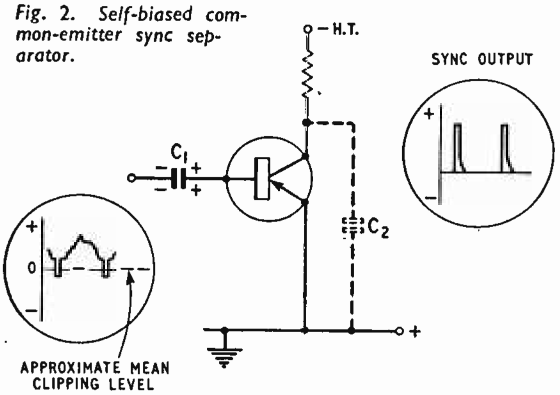
(2) In order to achieve fast turn-on and turn-off times, the separator has to be fed with a video signal from a low-impedance source.

(3) Compared with the common-emitter type of separator described later in this section, the common-base circuit is relatively insensitive.

Referring to Fig. 1(c) it may be seen that a common-base separator which is biased off requires a video input as shown. This video waveform could be obtained from a small resistor in the anode circuit of the video amplifier stage of a typical receiver which uses cathode modulation of the c.r.t. Experiments have shown that such an arrangement is hardly practicable, however, since the video input to the separator tends to be small and usually comparable in amplitude to the ripple on the h.t. line of the receiver.

Many of the disadvantages already mentioned may be overcome by the use of a common-emitter type of separator. If this arrangement is used in a biased-off condition it is possible for the separator to be self-biased. In addition, a separator which is biased off generally gives a sharper initial rise to the output pulse than one which is biased on. This is probably due to the fact that a device which is biased off has a much lower value of effective output capacitance. If the separator is driven into collector current by the sync portion of the video input signal, any degradation of the output pulse due to carrier storage effects in the transistor will tend to occur on the trailing edge.

Fig. 2. Self-biased common-emitter sync separator.



An example of this type of circuit is shown in Fig. 2. The base-emitter junction conducts on the tips of the negative-going sync pulses and the capacitor C_1 becomes charged as shown. Amplified positive-going sync pulses are then obtained at the collector. This circuit operates in a rather similar manner to a self-biased Class C amplifier. The discharge time-constant of the input circuit may be considered as C_1R, where R is the back resistance of the base-emitter junction. In addition, the value of C_1 should be such that it does not introduce a reactance at the frame frequency which is large in comparison with the input impedance of the separator. Experiments have shown that in order to avoid a loss of frame pulse output C_1 should be not less than $2\mu F$.

Although this circuit requires to be driven from a low-impedance source it is considerably more sensitive than the common-base type already mentioned. In addition, in a typical television receiver using cathode modulation of the c.r.t. a suitable low-impedance source of video signal of the required polarity is available from the cathode bias resistor of the video amplifier.

It may be noted that the output capacitance of the transistor (C_2 in Fig. 2) imposes a limit to the value of collector load resistance which may be used. Experiments have shown that a collector load of $47k\Omega$ is suitable for use with a transistor such as type EW80‡ for producing line sync pulses when operated from 60V h.t.

It may be mentioned that the output capacitance, C_2, is a function of the collector junction capacitance C_c, which is itself a function of the collector voltage, V_c. Thus for alloyed junction type devices:

$$C_c \propto \frac{1}{\sqrt{V + U}}$$

where U= the barrier potential across the collector-base junction (approximately 0.25 volt), and

$$C_2 \simeq \alpha_{cb} . C ,$$

where α_{cb} = the common emitter current gain factor.

When the transistor is driven into current by the sync portion of the video input signal the collector voltage rapidly decreases, the transistor bottoms and C_2 assumes its greatest value. The recovery time will be partly governed by the time taken for C_2 to recharge via the collector load resistance. Since the value of C_2 decreases with increasing voltage the recovery time will be less than if C_2 were fixed at its maximum value.

Typical performance figures of the common-emitter circuit using a type EW80 transistor with a collector load of $47k\Omega$ and 60V h.t. are:

Input signal	approximately 0.25V peak sync amplitude
Output line sync amplitude	approximately 50V peak
Rise time	approximately 2 μsec
Decay time	approximately 4 μsec
Mean collector potential ..	approximately 28V
Mean collector current ..	approximately 0.5mA
Mean collector dissipation	approximately 14mW

It may be noted that since the base of the separator is biased positively and conducts only on the tips of the sync pulses, the leakage current through the collector circuit will be less than the collector to emitter leakage current I_{ceo}. Also, if the base reaches a potential of approximately 0.25V positive with respect to the emitter the leakage current will approach its limiting value of I_{co}. Under these conditions the peak pulse output will approach the h.t. voltage.

The transistors used as sync separators were selected to have a high value of collector breakdown voltage. Specimens which gave the best results had an I_{co} of less than $8\mu A$ at a collector potential of approximately −70V.

‡ This type is essentially a high voltage version of type GET4.

Fig. 3 shows a practical form of a common-emitter sync separator circuit which was incorporated in a standard 17-inch receiver. The circuit has been modified slightly to work from the existing 200-V h.t. line in the receiver; R_1 and C_1 are included to limit the current through the emitter-base junction of the separator when the receiver is switched on. Line sync pulses are developed across R_3 and frame sync pulses are obtained across R_2 and C_2. A typical clipping circuit employing a GEX54 germanium diode is used to remove integrated line pulses from the frame pulse output.

The Z77 thermionic valve sync separator normally incorporated in the receiver produces negative-going sync pulses, which are applied to the screen of the line oscillator and the grid of the frame oscillator. It was found that the line oscillator would lock equally well from positive-going sync pulses applied to the screen via a small coupling capacitor, provided the delay time introduced was kept sufficiently small. In the case of the frame oscillator it was found that satisfactory operation was obtained with positive-going sync pulses applied to the oscillator triode anode.

Outputs of up to 90V peak line sync pulse and approximately 40V peak frame sync pulse (after clipping) could be obtained when using suitable transistors, for an input to the separator of approximately 0.25V peak sync amplitude.

Satisfactory synchronization was achieved with either the Z77 or transistor separator in circuit down to the same minimum level of input signal. The minimum input to the transistor separator at which satisfactory line and frame hold could be maintained was of the order of 0.05V peak sync amplitude (measured at the cathode of the video amplifier).

The frame interlace obtainable with the transistor separator in circuit was considered to be good (approaching 50-50).

In addition, the line tearing observed in the presence of locally generated impulse interference was slightly less when the transistor separator was used.

Blocking Oscillators.—In dealing with the timebase section of the 17-inch receiver, a blocking oscillator was used as the waveform generator, as this type could most conveniently be used with the existing thermionic valve output stages. The waveform generator developed for the frame timebase was subsequently used in conjunction with a transistorized output stage (to be described in Part 2 in a future issue).

Fig. 4 shows the basic blocking oscillator circuit[2], and Fig. 5 gives the voltage waveforms obtained at the collector (V_c), the base (V_b), and the emitter, (V_e). These indicate the voltages obtained when using a supply of 24V.

The transformer T_1 (Fig. 4) is connected such that the collector and emitter voltages are in phase. Assume the circuit to be initially uncharged and the h.t. then switched on; C_1 and R_1 together with L_1 and C_2 in parallel form a series charging circuit across the h.t. supply. (R_1 is appreciably less than the back resistance of the collector-base junction.) The collector voltage increases negatively, approximately in a linear manner, according to the curve V_c (Fig. 5) and the emitter voltage at first increases similarly although at a slower rate (curve V_e, Fig. 5), due to the step-down ratio of the transformer T_1. The voltage at the base (curve V_b, Fig. 5) increases initially more slowly than the emitter voltage, thus maintaining the emitter-base junction in a high resistance condition.

When the base voltage becomes very slightly negative with respect to the emitter the base-emitter junction conducts and the capacitor C_1 discharges through the transistor and L_2. The base current is amplified by the current gain factor α_{cb}, and causes a large pulse of current to pass via the collector and emitter. This produces a rapid voltage change at the collector and, combined with the action of L_2, the collector voltage is carried to a positive value. This causes the collector-base junction to become a low resistance and the base capacitor acquires a positive potential, thus blocking off the emitter circuit which consequently rings (curve V_e, Fig. 5). The negative portion of the ring reflected through the transformer is sufficient to carry the collector potential negative with respect to the base and to bias the collector-base junction in its high resistance condition. The cycle then repeats.

A negative-going sawtooth voltage approximately equal to twice the h.t. voltage is produced at the collector. If an n-p-n transistor is employed a positive-going sawtooth voltage output may be obtained. (Note: both p-n-p and n-p-n types may be operated from either polarity d.c. supply by suitable arrangement of the circuit, but the polarity of the sawtooth waveform is depen[illegible] on the type of transistor used.)

It was found by experiment that the best results were obtained

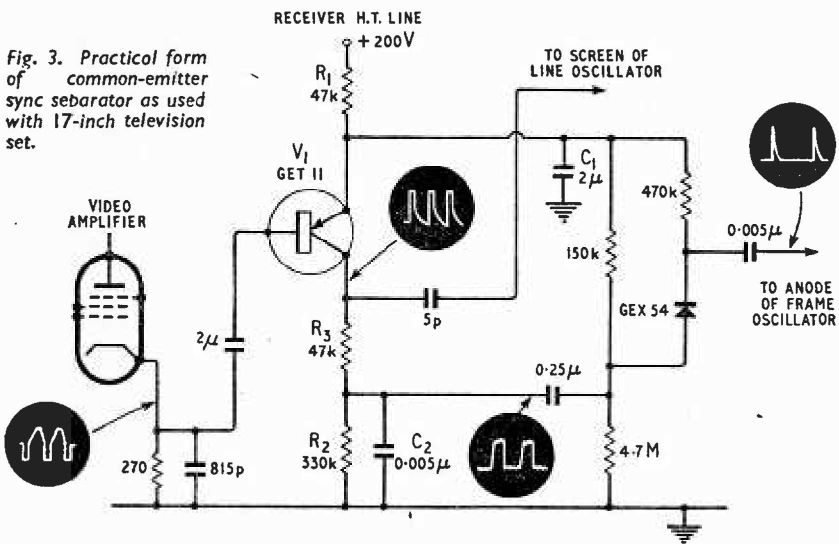


Fig. 3. Practical form of common-emitter sync separator as used with 17-inch television set.

[2] British Patent App. No. 17058/57.

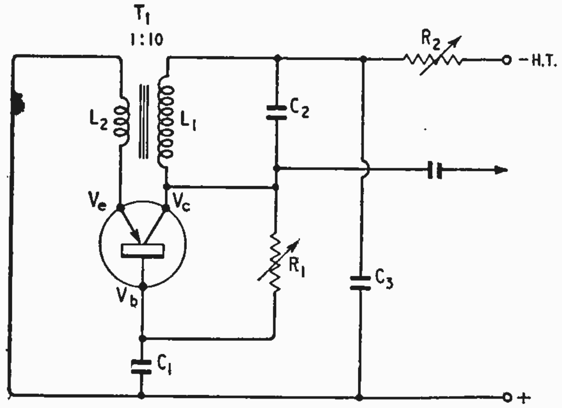


Fig. 4. Basic transistor blocking oscillator circuit.

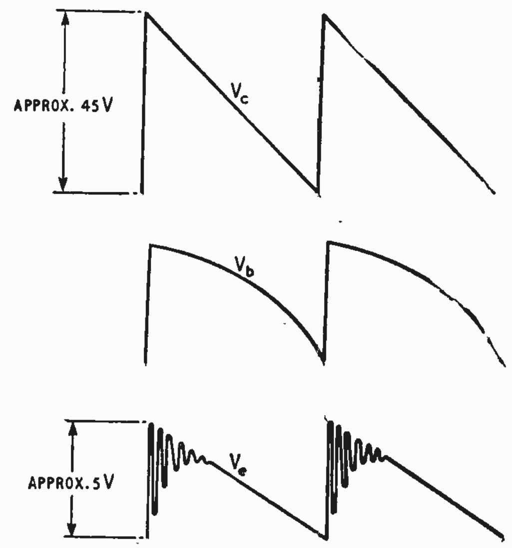


Fig. 5. Waveforms obtained with the Fig. 4 blocking oscillator circuit (using a p-n-p transistor).

using a transformer of about 10 to 1 step-down ratio between collector and emitter. A ratio of about 4 to 1 gave a slightly larger output voltage at the collector but of an inferior wave shape, and a ratio of about 20 to 1 tended to produce a sine wave output rather than a sawtooth.

Increasing the values of L_1 and C_2 tended to give a more linear rise waveform, but increasing C_2 or the resistance of L_1 or L_2 tended to lengthen the retrace time of the sawtooth output. Adjustment of R_2 gave a variation of output voltage of approximately 2 to 1 without significantly affecting the wave shape or period.

Synchronization was best effected by applying the appropriate sync pulse to the base terminal. When an n-p-n transistor is used a positive-going sync pulse is required at the base, alternatively a negative-going sync pulse is needed for the p-n-p type. It was found that a sync pulse amplitude of the order of 0.5V peak would give a satisfactory lock.

Frequency control is effected by variation of R_1, which controls the voltage across the base capacitor C_1. In addition, the turns ratio of T_1 also influences the frequency, since the instant at which the flyback commences is determined by the bias conditions existing at the base-emitter junction.

It may be noted that the transistor passes current mainly during the flyback period. Since the base-emitter junction is biased off during the rise period the collector current will be of the order of I_{co} until the flyback occurs.

No tendency to thermal instability was encountered at temperatures of the order of 25°C. Further investigation of the performance of this circuit at higher temperatures was not carried out. Provided, however, that the minimum value of R_2 is such that the maximum dissipation of the transistor cannot be exceeded no trouble should be encountered.

The circuit of the line oscillator is given in Fig. 6. Approximately 45V peak-to-peak of positive-going sawtooth output voltage was obtained by using an n-p-n transistor, type 2N98**, supplied from 24V h.t. The retrace time of the output waveform was approximately 10μsec. It was found that the e.h.t. generated by the line output stage was

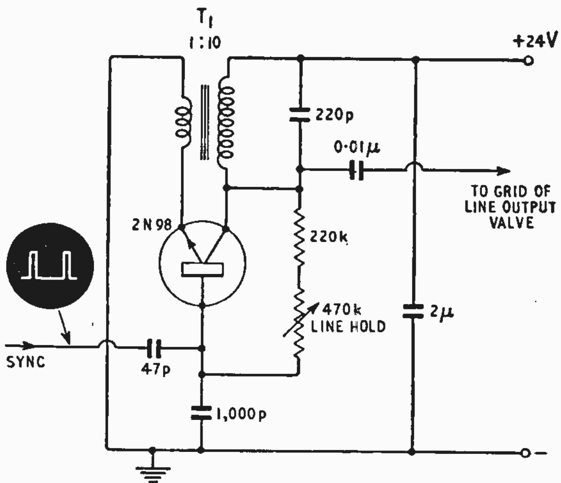


Fig. 6. Line oscillator circuit used with the 17-inch receiver. Details of T_1:—primary, 200 turns 34 s.w.g. Lewmex (not interleaved) 2 layers 3 mil paper, 72mH 4.5Ω; secondary, 2,000 turns 40 s.w.g. Lewmex (not interleaved); bobbin, midget Angelina; core, midget 0.015in Radiometal T and U stampings interleaved.

approximately 12kV when driven by the transistor oscillator compared with approximately 14kV when driven by the thermionic valve circuit of the receiver. (This comparison was made on Test Card C with the same settings of brightness and contrast.)

Sync pulses were applied to the base via a 47-pF capacitor from the p-n-p type separator described above. With a sync pulse amplitude of approximately 2V peak applied to the base, the line oscillator was found to pull in to lock between free-running frequencies of approximately ±10% on the nominal 10.125 kc/s.

The effect of increasing temperature on the free-

** This type of transistor was used as there were no suitable [illegible] types available on the British market.

running frequency of the oscillator was not investigated. It was noted, however, that once the timebase was correctly synchronized, no adjustment of the "hold" control was required for an operating period extending over several hours. This was also true in the case of the frame oscillator.

It may also be noted that a significant advantage of such transistor oscillators is that they require only a relatively small amplitude input pulse for satisfactory synchronization.

The line linearity with the transistor oscillator was slightly better than that obtained with the thermionic valve circuit.

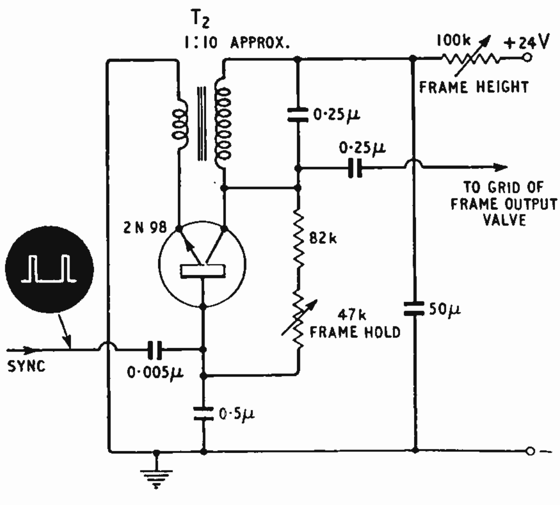
The current consumption was approximately 0.7mA at 24V h.t.

The original thermionic valve frame oscillator in the receiver produces a sawtooth which is peaked at the beginning and the end of the rise waveform. This is done to correct for any decrease in mutual conductance of the frame output valve with increasing negative bias and also to offset saturation effects in the frame output transformer. It was found to be impracticable to produce a similar waveform from the transistor blocking oscillator of sufficient amplitude fully to drive the existing frame output stage. A solution was found by obtaining a large amplitude of linear sawtooth voltage from the transistor blocking oscillator and by increasing the amount of corrective feedback on the frame output valve.

The circuit of the frame oscillator is given in Fig. 7, and the modifications to the frame output stage are shown in Fig. 8.

Approximately 45V peak-to-peak of positive-going sawtooth output voltage was obtained from the frame oscillator, which used an n-p-n transistor, type 2N98. The retrace time of the sawtooth waveform was approximately 0.6 msec. Sync pulses from the p-n-p type separator described above were applied to the base. With a sync pulse amplitude of approximately 0.5V peak at the base the pull-in frequency range was approximately ±10%. The current consumption at 24V h.t. was approximately 1mA.

Fig. 7. Frame oscillator used with the 17-inch receiver. Details of T_2:— primary, 700 turns 32 s.w.g. Lewmex (not interleaved) 1 layer 3 mil paper; 1.4H 14Ω; secondary, 7,500 turns 38 s.w.g. Lewmex (not interleaved) approx. 160H 680Ω; bobbin, "standard"; core, No. 10 0.015in Mumetal gate stampings.



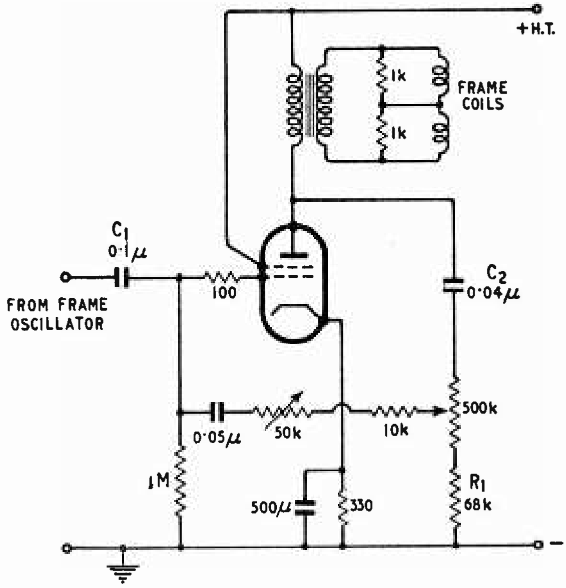


Fig. 8. Original frame output stage of the 17-inch receiver. Modifications for use with the transistor frame oscillator:—C_1 increased to 0.25μF; C_2 increased to 0.1μF; R_1 replaced by short circuit.

Line and frame linearity measurements were made using Test Card C with the transistor line and frame oscillators incorporated in the receiver. The non-linearity was as follows: line, 4%; frame, 14%.

The frame non-linearity was such that the height of a rectangle was a maximum in the middle of the picture and decreased uniformly towards the top and bottom.

Additionally, it was found that the line and frame hold were maintained with an input signal level to the transistor sync separator of approximately 0.05V peak sync amplitude (as given earlier). The frame interlace obtained appeared to be satisfactory, i.e. approaching 50-50.

The linearity measurements were made on the c.r.t. using dividers and a ruler. Care was taken to avoid parallax errors. Frame non-linearity was calculated as follows:

If x cm = height of the tallest "background" rectangle on Test Card C, and y cm = height of the shortest equivalent rectangle on the Card, then

non-linearity $= \frac{2(x-y)}{x+y} \times 100\%$. To calculate the line linearity the widths of rectangles were measured and used in the same formula. The extreme left-hand and right-hand rectangles of Test Card C were excluded since these are narrower than those in the middle of the test pattern.

A subjective comparison of the timebase linearity for both line and frame in the case of (a) the receiver in its original condition, and (b) the receiver with the transistor line and frame oscillators incorporated, indicated that the results in both cases were very similar.

(To be concluded.)

Exhibitors at the I. E. A. Show

THIS year's Instruments, Electronics and Automation Exhibition (Olympia, April 16th-25th) has the official backing of the radio and electronics industry, the Electronic Engineering Association (formerly R.C.E.E.A.) being one of the six sponsoring bodies of the show. An even greater number of the 240 U.K. exhibitors than last year are either in the industry or their products are used extensively in the manufacture or testing of radio and electronic equipment. The Scientific Instrument Manufacturers' Association and British Electrical and Allied Equipment Manufacturers' Association are among the five original sponsors of the show.

In addition to the U.K. radio and electronics exhibitors listed below, some 60 overseas manufacturers are represented, most of them by their U.K. agents.

As last year a conference is being run in association with the exhibition, but this year it will be confined to the mornings.

Among the conference papers is one by Dr. A. D. Booth (director of the Birkbeck College Computation Laboratory) on "Computers—Numerical Automation." Dr. G. E. R. Deacon, director of the National Institute of Oceanography, will deal with "Progress in the International Geophysical Year." Others will deal with instrumentation in various industries and in scientific research.

The exhibition opens daily (except Sunday) at 10.0 and closes at 6.0 except on the 18th and 23rd, when it will remain open until 9.0. Admission 2s 6d.

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British Electric Resistance Co.
British Physical Laboratories
British Power Transformer Co.
British Tabulating Machine Co.
Brown, S. G.
Burndept

Cambridge Instrument Co.
Cass & Phillip
Cinema-Television
Colvern
Cooke, Troughton & Simms
Cossor Instruments
Counting Instruments
Crompton Parkinson
Crosfield, J. F.
Croydon Precision Instrument Co.

Dawe Instruments
Day, J., & Co.
Dynatron Radio

Ega Electric
Ekco Electronics
Electrical Remote Control Co.
Electroflo Meters
Electro Methods
Electronic Components
Electronic Engineering
Electronic Instruments
Elliott Brothers (London)
E.M.I. Electronics
English Electric
English Electric Valve Co.
Ericsson Telephones
Evans Electroselenium
Everett, Edgcumbe & Co.
Evershed & Vignoles

Fairey Aviation
Fielden Electronics
Fleming Radio (Developments)
Foxboro-Yoxall

G.E.C.
General Radiological
Gloster Aircraft Co.
Goodmans Industries

Hallam, Sleigh & Cheston
Hatfield Instruments
Headland Engineering Developments
Hilger & Watts
Honeywell-Brown

Imhof, Alfred
Instruments and Automation
Instrument Practice
Instrument Review
Integra, Leeds & Northrup

Jobling, James A., & Co.

Kelvin & Hughes (Industrial)
Kent, George
Kerry's (Ultrasonics)

Langley London
Laurence, Scott & Electromotors
Lintronic
Livingston Laboratories

Magnetic Devices
Marconi Instruments
Metropolitan-Vickers
Microcell Electronics
Microwave Instruments
Minerva Detector Co.
Ministry of Supply
Morgan Crucible Co.
M.S.S. Recording Co.
Muirhead
Mullard

N.S.F.
Nagard
Nalder Brothers & Thompson
Nash & Thompson
New Electronic Products
Nuclear Engineering

Painton & Co.
Panellit
Paul, K. S.
Peebles, Bruce, & Co.
Philips Electrical
Plessey Development
Plessey International
Process Control & Automation
Pullin, R. B., & Co.
Pye, W. G., & Co.

Racal Engineering
Radiovisor
Reilly Engineering
Robinson, F. C., & Partners

Sanders, W. H., (Electronics)
Sangamo Weston
Semiconductors
Servomex Controls
Shaw Moisture Meters
Short Brothers & Harland
Siemens Edison Swan
Simmonds Aerocessories
Smiths Industrial Instruments
Society of Instrument Technology
Solartron Electronic Group
South London Electrical Equipment
Southern Instruments
Sperry Gyroscope
Sunvic Controls

Taylor Controls
Technical Ceramics
Technical Sales
Technograph Electronic Products
Teledictor
Telegraph Construction & Maintenance
Telephone Manufacturing Co.
Turner Electrical Instruments
20th Century Electronics

Ultrasonoscope Co. (London)

Vactric (Control Equipment)
Venner Electronics

Wayne Kerr Laboratories
W.S. Electronics (Production)
Wireless World and *Electronic & Radio Engineer*

Instructional Films on Transistors

FIVE new 16-mm sound films have recently been produced by Mullard to illustrate the basic principles of semiconductors, transistors and their application in radio receiver circuits.

"The Transistor—Its Principles and Equivalent Circuit" lasts 15 minutes and is in colour It is at a fairly high technical level and a detailed analysis of the complete and approximate equivalent circuits used in design is preceded by animated diagrams showing current carriers under different circuit conditions. This film serves as an introduction to "The Junction Transistor in Radio Receivers," which is in two parts· 1.—"Design of an I.F. Amplifier' (15 minutes) and 2.—"The Complete Receiver" (10 minutes). A third film. "The Manufacture of Junction Transistors" (10 minutes) gives a close view of the techniques employed at the Mullard factory at Southampton. All the foregoing are available from the Publicity Division of Mullard Ltd. Torrington Place, London W.C.1.

Another 16-mm sound film. "The Principles of the Transistor" (20 minutes, black and white), and a colour film strip. "Semi-conductor Devices" (35 mm) have been produced for teaching by the Mullard Educational Service in collaboration with the Educational Foundation for Visual Aids to whom schools should make application; other organizations should apply to the Mullard Educational Service.

Television Society Exhibition 1958

COLOUR RECEIVERS AND TEST EQUIPMENT

AT the Television Society's exhibition this year the main accent was on colour. Four manufacturers (Bush, Ekco, G.E.C. and Murphy) were showing experimental receivers designed for the B.B.C. tests of the "Anglicized" N.T.S.C. system. These were, in the main, similar—all used the R.C.A. tri-gun shadow-mask tube which dictates, to a large extent, the design of the receiver.

One of the main differences between the sets was in the local sub-carrier oscillator section. This oscillator must be accurately synchronized with the sub-carrier burst which occurs during the back porch of the line synchronizing pulse, and the maximum phase "wander" which can be allowed between colour bursts is very small. The transmitted sub-carrier can change by as much as ±8 c/s from its nominal frequency, and the local oscillator in the receiver also drifts. These factors render mandatory the use of an a.f.c. system.

The Bush and Ekco receivers on show were using a crystal-controlled oscillator with a relatively simple a.f.c. system, while G.E.C. and Murphy were employing a much more comprehensive system (phase discriminator and quadri-correlator) to give the wide pull-in range necessary with a less stable oscillator. (A full description of the Murphy receiver appeared in the March and April 1956 issues of *Wireless World.*)

The sub-carrier frequency must be attenuated in the luminance channel to avoid the "crawling-dot" effect and the possible desaturation of colours. Particular care has been taken in the design of the filter in the Bush receiver so that the luminance information in the picture is not adversely affected. The trap is of the "bridged T" type, having a stop-band only 200 kc/s wide. This, coupled with the excellent response of the i.f. amplifier enabled the receiver to produce a picture of excellent definition.

The colour rendering varied greatly between receivers —even between two receivers of the same manufacture —and, like the little girl with the curl, when it was good it was very, very good, but when it was bad it was horrid!

Colour signals at the exhibition came from three sources: the B.B.C. Channel 1 colour test transmissions; colour slides from a scanner at the Kew laboratories of Bush Radio; and a G.P.O. colour bar generator.

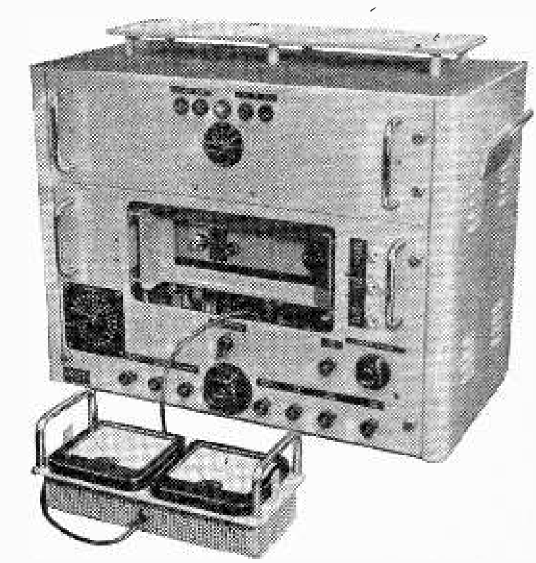
The B.B.C. transmissions were received in the normal way and distributed by a standard "Belling-Lee" distribution system.

The colour slide scanner and encoding equipment at Kew was used to modulate an amateur television transmitter (call sign G3ILI/T) operating on 439 Mc/s. This was received on a stack of four six-element Yagi aerials, converted to Channel 2 and fed into the distribution network.

The G.P.O colour bar generator was noteworthy for its considerable economies in size and number of valves. These were accomplished by feeding the output from the colour sub-carrier oscillator along a delay line with an imperfect magnetic shield. Pickup coils mounted along the delay line at positions appropriate to the phase-shift required for any particular colour have their outputs gated and combined with synchronizing pulses into a composite colour bar pattern waveform. This, too, was used to modulate a carrier which was fed into the distribution system.

Mention must be made of colour display system developed and exhibited by R. W. Wells. Interference phenomena occurring when linearly polarized light is passed through a substance such as Cellophane can produce colours, the actual hue depending on the position of the molecular "grain" of the Cellophane or the plane of polarization of the light. This method of producing colour is used in front of the display c.r.t. as an infinitely variable subtractive colour filter. Instead

The Ekco colour receiver. The picture on the screen is a test slide from the amateur transmitter G3ILI/T.



The B.B.C. television peak white signal to r.m.s. noise ratio meter. The meter panel is shown in the operating position.

of relying on physical movement of the Cellophane or the polarizing medium to produce the colours (this has always been the downfall of a system of this type in the past) the plane of polarization of the light is shifted by a rotator employing the Faraday effect.

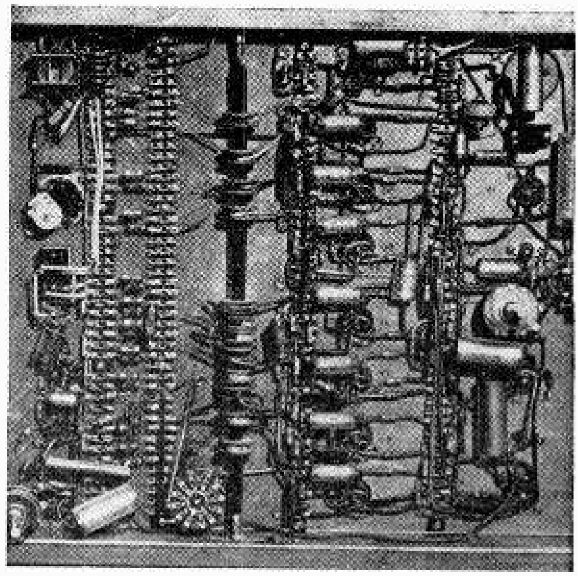
The system is clearly in an early stage of development—possibly on a par with John Baird's original 30-line monochrome demonstrations—but even the two-colour sequential frame demonstration given shows that the system is, in principle, workable.

Test equipment on show included new transistorized pattern generators by Thorn Electrical Industries and Siemens Edison Swan. Both generators employed binary digital techniques, instead of the more usual synchronized "count-down" circuits, to give better long term stability. Thorn were also showing a development model of a generator with a long lock-in time constant so that it could be locked to the mains supply without manual frequency correction.

Siemens Edison Swan had set up the equivalent circuit of a line output stage with a motor-driven capacitor tuning the leakage inductance. The reduction in peak voltage across the transformer and ringing when the leakage inductance was tuned to the third harmonic was seen clearly on an oscilloscope.

The B.B.C. exhibit included a TV signal-to-noise ratio meter. The measurement of the true signal-to-noise ratio of a television system is difficult, because among other factors the synchronizing pulses and camera lens aberrations can upset results. To overcome these difficulties the central portion of a peak white raster is gated out and the d.c. component cancelled, leaving pulses of noise. These are measured on an r.m.s. meter. The output from an internal oscillator (previously set to peak white amplitude) is then applied to the meter, and a calibrated attenuator adjusted to give a deflection equal to that given by the noise. The peak white signal to r.m.s. noise ratio can then be read directly from the attenuator.

The exhibit organized by Norwood Technical College featured methods of adapting class demonstration techniques to present day crowded conditions where each classroom or laboratory is utilized to the maximum possible extent Under these conditions the only time available for setting up demonstrations is the short interval between two consecutive teaching periods. The example of a video amplifier was shown. Individual components could be plugged into circuit with wander

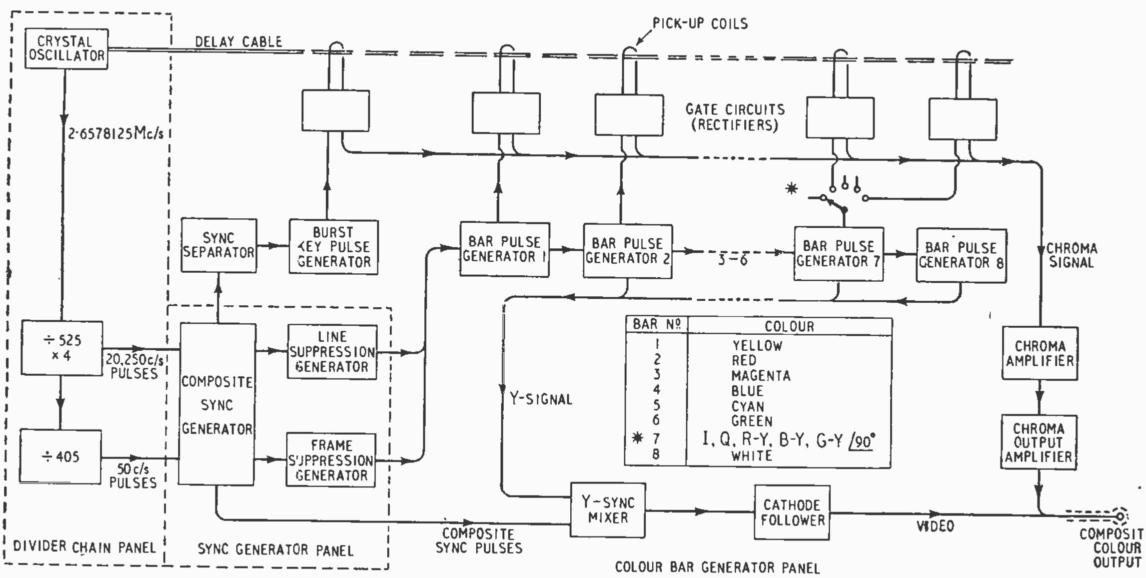


The gating and mixing circuits and delay line of the G.P.O. colour bar generator. (Pat. App. No. 6610/58.)

plugs to simulate the effects of various distortions and to show how compensation for these distortions is applied.

Three firms (Aerialite, "Belling-Lee" and Wolsey) were showing aerials for the present B.B.C. monochrome tests in Band V.

The "Belling-Lee" stand featured aerial development and measurements. Two of the most interesting items on show were a Rohde and Schwarz semi-automatic impedance bridge which indicates directly the impedance of an aerial on a Smith chart and a high speed automatic polar diagram plotter. This displays the polar diagram of a scaled down aerial on the screen of a long persistence c.r.t. The aerial is rotated, this rotation being coupled to the c.r.t. by a magslip. The spot is brightened at a distance from the centre of the tube depending on the signal amplitude, thus displaying the polar diagram of the aerial under test.



Block schematic diagram of the G.P.O. colour bar generator.

Band-V Signal Strength

Investigation of Reception Conditions Along Two Routes Radiating from London

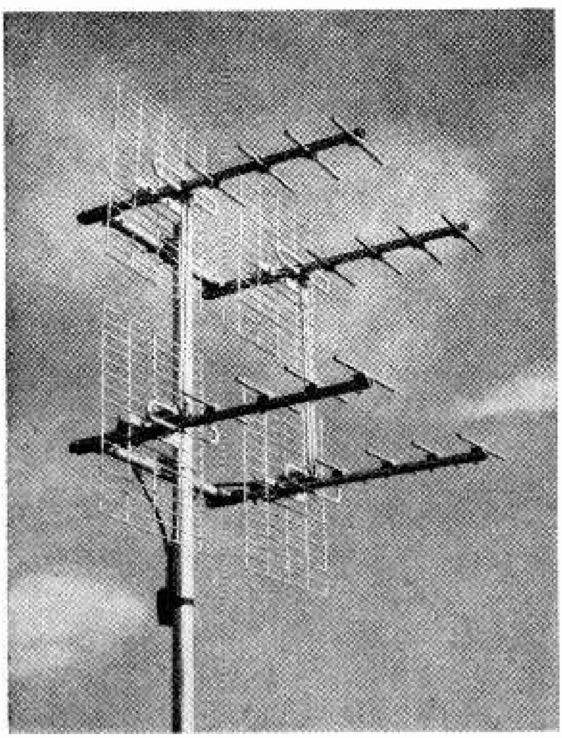
By A. HALE, A.M.I.E.E.*

SINCE the start of the B.B.C. Band-V test transmissions an attempt has been made to determine the effective range of the signals, and to get some idea of the difficulties likely to be encountered in installing aerials. The points of interest so far investigated concern the effect of ground contours on the signal strength, and the local variation of the signal when a receiving aerial is moved small distances in a built-up area.

Ground Contours

The results of two series of measurements of signals over long radials from the transmitter are shown in Figs. 1 and 2. The test procedure was to mount a Band-V aerial at a height of 25ft on a vehicle, and carry out field-strength measurements at frequent points on, or as near as possible on, routes radiating from the transmitter. The readings, expressed as dB relative to 1μV of the voltage appearing at the terminals of the test array, are plotted, and are compared with the height of the ground above sea level. The aerial used on all these tests comprised a standard commercially available "box" array, consisting of four Yagi aerials each having 4 directors, a folded dipole and reflecting screen. The aerial gain was 13dB above a half-wave dipole.

* Belling and Lee Ltd.



The aerial used for the measurements of signal strength on Band V and described in the text.

The two routes covered by Figs. 1 and 2 are basically along roads A5 and A10, stretching as far as Towcester and Cambridge respectively. In all cases readings were taken on good sites, where there was no undue local shielding.

Points of interest are that the range of the transmitter is much greater than was at first expected, and quite good pictures were obtainable at more than 50 miles from the transmitter, providing the receiving site was situated near the top of a hill. It is significant to note that signal strength variations follow the ground contours very closely, and fall to low levels in valleys even close to the transmitter. The type of signal variation is very similar to that found on Band III, but is noticeably more severe.

Local Variations

The curves in Figs. 1 and 2 give an idea of the signal available at a good site, but it was considered likely that screening from buildings could account for very much worse results than these curves indicate. Tests were therefore made using the same aerial but this time connected via a measuring set and short time-constant rectifier to a pen recorder. The aerial mounted on the vehicle then moved down a straight road and signal variations recorded. The aerial was oriented for maximum signal at all times. As a highly directional array was used the signal variations can be assumed to be due exclusively to shielding and standing waves do not affect the result.

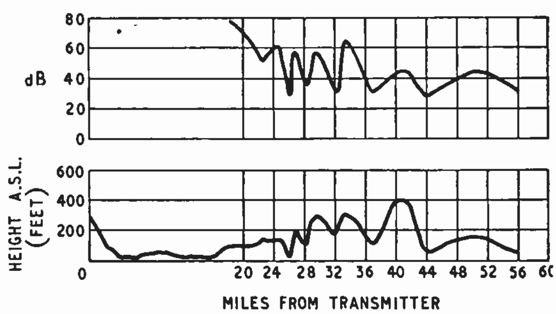


Fig. 1. Variations in signal strength on Band V and contour of country along road A5 towards Towcester

The curve shown in Fig. 3 is the result of a typical part of a test run taken in Bengeo (Hertford) by moving down a road approximately at right angles to the signal path. The road in question was in the middle of a housing estate, and was on a fairly flat hill top. The aerial was at about roof ridge height,

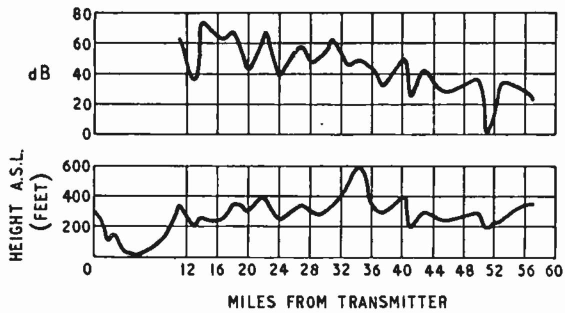


Fig. 2. Variations in signal strength on Band V and contour of country along road A10 towards Cambridge.

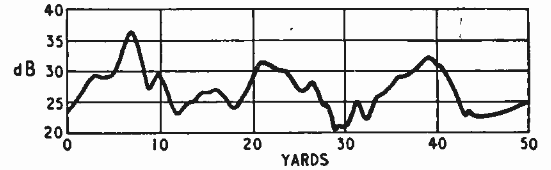


Fig. 3. Local variations in signal strength on Band V caused by proximity of buildings.

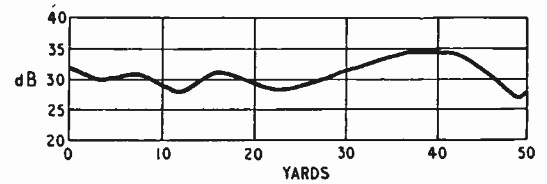


Fig. 4. Local variations in Band-I signal strength in same locality as Fig. 3.

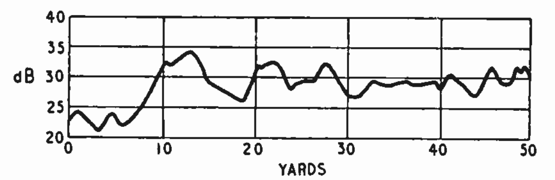


Fig. 5. Local variations in Band-III signal strength in same locality as Fig. 3.

that is at about the same height as normally installed Band-I and -III aerials. For comparison similar curves of the same section of road are shown in Figs. 4 and 5 for Bands I and III respectively. In these cases a "H" and a six-element aerial were used.

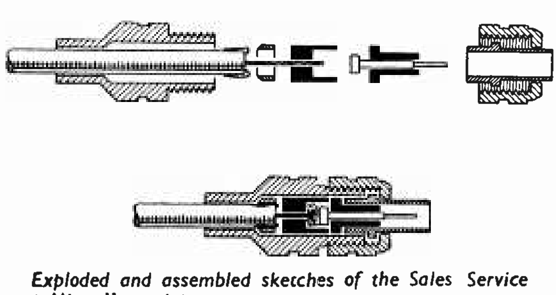
It can be seen that whilst signal variations are very violent, they are much as would be expected from the lower frequency tests. In general, the higher the frequency the more intense the variation of signal.

As a conclusion from these limited tests, it can be deduced that Band-V signals can be received at ranges well beyond the optical horizon, provided the receiving site is well placed. Conversely, close to the transmitter, a bad site in a valley may be unable to receive signals. In all cases, it is very necessary to move the aerial around the site and select a position where the signal is strong. This advice has been given many times for Band III, but on Band V the procedure becomes essential, and the aerial cannot be fixed in the most convenient place regardless of the signal strength.

Sub-miniature Plugs and Sockets

A RANGE of tiny coaxial plugs and sockets, which rightly justify the description sub-miniature as they are designed to take a coaxial cable only ⅛in in diameter over the outer polythene insulation, is now obtainable from Sales Service, Pathway, Radlett, Herts. They are known as "Micro" connectors. The plug part of the connector, which is made of nickel-plated brass, measures just under ⅞in long and ¼in diameter overall. As shown in the exploded drawing, the plug consists of five parts, and this drawing shows also the method of assembling the cable.

There is also a moulded-type plug connector in which the outer insulation forms an integral part of the cable insulation. These are normally supplied with a cable of specific length and with a plug at one or at both ends, normal lengths of cable being 13in, 3ft or 3yd. Other lengths of cable with moulded-plug terminations can be supplied to special order.



Exploded and assembled sketches of the Sales Service "Micro" coaxial connector.

All connectors are rated for 250V working and a loading of 1A. The samples examined had ebonite insulation and thus primarily suitable for use at a.f. A new series with p.t.f.e. insulation and polystyrene mouldings will shortly be available and these will cater for v.h.f. and u.h.f. applications.

The socket part is available in several different styles comprising flush-mounting (as shown in our illustration), stand-off mounting with two styles of fixing flanges and upright mounting with what is described as a "hank-bush" base.

The connectors embody a "click" locating mechanism which provides sufficient lock to secure the plug under all normal conditions of use. Considering the type of connector prices are quite reasonable, sockets cost from 2s 6d to 5s each and the plug 5s 6d. Cellular polythene coaxial cable in 50-Ω and 72-Ω types and measuring ⅛in outside diameter is also available. The capacitance is 30pF/ft and the attenuation about 12dB per 100ft at 200 Mc/s.

"The Magnetodynamic Pickup." We regret that the sensitivity of this pickup was given, on p. 142 of the March issue, as 44 mV/cm/sec. This should, of course, have been 4 mV/cm/sec

WORLD OF WIRELESS

N.P.L. Reorganization

CHANGES in the organization affecting the work undertaken by four sections of the National Physical Laboratory are announced by the Department of Scientific & Industrial Research. The work previously carried out by the Divisions of Electricity, Metrology and Physics and in the Test House, will in future be undertaken by three new divisions to be known as Standards, Applied Physics and Basic Physics.

The Standards Division will be responsible for all fundamental work on standards of length, mass and time, of electrical and magnetic quantities and also of temperature. Basically it will consist of the present Metrology Division, expanded to include certain work on standards now carried out in the Electricity and Physics Divisions. The superintendent will be Dr. H. Barrell, at present in charge of the Metrology Division.

The Applied Physics Division will be responsible in general for work in the field of classical physics of fairly immediate value to industry (but excluding optics, all of which will continue to be done in the Light Division). The principal areas covered will be electrotechnics, acoustics, heat and radiology. Test House will become an integral part of this division, but will preserve its identity under H. Bowley. The superintendent of the Applied Physics Division will be Dr. B. Wheeler Robinson, in charge of the present Physics Division.

The Basic Physics Division will be responsible for pioneering developments in certain branches of non-nuclear physics which have potential industrial applications in the less immediate future. The post of superintendent has yet to be filled.

Receiver Sales

COMPARATIVE sales figures for domestic receivers for the past three years, issued by the British Radio Equipment Manufacturers' Association, show that the 1957 sales of both sound receivers and radiograms were up by 18% on the previous year. Television receiver sales were down by 3% in comparison with 1956 but up 8% compared with 1955. As the table shows the industry's overall sales have increased each year.

	1955	1956	1957
Television	1.335 M	1.484 M	1.439 M
Sound-only	1.048 M	0.982 M	1.162 M
Radiogramophones	0.269 M	0.212 M	0.250 M
Total sales	2.652 M	2:678 M	2.851 M

The figures for January this year show an 11% increase in television sales compared with last January. Sound receivers show a 3% decrease and radiogramophones a 26% decrease. The proportion of hire-purchase sales for each class of receiver was the lowest for over a year.

Siemens' Centenary

AS part of the celebrations to mark the 100th anniversary of the formation of the Siemens organization in this country, Dr. J. N. Aldington, managing director of Siemens Edison Swan, Ltd., delivered a centenary lecture on 100 years of electrical engineering to an audience of 2,400 in the Central Hall, Westminster, on March 5th. There was also a centenary dinner, attended by 1,200, on March 6th.

"Siemens Brothers 1858-1958" is the title of a book commissioned by the board of directors dealing with the history of the British company, which was originally part of the Siemens & Halske organization in Germany. The 280-page book, written by J. D. Scott, is published by Weidenfeld & Nicolson, price 35s.

To mark the centenary the Science Museum, South Kensington, has set up a Sir William Siemens exhibition, which will remain open for several months.

Trader Year Book

CONDENSED specifications of 250 current television receivers and nearly 400 sound radio receivers are among the many features of the 1958 edition of the "Wireless and Electrical Trader Year Book." Brief specifications of tape recorders and Band III convertors are also given this year and the comprehensive list of intermediate frequencies of sound receivers marketed during the past 10 years has been revised and extended.

The directories of manufacturers, wholesalers and trade names are annual features of this invaluable reference book of the radio and electrical industry. Published by the Trader Publishing Co., Dorset House, Stamford Street, London, S.E.1, it costs 12s 6d (postage 1s 8d).

The Radio Show.—The Radio Industry Council reports that more than 30 manufacturers have signified their interest in the proposal to incorporate an audio section with sound-insulated demonstration rooms at the forthcoming National Radio Show (Earls Court, London, August 27th to September 6th).

R.I.C. Exhibition Technical Committee.—There have been several changes in the composition of the R.I.C. Exhibition Technical Committee. P. D. Canning (Plessey), formerly vice-chairman, takes the place of R. W. Addie as chairman. S. Hill (S.T.C.) is vice-chairman. The other members are W. L. Brown (Belling & Lee), M. A. E. Butler (Philips), M. P. G. Bull (Ekco), R. Chapman (K.B.), A. P. Hale (Belling & Lee), L. A. Isaacson (E.M.I.), T. A. Julian (G.E.C.) and R. W. Murphy (British Radio Corporation).

Broadcast receiving licences in the U.K. at the end of January totalled 14,641,274. Television licences increased during the month by 137,453, bringing the total to 7,898,247. Sound-only licences, including 327,266 for car radio, totalled 6,743,027.

Electronic Engineering Association.—The words "Radio Communication" have been dropped from the title of the R.C.E.E.A. so that in future it will be known as the Electronic Engineering Association. The council for 1958 consists of the following representatives of member firms: F. S. Mockford (Marconi's), chairman; V. M. Roberts (B.T.H.), vice-chairman; F. J. Dellar (Cossor), C. H. T. Johnson (Decca Radar), F. J. Preston (E.M.I.), J. N. Toothill (Ferranti), C. G. White (Kelvin & Hughes), L. H. J. Phillips (Metropolitan-Vickers), R. R. C. Rankin (Mullard), K. S. Davies (Murphy), P. D. Canning (Plessey) and L. T. Hinton (S.T.C.). The new chairman of the Association's General Technical Committee is E. S. Hall (B.T.H.), with E. P. Fairbairn (G.E.C.) as vice-chairman.

Mechanical Handling.—Among the 350 or so exhibitors at the Mechanical Handling Exhibition, which opens at Earls Court, London, on May 7th for 11 days, are seven firms showing electronic and electrical control equipment. They are B.T.H., Cass & Phillip, E.M.S. Electrical Products, English Electric, Igranic Electric, Metropolitan-Vickers, and Sharp Control Gear. The exhibition, the 6th organized by our associate journal *Mechanical Handling*, will for the first time include overseas exhibitors. Tickets for admission to the exhibition and convention are obtainable free from *Mechanical Handling*, Dorset House, Stamford Street, London, S.E.1.

Third Production Exhibition, sponsored by the Institution of Production Engineers, opens on May 12th at Olympia, London. Among the speakers at the Conference organized in connection with the exhibition will be Dr. F. H. George of Bristol University, who will deal with cybernetics (May 15th) and Dr. F. Koenigsberger, Manchester College of Science and Technology, who will discuss the design of machines for electronic control (May 16th). The show closes on May 21st.

Douglas, Isle of Man, v.h.f. station, which has been transmitting experimentally since before Christmas, was brought into regular service on March 9th. The transmitter radiates the Home Service only on 92.8 Mc/s with an e.r.p. of 6kW.

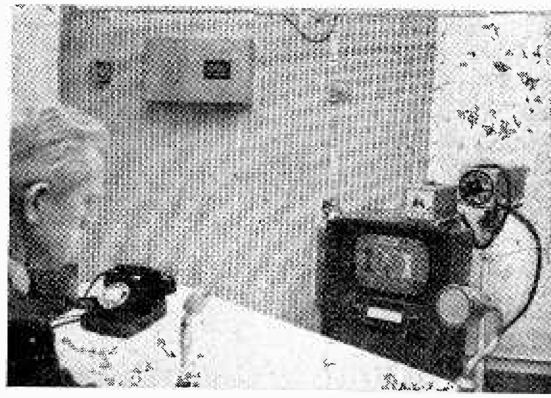
I.E.E. Scholarships.—Seven research and graduate scholarships (valued at from £100 to £500 p.a.) and eight student scholarships (£25-£200) are being offered by the I.E.E. this year. Conditions governing the awards, and application forms are obtainable from the I.E.E., Savoy Place, London, W.C.2. Applications for student scholarships must be received by May 1st and for graduate and research scholarships by June 2nd.

High-Quality Reproduction.—For the third year the Northern Polytechnic (Holloway, London, N.7) has arranged a series of ten lecture-demonstrations on high-quality sound reproduction. The two-hour lectures will be given each Tuesday from April 29th at 6.30. Admission is limited to 150. Further details are obtainable from J. C. G. Gilbert, head of the Polytechnic's department of telecommunications.

Subscription TV.—Rediffusion, Ltd., announce that the arrangements between themselves and Skiatron International Corp., of America, referred to on page 2 of our January issue, have not been brought into force.

Antarctic Communications.—During their trans-Antarctic journey Dr. Fuchs and his party carried two Army Type C12 sets manufactured by Pye Telecommunications.

"Portable Transistor Receiver."—A reprint of this constructional article which appeared in our May and July issues last year, is now available from our publishers. The reprint, which also includes the further notes published in the September issue, costs 2s 6d.



UNATTENDED TV STUDIO.—The camera and lights in this studio at Westminster are controlled from Alexandra Palace (the News Centre) eight miles away. It is used for on-the-spot reports by the B.B.C.'s Parliamentary correspondents. The speaker can see himself in the monitor on top of the receiver which shows the transmitted picture.

"Language and Speech."—A new quarterly journal is to appear in April under this title. Under the editorship of Dr. D. B. Fry, of the department of phonetics, University College, London, it will cover psychological, physiological, statistical and technical aspects of research in speech and language.

Standard Frequency Transmissions.—A new edition of "MSF," the pamphlet giving the schedule of standard frequency transmissions from the Post Office station at Rugby, has been issued by the Department of Scientific and Industrial Research.

Abstracts and References.—Over 4,000 abstracts from and references to articles in the world's technical press were published in *Electronic & Radio Engineer* last year. The annual index to this regular monthly feature of our sister journal costs 2s 6d.

CLUB NEWS

Bexleyheath.—The North Kent Radio Society meets on alternate Thursdays at 7.30 at the Congregational Hall, Chapel Road. On April 10th C. Leal (G3ISX) will speak on "An approach to aerials for the beginner." Sec.: D. W. Wooderson, 39, Woolwich Road, Bexleyheath.

Bradford.—"Oscilloscope interpretation" is the title of the talk to be given by G. F. Craven to members of the Bradford Amateur Radio Society on April 15th. A fortnight later A. Walker (G3DAR) will speak about single sideband. The club meets at 7.30 at Cambridge House, 66, Little Horton Lane, Bradford. Sec.: D. M. Pratt (G3KEP), 27, Woodlands Grove, Cottingley, Bingley.

Leicester.—Meetings of the Leicester Amateur Radio Society are held each Monday at 7.30 at Old Hall Farm, Braunstone Lane, Leicester. At the meeting on April 14th P. G. Goadby (G3MCP) will deal with the "Cub" transmitter and on the 28th R. G. Frisby (G2CFC) will discuss aerials. Sec.: P. G. Goadby, 535, Welford Road, Leicester.

North Midland Mobile Rally is being organized jointly by the Midland Amateur Radio Society and Stoke Radio Society for April 20th. It will be held at Trentham Gardens (between Stoke and Stafford). Particulars are obtainable from P. G. Turton, 2, Holloway Head, Birmingham, 1.

Sidcup.—At the meeting of the Cray Valley Radio Club at 8.0 on April 22nd at the Station Hotel, Sidcup, C. Burgess will deal with some aspects of directional aerial design. Sec.: S. W. Coursey (G3JJC), 49, Dulverton Road, New Eltham, London, S.E.9.

Personalities

Sir James Swinburne, Bart., F.R.S., who celebrated his 100th birthday on February 28th, was chairman of Bakelite, Ltd., until his retirement in 1948. He is now honorary president of the company. A consultant electrical engineer by profession, he turned his attention to the development of synthetic resins and in 1910 formed Damard Lacquer Co., which in 1926 became Bakelite, Ltd. Sir James was president of the I.E.E. in 1902.

SIR JAMES SWINBURNE

W. WOODS-HILL

W. Woods-Hill, contributor of a number of articles to *Wireless World* on computer techniques, has joined the Microcell Group as manager of computer developments. He was previously manager of the calculator research laboratories of the British Tabulating Machines Co. He spent several years in R.A.F. radar and radio development units during the war and was at one time liaison officer attached to the French air force during the installation of its radio school at Auxerre, Yonne. Mr. Woods-Hill operates amateur station G4JV.

Edward Lee, M.Sc., Ph.D., director of operational research in the Royal Naval Scientific Service for the past three years, has been appointed to the newly-created post of deputy director of the Research Council of the D.S.I.R. Dr. Lee, who will take the main responsibility for work in the National Physical Laboratory concerned with immediate demands from industry, joined the staff at the Admiralty Research Laboratory in 1939.

F. S. Mockford, re-elected for his third term of office as chairman of the R.C.E.E.A. (now re-named the Electronics Engineering Association), has been commercial director of Marconi's Wireless Telegraph Co. since 1947. He is also a director of Scanners, Ltd. Before joining Marconi's in 1930 he was for some years in charge of radio at Croydon airport.

Dr. John Douce, of Manchester University, has been retained by Servomex Controls, Ltd., as consultant to advise them on theoretical problems arising in the field of non-linear control systems, and systems subject to random fluctations.

W. J. Lloyd, B.Sc., A.M.I.E.E., has joined Short & Mason, Ltd., the scientific instrument manufacturers, as general manager. He was at one time in the scientific instrument division of Sunvic Controls, Ltd., and was until recently sales manager of Technograph Electronic Products.

W. R. Fletcher, B.Sc.(Eng.), A.M.I.E.E., has been appointed Regional Engineer, B.B.C. North Region, in succession to **B. H. Vernon,** who has retired owing to ill-health after nearly 35 years' service with the Corporation. Mr. Fletcher joined the Engineering Division of the B.B.C. in 1936 and has served at a number of stations. In 1949 he was seconded from the B.B.C. to serve as chief engineer of Radio Ceylon, and last year was appointed resident engineer at the British Far Eastern Broadcasting Station near Singapore.

B. A. Hensler, who is appointed to the board of Siemens Edison Swan, Ltd., joined Siemens Brothers in 1929 and throughout the war was concerned with production control of radar calculator equipment and technical liaison work on airborne and other types of radar. He became general manager and chief engineer of Siemens' telephone branch in 1954 and since the merger of Siemens and Edison Swan has been managing director of Siemens Edison Swan (Export), Ltd.

With the completion of the merger of Siemens and Edison Swan the company was split up into a number of product divisions each of which is to have a chief engineer. **T. H. Partridge,** A.C.G.I., D.I.C., A.M.I.E.E., who was chief engineer of the marine division of Siemens Bros., has been appointed to the same post in the new company. He had been with Siemens since 1929 where he was for some years in charge of the radio division. He is a member of the C.C.I.R. study group concerned with operational-technical problems. **J. A. Pim,** B.Sc.(Eng), Ph.D., M.I.E.E., is chief engineer of the telecommunication transmission division. After graduating at University College, London, he joined the G.E.C. and in 1942 went to the R.A.E., Farnborough. After the war he returned to University College to work for his Ph.D. Dr. Pim joined Siemens in 1948 and in 1954 became head of the line transmission laboratory at Woolwich. **F. Sibbald,** B.A.(Eng.), is chief engineer of the company's Tottenham Works where he is responsible for the special products department and the radio components department. Prior to joining the company last year he was engineer in charge of designs at the E.M.I. Greenford establishment.

R. W. Elliott, D.F.H., Grad.I.E.E., who has been with Belling & Lee for five years, has become senior technical representative in succession to **P. A. Clayton,** who is now sales manager of Amphenol (Great Britain), Ltd. Mr. Elliott was formerly on the research and development staffs of Decca Radar and Elliott Brothers.

R. W. ELLIOTT

D. H. W. BUSBY

D. H. W. Busby has joined Beam-Echo, Ltd. the Witham, Essex, manufacturers of Avantic sound equipment, as chief engineer. He was previously in Mullard's application research laboratory, where he was engaged on the development of audio-frequency equipment.

W. Williamson, assistant inspector of wireless telegraphy, has retired from the Post Office after nearly 46 years in telecommunications. He had served at a number of Post Office transmitting and receiving stations, first as an operator and subsequently in administrative posts. After the last war he was concerned with the re-organization of coast radio stations. Recently he has been responsible for the P.M.G. certificate examinations.

H. J. H. WASSELL

H. J. H. Wassell, O.B.E., B.Sc., chief radar engineer of Marconi's since 1955, has been appointed manager of the company's newly created test department. He has been with Marconi's since graduating from Birmingham University in 1929. He was for some years chief of the transmitter development group. The new chief radar engineer is **J. K. Todd**, M.A. (Cantab.), A.M.I.E.E., who joined Marconi's in 1937. He has been chief of the missile radar research group since 1956.

L. Newnham, B.Sc., the new president of the R.S.G.B. has been closely associated with technical education throughout his teaching career and was for some time on the staff of the R.A.F. Radio School, Cranwell. He has been a licensed operator since 1926, his present call being G6NZ. Mr. Newnham is at present headmaster of Eastney Secondary School, Portsmouth.

G. D. Clifford completed 21 years as secretary of the British Institution of Radio Engineers on March 3rd. Until 1944 he acted in an honorary capacity. For some years before joining the staff of the Institution he was a recording engineer with the Columbia Graphophone Co. and also a part-time teacher of radio theory. Among the many committees on which he represents the Institution is the Parliamentary and Scientific Committee of which he has been a member since 1940.

K. Short, D.L.C.(Hons.), A.M.I.E.E., for many years with Truvox, recently formed his own company, Recording Devices, Ltd., to manufacture tape recording equipment and accessories. The company is initially marketing an Austrian tape recorder, the Stuzzi Mambo. Mr. Short left Truvox, of which he had been chief engineer and technical director, in 1956, and was for 15 months director of production with British Communications Corporation (an associate company) from which he resigned last August.

Dennis G. Packman, appointed chief engineer of Tyne Tees Television, Ltd., programme contractors for the I.T.A. North East England transmitter, was with the B.B.C. from 1944-1955. He then joined Central Rediffusion Services, Ltd., as an engineer in the television department. He became head of the department a few months ago. He is 30.

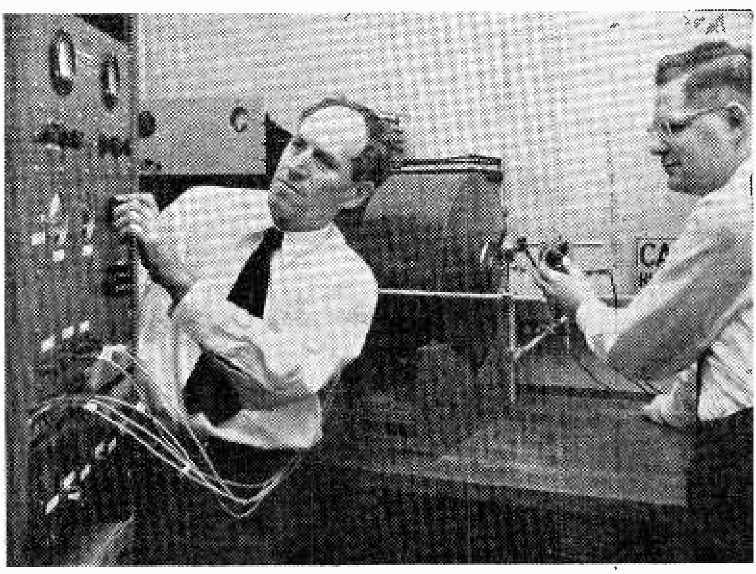
N. G. Worster, A.M.I.E.E., is appointed chief development engineer of Measuring Instruments (Pullin), Ltd. He was previously with S. Smith & Son (England), Ltd.

OUR AUTHORS

J. N. Barry, M.Sc., who, with G W. Secker, discusses the use of transistors in television receivers in this issue, joined the G.E.C. Research Laboratories in 1946 after a year at R.A.E., Farnborough. He is at present engaged in the application of semi-conductor devices to electronic telephone exchanges, having previously been concerned with their uses in domestic entertainment equipment. He is 32. **G. W. Secker** has worked on the application of semi-conductors in sound and television equipment since joining the G.E.C. Research Laboratories in 1953. After war service as a wireless operator-mechanic in the R.A.F. he joined the Communications Branch of the Home Office where he was concerned with the design and installation of police v.h.f. equipment.

D. J. Collins, B.Sc.(Eng.), A.M.I.E.E., one of the authors of "Stabilized E.H.T. Unit," has been with Solartron Research and Development since 1952. For the previous five years he was with E.M.I. Engineering Development, where for three years he worked on guided weapon projects. He obtained his London University engineering degree in 1950, after a part-time course at Northampton Polytechnic. His co-author **J. E. Smith**, B.Sc., joined Solartron in 1956. After obtaining his degree from Durham University in 1952 he did his national service as an "electrical" officer in the navy and then went to Decca Radar for two years.

J. R. G. Twisleton, B.Sc., A.M.I.E.E., contributor of the note on p. 193. has been in the B.T.H. Research Laboratory since graduating from Leeds University in 1949. He has been working on the development of microwave valves and his interest in exponential horns, about which he writes in this issue, is purely a spare-time activity.



Dr. Rudolf Kompfner, *who came to this country from Austria in 1934 and since 1952 has been in the U.S.A., is now director of electronics and radio research at the Bell Telephone Laboratories, New Jersey. From the end of the war, during which he was at Birmingham University, until going to the U.S.A. he was in the Clarendon Laboratory, Oxford. Dr. Kompfner, originator of the travelling-wave valve which he first described in* **W.W.** *in November 1946, is here seen (left) with C. F. Hempstead working on a 5-mm backward-wave oscillator.*

News from the Industry

Solartron Electronic Group, which includes seven companies in this country, one in the U.S.A. and another in Italy, had a turnover of over £1M during the year ended last June. In the Group's annual report the chairman, John Bolton, announced the introduction from January 1st of a two-year guarantee on all the company's equipment.

V.H.F. Transistors. — Production at the recently completed Swindon factory of Semiconductors, Ltd., will begin by the middle of this year with germanium surface-barrier transistors for operation in the 30 to 90 Mc/s range and micro-alloy diffused transistors for operation up to 500 Mc/s. Later this year silicon surface-alloy transistors will be made specifically for requirements involving high-temperature operation.

Decca House, 9, Albert Embankment, London, S.E.11, is the new headquarters of the Decca Group of companies (Record, Radar and Navigator). The telephone number is unchanged (Reliance 8111). Decca Radio & Television will remain at 1-3, Brixton Road, London, S.W.9, but with a new telephone number (Reliance 6011).

Instrument Shows. — Rohde & Schwarz, Narda, and Cascade should not have been included among the exhibitors at the International Instruments Show given in our last issue. Their agents, Aveley Electric, are, however, exhibiting their equipment at the Instruments, Electronics and Automation Exhibition.

Radio Heaters, Ltd., supplied a modified Radyne heater to provide the r.f. voltage to ionize heavy hydrogen gas in ZETA described last month.

Soundrite, Ltd., of 83, New Bond Street, London, W.1, have been appointed sole U.K. distributors and agents for Altec Lansing Corp., the well-known microphone manufacturers, and Stancil Hoffman Corp., makers of specialized recording equipment, both of California.

Partridge Transformers, Ltd., have not moved although their address has been changed to Roebuck Road, Chessington (not Tolworth), because of new Post Office sorting arrangements in the area.

R. B. Pullin & Co., Ltd., have opened a new six-storey factory, providing a floor space of 70,000 square feet, at their Phœnix Works, Brentford, Middlesex.

Rank-Cintel is the new name of **Cinema-Television, Ltd.,** a member of the Rank group of companies.

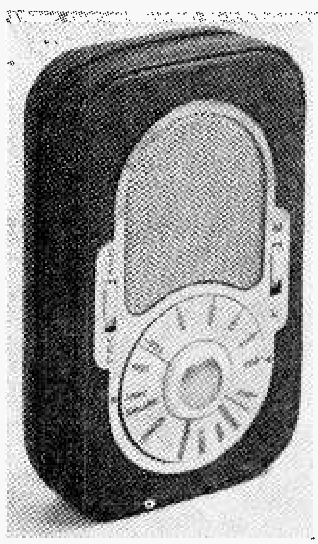
Bendix. — As announced last month, Elliott Brothers have discontinued the sale and servicing of American-made Bendix equipment. Field Aircraft Services, Ltd. (72, Wigmore Street, London, W.1), one of the Hunting-Clan group of companies, have been appointed sales and servicing representatives of the Bendix Aviation Corp. in the U.K. Field's have now opened a new radar and radio centre at London airport.

Cawkell Research & Electronics, Ltd., 6-8, Victory Arcade, Southall, Middlesex, has been formed to extend the activities of the former A. E. Cawkell, electronic engineers, of the same address. (Tel.: Southall 3702.)

Electrical Remote Control Co., manufacturers of low-voltage soldering irons, relays and control equipment, have moved to a new factory on the industrial estate of Tye Green, Harlow New Town, Essex (Tel.: Harlow 24032).

Woden Transformer Co.'s extensions to their factory at Bilston, Staffs., will add a further 20,000 square feet of floor space.

Ariel Sound, Ltd., have moved from Paddington to North London Iron Works, Wenlock Road, London, N.1 (Tel.: Clerkenwell 7184).



PERSONAL PORTABLE presented to H.M. The Queen by the Radio Industry Council. Specially made by Roberts Radio, the transistor receiver covers both the long- and medium-wave bands. The set, measuring 6½in x 3¾in x 1¼in, is in a red leather zip-fastened case.

OVERSEAS TRADE

A record figure for January exports is announced by the Radio Industry Council. The month's total of £3.78M was over half a million pounds more than the January 1957 figure.

Industries Group Sales, Ltd., was recently set up with offices at 7 Rugby Street, London, W.C.1, to act as an "extended selling organization," especially in Eastern Europe and China, on behalf of a cross-section of British industry. It is proposed to open an office in Warsaw. Among the firms in the radio and electronics field who have joined the enterprise are Advance Components, Aerialite, Ardente, Dulci, Duratube & Wire, E.M.I. Electronics, Fielden, Murphy, Racal, Radiovisor, Short Bros. & Harland, Winston Electronics.

Canadian Visit.—A team of seven senior executives from member firms of the Scientific Instrument Manufacturers' Association, led by L. A. Woodhead (Cossor Instruments) is on a goodwill visit to Canada. The other members of the team are D. A. Pitman (Electronic Instruments), P. Schilling (Stanton Instruments), V. A. Sheridan (British Physical Laboratories), D. R. Stanley (Hilger & Watts), W. H. Storey (Unicam Instruments), J. R. Waite (Oertling).

Radio *v* Rustlers.—A v.h.f. radio-telephone system linking 14 police posts with a central headquarters has been installed in the Karamoja district of Uganda to assist in combating the sporadic raids of local tribes on the herds of neighbouring villages. The system is a further extension of the country-wide h.f. and v.h.f. network installed by Marconi's for the Uganda police during the past four years.

Greek Television.—The Hellenic National Broadcasting Institute is seeking tenders for the supply and installation of a central television transmitting station near Athens. The transmitter is for operation in Band III on the 625-line standard with f.m. sound. The specification (reference ESB/2839/58) is obtainable from the B.o.T. Export Services Branch, Lacon House, Theobalds Road, London, W.C.1.

High-Fidelity Equipment.—J. M. Feiring A/S, Lilletorvet 1, Oslo, Norway, are interested in obtaining the representation of United Kingdom manufacturers of microphones, loudspeakers, amplifiers and pre-amplifiers.

Atomic Electrons in Action

From Piccadilly Circus to the Ionosphere

By "CATHODE RAY"

THIS is the stage in our examination of the atom at which it is all too easy to get lost in a maze of detail. Mind you, it is very fascinating detail, and that is all the more reason why we shall have to be resolute in ignoring most of it.

Last month we had the Bohr picture of the atom, with its electrons revolving around the nucleus in clearly defined and easily calculable orbits like planets around the sun, snatched away and replaced by the Schrödinger picture, in which the electron orbits are blurred into hazes of probability. The justification for this apparently unsatisfactory bargain was that either way it is known that the electron can possess only certain fixed amounts of energy and therefore only certain possible orbits, but whereas in the Bohr picture this is just an observed fact with no apparent reason, in the Schrödinger picture it all comes out as a necessary result of the nature of the atom assumed in wave mechanics. The basic equation of wave mechanics indicates the allowable amounts of energy and the shapes and sizes of the corresponding hazes.

Salient Points

If we went into full detail about all the possible electron haze patterns in the atoms of the 92 and more elements—to say nothing of their innumerable compounds—we would soon get bogged down, so I shall try to pick out the main points that concern us:

(1) Each element is identified by the *normal* number of electrons in each of its atoms; i.e., the number needed to neutralize the positive charge of its core or nucleus. (Atoms that lose or gain one or more of their electrons remain the same element, but have a positive or negative electric charge and are called ions.)

(2) Each electron in an atom has a certain amount of energy; partly kinetic (due to its speed of movement around the nucleus) and partly potential (due to its distance from the nucleus).

(3) Its total energy being known within close limits, its position is indefinite (Heisenberg's Uncertainty Principle), but wave mechanics enables on to calculate the relative probability of its instantaneous whereabouts in relation to the nucleus.

(4) There is a series of possible probability patterns or hazes, each identifiable by a four-figure code, and each corresponding to a certain energy level of the electron. The farther from the nucleus (on the average) the greater the energy.

(5) In any atom, not more than one electron can occupy any one of these levels or states at a time (Pauli's Exclusion Principle).

(6) An electron can move suddenly from one level to another, provided it gives out or receives an amount of energy equal to the difference. When there is no incoming energy the electrons settle down into the lowest energy levels, like a "snowstorm" paperweight when it is not being shaken.

Points (1) to (5) are just a recapitulation; (6) is our main subject this month. To illustrate it, let us take a look at a few typical atoms.

We have already glanced at hydrogen, which being No. 1 in the list of elements normally has only one electron. A diagram of the state this electron is normally in—at low temperatures, anyway—showed its most probable distance from the nucleus to be 0.53Å ($1Å = 10^{-8}$cm). The distribution of probability is the same in all directions from the nucleus, so the electron can be visualized as a spherical haze around it. The code for this state can be written as 1.0.0. If you object that this is only a three-unit code, I will remind you that the fourth does no more than specify in which of the two possible directions the electron itself spins, and for our present purpose that is not really important.

What *is* important is that besides the fourth number being limited to two alternatives there are certain restrictions on the second and third; namely that the second number must always be less than the first, and the third not greater than the second (but it can be either + or −). So the next state must be 2.0.0. It represents another spherical haze, or rather two concentric hazes, larger and more diffuse than the first. The next, 3.0.0, is three concentric hazes, still larger. But still indicating the relative position-probability of one electron. And so on.

Besides these spherical states, there are those with the second figure higher than 0, represented by what may approximately be described as "dumb-bell" shapes in the Schrödinger picture. Although it is possible for the single hydrogen electron to be pushed up into these states, they are of more interest when there are enough electrons to fill them normally, so we shall return to them later.

Electron Energy Change

In the meantime it will be interesting to find out how much the energy of the electron has to change in order to move from one level to another. Planck's law ($E=hf$) then tells us the frequency of the radiation causing or being caused by the change.

Seeing that one reckons the potential energy of a weight in terms of its height above ground level—which is regarded as zero—it might be supposed that the potential energy of the electron is reckoned from the position of the nucleus as zero. But the comparison is wrong; whereas the force of gravity is practically uniform near the earth's surface, a nucleus is so nearly a point charge that the force between it and an electron is very nearly inversely proportional to the square of the distance between them, so becomes indefinitely large as they approach closely. So it is usual to reckon zero potential (which corresponds with height in the gravitational analogy) as being at an infinite distance from the nucleus. This custom has the slight disadvantage of making all values negative. But since it is only *differences* of potential that matter, the results are the same whatever zero is chosen.

According to the ordinary laws of electricity, the potential at a distance r metres from a charge of q coulombs is

$$\frac{q}{4\pi\epsilon r}$$

where ϵ is the absolute permittivity in m.k.s. units. In this system $1/4\pi\epsilon$ is 9×10^9, and for one electron or hydrogen nucleus q is 1.6×10^{-19} as we have seen. If we put $r=0.53\times10^{-10}$ to represent the lowest energy state of a hydrogen atom, the potential works out at 27 volts. (Surprising, isn't it, that calculations with such fantastically small quantities should yield such an everyday thing as 27 volts!) An electron at that distance therefore has a potential energy of -27 electron-volts (eV). But according to the ordinary laws of mechanics as used in the Bohr picture (and the wave-mechanics picture agrees so far as its haziness allows) the electron has to keep itself from falling by moving around the nucleus at a speed which gives it a kinetic energy equal to +13.5eV. So the total energy is -13.5eV.

To remove the electron to an infinite distance from the nucleus one must therefore give it an additional energy of 13.5eV. (Compared with 10^{-10} metre, a very short removal distance by ordinary standards is near enough to infinite for us to be able to say that the electron has been knocked clean out of the atom.) According to Planck's law the frequency f of energy E is E/h, and h (Planck's constant) is 4.1×10^{-15}eV-sec; in this case f is $13.5/(4.1\times10^{-15})=3.3$kMMc/s, which is well into the ultra-violet band of radiation (see Fig. 1). Ordinary light, then, cannot ionize hydrogen atoms—at least, not if they are in their basic state. But another electron travelling fast enough can, by giving up some of its kinetic energy.

Radiation Frequencies

The energies in the other spherical states are found by dividing by n^2, n being the first number in the code, and known, incidentally, as the principal quantum number. So we have -3.4eV, -1.5eV and -0.85eV as the energies in the second, third and fourth states. The change in energy on passing from the first to the second is $-3.4-(-13.5)=$ 10.1eV. The frequency of radiation needed to bring this about, though lower, is still in the ultra-violet band. Other isolated radiation frequencies are right for pushing electrons up from, say, first to third or fourth, second to fourth, etc., and some of these are obviously in the visible band. So when hydrogen is exposed to radiation covering a broad band of frequencies, it is found on using a spectroscope to examine the light which gets through that there are a number of dark lines, showing these isolated frequencies at which light energy is absorbed by electrons. This is rather like the absorption crevasses one would get on examining with a wobbulator and oscilloscope an electrical circuit with a number of acceptor resonances.

The tendency for electrons to occupy the lowest energy levels soon asserts itself, however, and in fact the "excited" electrons drop back again after a lapse of only about 10^{-8} second, which by comparison makes lightning seem sluggish. In doing so they give up their energy in the form of radiation. Since this radiation has the same frequencies as the original exciting light, it is not very conspicuous; but we remember that atoms can also be excited by bombarding them with electrons. One way of doing this would be to let a little hydrogen into a valve or cathode-ray tube, and the result would soon be visible as a glow inside the tube. It can be done more cheaply and conveniently in a plain tube fitted with cathode and anode. If this glow is examined with a spectroscope, it shows up as a number of bright lines corresponding in frequency to the previous dark ones. All this sort of experimentation was done long before the quantum theory, and it was the agreement between the consequences of the quantum theory and these experimental results which indicated that the theory was on the right lines.

Higher Atomic Numbers

Element No. 2 is also a gas—helium—and its nucleus has of course twice the positive charge of hydrogen, normally neutralized by two satellite electrons. All three particles attract or repel one another, and in ordinary dynamics the problem of three such bodies is notoriously insoluble. Again, wave mechanics comes to the rescue. In the normal or lowest-energy condition the two electrons are both in the 1.0.0 state, and differ only in their opposite directions of spin. In accordance with the rules already mentioned, there can be no other states in which the principal quantum number n is 1. So the two electrons in it complete the $n=1$ community, which is also known as the K shell, or (by us) the first table in the atomic restaurant. The greater charge of the nucleus draws the electrons closer than in the hydrogen atom, and an energy of 24.5eV is needed to remove either of them. This is quite a large amount, so helium electrons are stay-at-homes and show no tendency to flirt with those of other elements. Helium, in fact, does not combine chemically with anything else. Its pair of electrons is a highly stable group, closely bound to the nucleus.

The next element is lithium, with three electrons; and since two of them normally occupy the whole of the $n=1$ (or K) shell the third can get no nearer the nucleus than the $n=2$ (or L) shell. According to the rules already stated, this can include several pairs of electron states: 2.0.0, 2.1.0, 2.1.1 and 2.1.-1. The first of these is our second spherical haze; the other three are non-spherical, but add up to give a spherical group which is very stable. Of the four, the 2.0.0 has the lowest energy, so the third lithium electron is normally found there. The attractive force of the +3 charge of the nucleus is considerably reduced by the repulsion of the two inner electrons, so the third electron is relatively loosely bound. Only 5.5eV is required for complete ionization, and quite small amounts for raising it to the slightly higher 2.1 set of levels. Lithium is the lightest of the metals, and readily combines with other elements, especially those that have one vacancy in a shell.

In atoms of successively higher atomic number, the electrons first fill up the remaining vacancies in the L shell. Since there are four possible sub-groups, each with a pair of oppositely-spinning electrons, its total capacity is 8. Added to the 2 in the K shell this makes 10, so we would expect element No. 10 to be another stable one like helium. And we would be right, for it is neon. When this gas is bombarded by electrons, many of its own electrons are made to move between two levels having an energy difference corresponding to the frequency of orange-red light. Other gases have excitation frequencies interpreted by the eye as green and blue. The results of such continuous atomic rearrangements can be studied in Piccadilly Circus and such places, where the bright colours are used to attract the attention of the unsophisticated.

The first two shells being full, element No. 11 must have one electron in the third, and this electron finds itself in the same sort of position as the odd one in lithium, only more so. We would therefore expect it to be a similar sort of element—chemically a very active metal. And so it is. If you drop some of it—sodium—into water you will be left in no doubt about its chemical activity. When its vapour is excited, it has a most notable radiation frequency seen as yellow. Besides being an extremely sensitive test for the presence of sodium—there is enough in almost any speck of dust to give a yellow flash when it passes into a flame, as one can see by looking at a freshly-lit gas fire—it makes an exceptionally efficient form of electric lighting. Since sodium is solid at ordinary temperatures, the discharge has to be started through neon, which is why sodium street lights glow dimly red at first and gradually turn bright yellow as they warm up. Another much used filling is mercury which, being a liquid, vaporizes quicker and gives the familiar bluish light.

The fair sex unite with poster advertisers, shopkeepers and others in deploring lighting of this kind—electrical discharge through gases and vapours—on the ground that it upsets their carefully selected colourings. The reason is clear: such light radiates on only a few isolated frequencies and so is as different as possible from daylight, which covers the whole visible band. Later we shall see how the solution to the objection can be met by taking advantage of other aspects of atomic structure, but in the meantime we may care to note another example of gas excitation—one more clearly within the scope of *Wireless World*. Radiation from the sun includes a large proportion in the ultra-violet band. In certain regions of the upper atmosphere the air atoms are exposed to this, and the energy required to expel their electrons completely (i.e., ionize them) comes within the ultra-violet frequency band, so much of the radiation is absorbed thereby and we are preserved from sunburn of disastrous intensity. Since the electrons and the positive ions they leave behind are both electric charges, this part of the atmosphere—known as the ionosphere—is conductive, and reflects radio waves of not-too-high frequencies, with results we all know.

The succession of elements from neon onwards continues in the same way as those from helium onwards, as can be seen from the Table. That is to

Element			n=1 (K)	n=2 (L)		n=3 (M)			n=4 (N)			
Atomic No.	Symbol	Name	0	0	1	0	1	2	0	1	2	3
1	H	Hydrogen ...	1									
2	He	Helium ...	2									
3	Li	Lithium ...	2	1								
4	Be	Beryllium ...	2	2								
5	B	Boron ...	2	2	1							
6	C	Carbon ...	2	2	2							
7	N	Nitrogen ...	2	2	3							
8	O	Oxygen ...	2	2	4							
9	F	Fluorine ...	2	2	5							
10	Ne	Neon ...	2	2	6							
11	Na	Sodium ...	2	2	6	1						
12	Mg	Magnesium ...	2	2	6	2						
13	Al	Aluminium ...	2	2	6	2	1					
14	Si	Silicon ...	2	2	6	2	2					
15	P	Phosphorous	2	2	6	2	3					
16	S	Sulphur ...	2	2	6	2	4					
17	Cl	Chlorine ...	2	2	6	2	5					
18	A	Argon ...	2	2	6	2	6					
19	K	Potassium ...	2	2	6	2	6		1			
20	Ca	Calcium ...	2	2	6	2	6		2			
21	Sc	Scandium ...	2	2	6	2	6	1	2			
22	Ti	Titanium ...	2	2	6	2	6	2	2			
23	V	Vanadium ...	2	2	6	2	6	3	2			
24	Cr	Chromium ...	2	2	6	2	6	5	1			
25	Mn	Manganese ...	2	2	6	2	6	5	2			
26	Fe	Iron	2	2	6	2	6	6	2			
27	Co	Cobalt ...	2	2	6	2	6	7	2			
28	Ni	Nickel ...	2	2	6	2	6	8	2			
29	Cu	Copper ...	2	2	6	2	6	10	1			
30	Zn	Zinc ...	2	2	6	2	6	10	2			
31	Ga	Gallium ...	2	2	6	2	6	10	2	1		
32	Ge	Germanium	2	2	6	2	6	10	2	2		
33	As	Arsenic ...	2	2	6	2	6	10	2	3		
34	Se	Selenium ...	2	2	6	2	6	10	2	4		
35	Br	Bromine ...	2	2	6	2	6	10	2	5		
36	Kr	Krypton ...	2	2	6	2	6	10	2	6		

Table of first 36 elements, showing electron groupings in their lowest states. It will be seen that the total number of electrons for each element equals the atomic number.

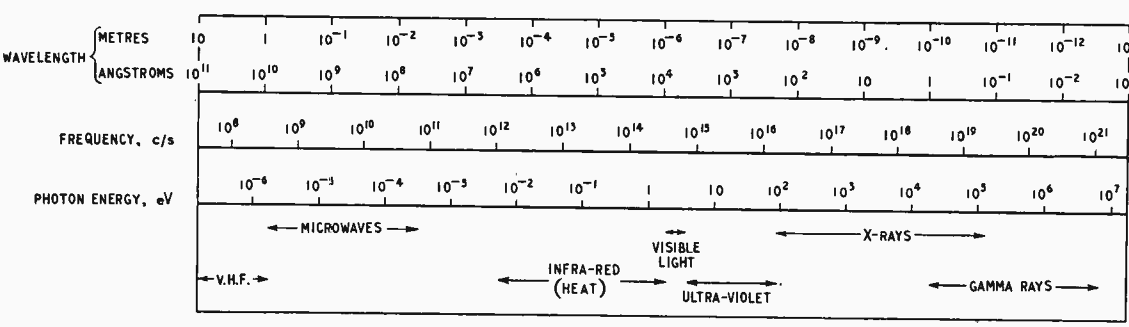


Fig. 1. Spectrum diagram, showing comparative scales of frequency, wavelength and photon energy in the various named bands of radiation. (The limits of most of these bands are not precisely defined, so the markings should be regarded as only approximate.)

say, in No. 12 (magnesium) the first sub-shell (3.0.0) is complete with its two oppositely spinning electrons; the next sub-shell (3.1.0, 3.1.1 and 3.1.-1) holds six electrons, and when complete we have another inert gas—argon. After that, things become a little more catchy. Because $n=3$, the quantum rules tell us that there is another possible group or sub-shell, 3.2.0, 3.2.1, 3.2.2, 3.2-.1 and 3.2-.2, which when complete adds up to a third spherical haze in shell M or 3. This comprises 10 electrons, so to fill all the places in the first three shells requires $2+8+18=28$ electrons. We would therefore expect element No. 28 to be another inert gas. It is, however, the metal nickel!

This is one of those little anomalies that used to worry us when we studied the Periodic Table in chemistry. The reason, we now find, is that the energy level of the fourth spherical series (4.0.0) is lower than those in the third group of the third shell, so electrons start occupying the fourth before the third is complete. This behaviour, as we may imagine, is very upsetting for the managers of atomic restaurants, and is bad enough for us just when we thought we could continue our table of elements from 18 onwards by simply following the rules. But it makes life much more interesting, especially for the engineer, as we can gather merely by reading the names of the elements in this rather unruly group (known as the transition elements) from 19 to 28 inclusive.

After that, things proceed much as they did beginning with sodium. The first three shells are all quite full, and there is one lone electron in the fourth. Again we have a metal, and a very useful one for us—copper. When there are four electrons in this shell we have another interesting element, germanium, in which each of the four is ready to link with one electron each in four other atoms to begin a germanium crystal—the raw material of transistors. Looking at the Table we can see that the corresponding element with one shell fewer is another transistor material—silicon.

By now we are well among the solids, and I must warn you that changing over to them is even more drastic for us than for a baby. Until now we have been assuming that our atoms are far enough apart for their influence on one another to be neglected. That is true of gases, but in order to form a solid the atoms have to pack closely together so that the spacing between them is of the same order as the size of the atoms themselves. That complicates matters a great deal, because there are not only all the forces between the component parts of one atom but between them and all the components of the neighbouring atoms. Some idea of these complications must be had before we can go on to such important things as conduction and emission, and that is so much of a subject that it will have to be left to next time.

Footnote: Having stuck my neck out so far by attempting to translate the more abstruse works of physicists into *Wireless World* language, and especially by attempting to fill in the gaps between their world and ours, I am not surprised if some missiles are attracted. Some readers didn't get through the very first page (89, in the February issue) before protesting about my statement that mass is annihilated when energy is given out by chemical action. What weighted this particular missile was that the example was given to show that accuracy and the Cathode Ray manner are necessarily incompatible. So I would like to make clear that although I do not make myself responsible for the correctness of the theories currently held by the most eminent authorities in their field (it would be a trifle presumptuous if I did!) I do accept responsibility for the correctness with which I report them. So I hope no error will be allowed to pass without comment. I would be grateful, too, to hear of any difficulties that arise. Though I don't undertake to answer all comments individually if they come in a flood, I always correct any definite errors, and often use readers' suggestions.

Fortunately there is no difficulty in quoting the highest authority for the statement about chemical energy, but since it contradicts what we—the old 'uns, anyway—learnt at school, and I offered no explanation, I shall try to bring it in again later.

Commercial Literature

Miniature Hearing Aid of which the main unit is small enough to be worn on the head—behind the ear, fitted to spectacles, as part of a hair-slide or headband—is described in a leaflet from The Belclere Company, P.O. Box 22, 117, High Street, Oxford. It measures 1½in × ¾in × ½in and weighs under 1½oz. The four-transistor amplifier is claimed to run for 80 hours continuously on one battery.

Coloured Self-Adhesive Tape made of p.v.c. and available in widths from ¼ inch to 1 inch. Electrical data and prices in literature from Smith and Nephew, Bessemer Road, Welwyn Garden City, Herts.

Power Oxide Resistors, composed of metal oxide bonded to porcelain rod, intended to replace smaller types of cement-covered wire-wound resistors. Claimed to be extremely rugged and resistant to mechanical damage and effects of moisture. Values from 10Ω to 20kΩ and ratings of 3 to 8 watts. Details on a leaflet from Welwyn Electrical Laboratories, Bedlington, Northumberland.

Epoxide Resins, notable for good adhesive properties, general toughness and resistance to chemicals. Information sheets on various types, ranging from liquid to solid, and on appropriate hardeners, fillers and diluents, from Bakelite, 12-18, Grosvenor Gardens, London, S.W.1.

Cabinets for standard 19-inch front panels, with "picture frame" front appearance. Various heights from 12¾ inches to 20¾ inches; depth, 11 inches. Leaflet from Phillips and Bonson, Pond Works, 8, Millfields Road, London, E.5.

Versatile Signal Tracer which can be used to follow r.f., i.f., a.f., oscillator, timebase and other signals without the need for switching or changing the probe. Presence and amplitude of signals is indicated on a "magic eye" and any a.f. component by a loudspeaker. Also a **Transistorized D.C. Voltmeter** with six ranges from 1V f.s.d. to 20kV f.s.d. (another model with nine ranges up to 1000V f.s.d.). Made by Amos of Exeter. Leaflets from RGA Sound Services (Plymouth), 2, Sarnesfield Road, Enfield, Middlesex.

Tea Break Timer closes an electric bell circuit at the beginning and end of a standard period which can be 10, 15, 30, 45 or 60 minutes. It is started by a push-button and resets automatically at the end of the timing cycle. Leaflet from the Electrical Remote Control Company. Distributors are Equipment and Services, Bush Fair, Tye Green, Harlow New Town, Essex.

V.h.f./A.m. Receiver crystal controlled for one channel frequency (up to ten can be arranged to special order) between 30 and 180Mc/s, employing a double superhet circuit and with internal monitor speaker is described in a leaflet from R. E. E. Telecommunications, Greenham Mills Works, Crewkerne, Somerset.

A.C. Mains Voltage Stabilizer using magnetic saturation is described in a leaflet from Mercia Enterprises, Godiva House, Allesley Old Road, Coventry. The "Sabir" load limits are 25 to 250 watts, and the compensation time less than 0.02 seconds. Regulation and total harmonic distortion characteristics are given.

Double Tetrode Oscillator

V.H.F. POWER GENERATOR COVERING 150 TO 500Mc/s

By J. H. ANDREAE, Ph.D. and P. L. JOYCE**

AN oscillator using the Mullard double tetrode valve type QQVO6-40 has been developed for a programme of ultrasonic research. The oscillator was required to have a continuous frequency range from 150 to 300Mc/s and it was to be anode modulated with 3-μsec 3-kV pulses repeated at about 300 p.p.s. This account records preliminary work carried out with the oscillator to test its performance under low-voltage continuous-wave conditions. The frequency range of the oscillator is from 150 to 500Mc/s and numerical values of power and efficiency are given to indicate its capabilities; these figures do not represent the optimum performance of the valve but the details given here may be of interest in connection with the design and construction of similar oscillators.

Construction.—The circuits of the push-pull oscillator are shown in Fig. 1; in circuit (a) "cross-over" feedback is used consisting of small variable capacitances connecting each anode with the opposite grid electrode. In circuit (b) "straight" feedback, in the form of small variable capacitances between each anode and its own grid electrode, is used in conjunction with a resonant grid circuit. Circuit (a) is simpler to operate but is unsatisfactory at frequencies above about 300Mc/s and so circuit (b) is employed at the higher frequencies.

A composite photograph of the oscillator is shown in Fig. 2. This shows the oscillator set up for an output power measurement, while Fig. 3 indicates more clearly the detailed construction of the valve assembly. Alternative lines, coupling coils, plug-in grid circuits and feedback capacitors are shown laid out by the side of the oscillator in Fig. 2. In the foreground can be seen the load resistance, transformer and a.c. meters for power measurement.

The frequency of the oscillator is determined by the length of the main anode line A and this is varied by moving the valve assembly B relative to the fixed short-circuit C by means of the screw D. Power is drawn from the anode line *via* the coupling coil E. This coil can be moved along the carriageway formed by the top of the frame but normally it is situated near to the short-circuited end of the anode line where the magnetic field is a maximum. To vary the length of the anode line the valve assembly is moved rather than the short-circuit so as not to disturb the coupling between the anode line and the coupling coil at every change in oscillator frequency.

Power connections to the oscillator are made *via* the cable F with the exception of the high tension voltage to the anodes which enters through the coaxial cable G. The screened cable F contains four insulated conductors which carry the screen-grid voltage, the heater current, and grid current to the external meters; the four conductors are numbered (1), (2), (3) and (4), respectively, in Fig. 1 (a).

Anode Lines.—Three separate anode lines have been provided for the oscillator and they are readily interchanged. Connection to the anode pins is *via* two copper strips H (Fig. 3 (b)) which are soldered to copper bushings electrolytically deposited on to the pins. The low-impedance line comprises two parallel strips as shown in Fig. 3 (a). Each strip is made from 1in × ⅛in silver-plated brass. Because of the length of line

* Imperial Chemical Industries Ltd., Research Department.

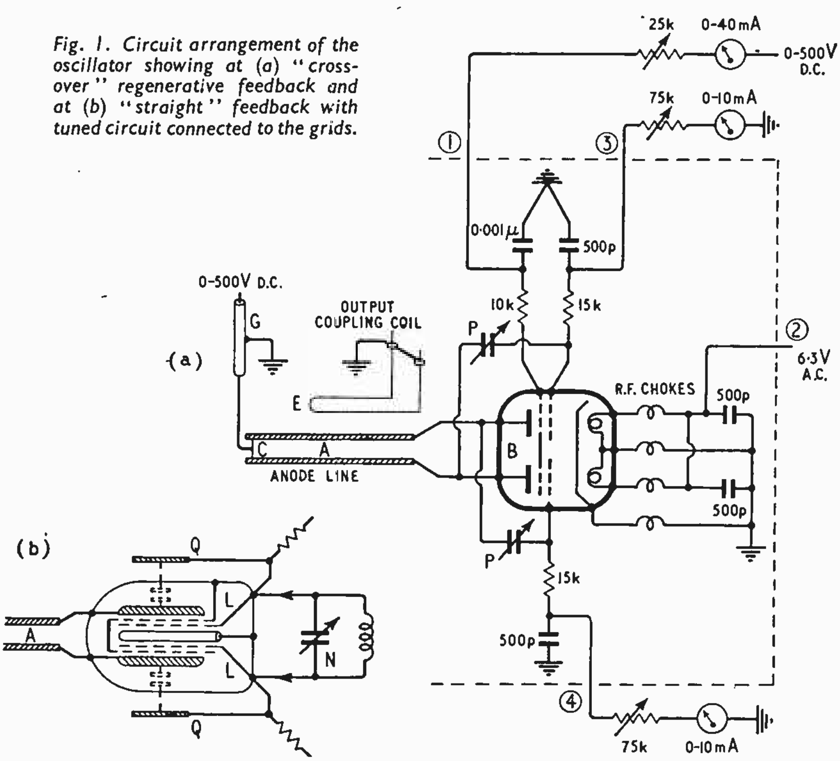


Fig. 1. Circuit arrangement of the oscillator showing at (a) "cross-over" regenerative feedback and at (b) "straight" feedback with tuned circuit connected to the grids.

required at the lower frequencies it is made in two halves, one of which can be used alone at the higher frequencies. The separation of the strips is 0.2in, from which the characteristic impedance is calculated to be 75 ohms. Neglecting edge effects:—

$$\text{impedance } Z_0 = 337 \frac{\text{separation}}{\text{width}} \text{ ohms}^1 \; \ldots\ldots \quad (1)$$

The other two lines provided consist of parallel, silver-plated, brass rods, ⅜in in diameter. The rods are in 3-in lengths which screw into each other so that parts of the lines can be removed at higher frequencies. A medium-impedance line is obtained with these rods at a separation of ⅝in as shown in Fig. 3 (b), while a high-impedance line is obtained at a separation of 1½in. The characteristic impedance of a parallel-wire line is given by the well-known formula:—

$$Z_0 = 276 \log_{10} \frac{\text{separation}}{\text{radius of wire}} \text{ ohms} \; \ldots\ldots\ldots\ldots \quad (2)$$

which yields a value of 150 ohms for the medium-impedance line, and 250 ohms for the high-impedance line.

In order to calculate the resonant frequencies of the three lines it is necessary to take into account (*a*) the capacitance between the valve anodes, (*b*) the length and characteristic impedance of the anode pins within the valve envelope, (*c*) the length of the connections from the anode pins to the lines, and (*d*) the length of the short-circuiting conductor.

The capacitance between the anodes was measured with the valve *in situ* and found to be exactly 2.0pF. The length of the anode pins within the valve envelope is 2cm and the characteristic impedance of the pins is calculated from formula (2) to be 350 ohms.

The low-impedance line is held right up against the valve envelope so that no allowance need be made for connections from the valve pins to the line; also the short-circuit is of negligible length. Therefore, if the distance measured from the short-circuit to the valve envelope is x cm, the anode resonant circuit comprises a 75-ohm line, x cm long, connected to a 350-ohm line, 2cm long, the latter being terminated by a capacitance of 2pF. A comparison of theoretical curves and experimental points for the 75-ohm line is made in Fig. 4, the former being calculated by means of the transmission line calculator described elsewhere in this issue. The slight divergence between the experimental and theoretical values for longer lengths of the line is probably due to bowing of the line with a consequent increase in effective characteristic impedance.

The medium-impedance line joins the valve pins about 1cm from the valve envelope so that, in calculating the resonant frequency of the anode circuit, the length of the 350-ohm line needs to be increased to 3cm and the length of the 150-ohm line will be $(x-1)$cm. The same short-circuit is used as for the 75-ohm line. A comparison of theory and experiment is given in Fig. 4.

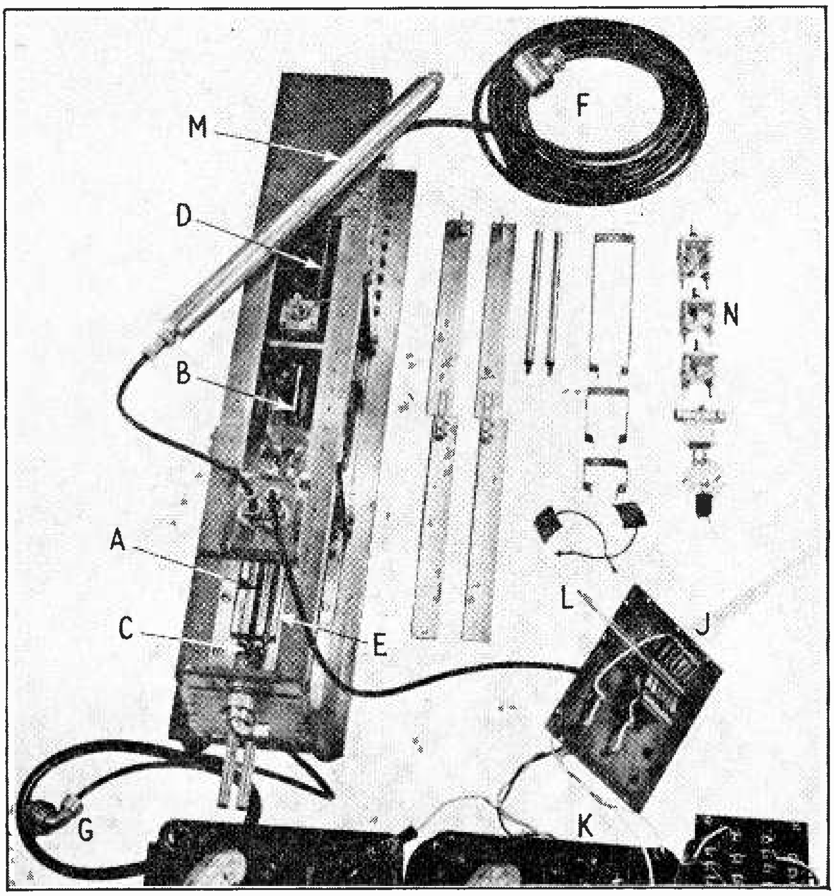


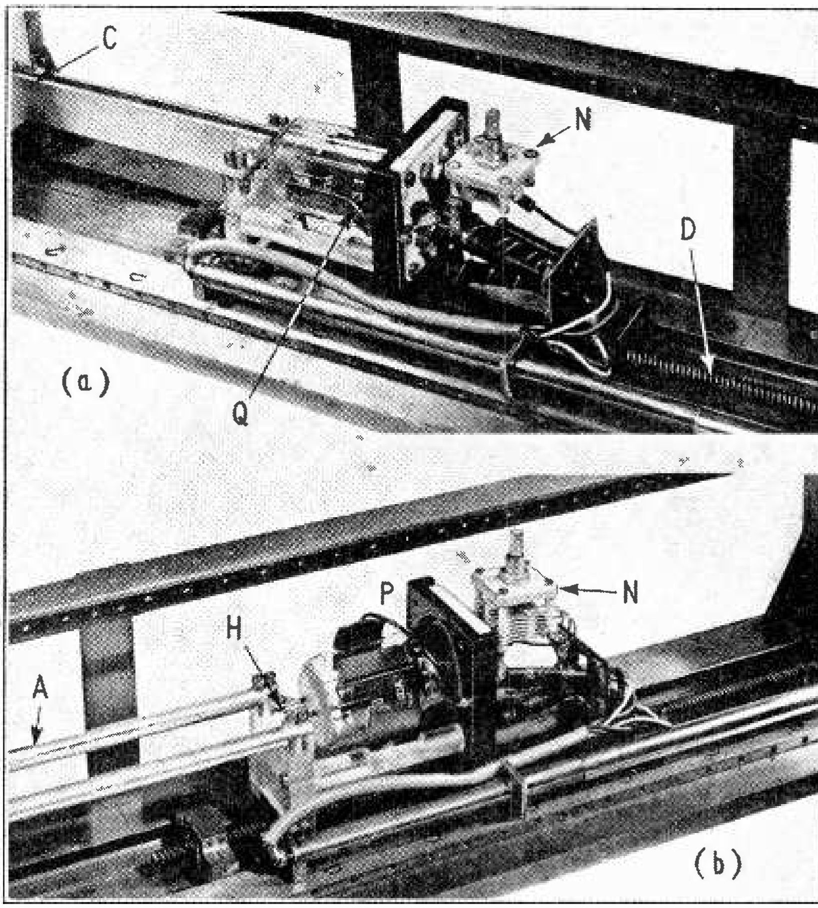
Fig. 2. The oscillator set up for power output measurements and including spare anode lines and grid circuit elements. Lettering enables components to be identified in the circuits of Fig. 1.

Because of the large separation of the conductors in the 250-ohm line the lengths of the connections from the valve pins to the line and the length of the short-circuit are appreciable. In order to allow for these additional lengths of conductor, 2cm are added to the length of the line and it can be seen from Fig. 4 that this reasonable estimate results in good agreement between theory and experiment.

The experimental points shown in Fig. 4 illustrate how the frequency range of the oscillator depends on the impedance of the line employed. Other features of the anode circuit will be discussed later in connection with the grid circuit, feedback and power generation.

Grid Circuit. — Two forms of feedback have been used, cross-over feedback (P in Fig. 3 (b)) at the lower frequencies and straight feedback (Q in Fig. 3 (a)) at higher frequencies. These are shown in Fig. 1 (a) and (b) respectively. The oscillator does not oscillate satisfactorily with cross-over feedback at frequencies above 300Mc/s and it is thought that this accounts for the definite divergence of the experimental and theoretical values shown in Fig. 4 for this type of feedback at the higher frequencies. On the other hand, with the small feedback capacitances which are used, straight feedback becomes ineffective at frequencies below 300Mc/s.

Below about 200Mc/s cross-over feedback can be employed without a resonant grid circuit unless the maximum power is required from the valve. Otherwise it is necessary to resonate the inter-grid-electrode capacitance and the inductance (L in Fig. 1 (b)) of the grid leads within the valve envelope with an externally added circuit. A measurement of the grid



Above : Fig. 3. Details of the valve assembly, (a) with low-impedance parallel-strip anode line and "straight" feedback capacitators and (b) with wide-spaced line, "crossover" feedback capacitors and tuned circuit.

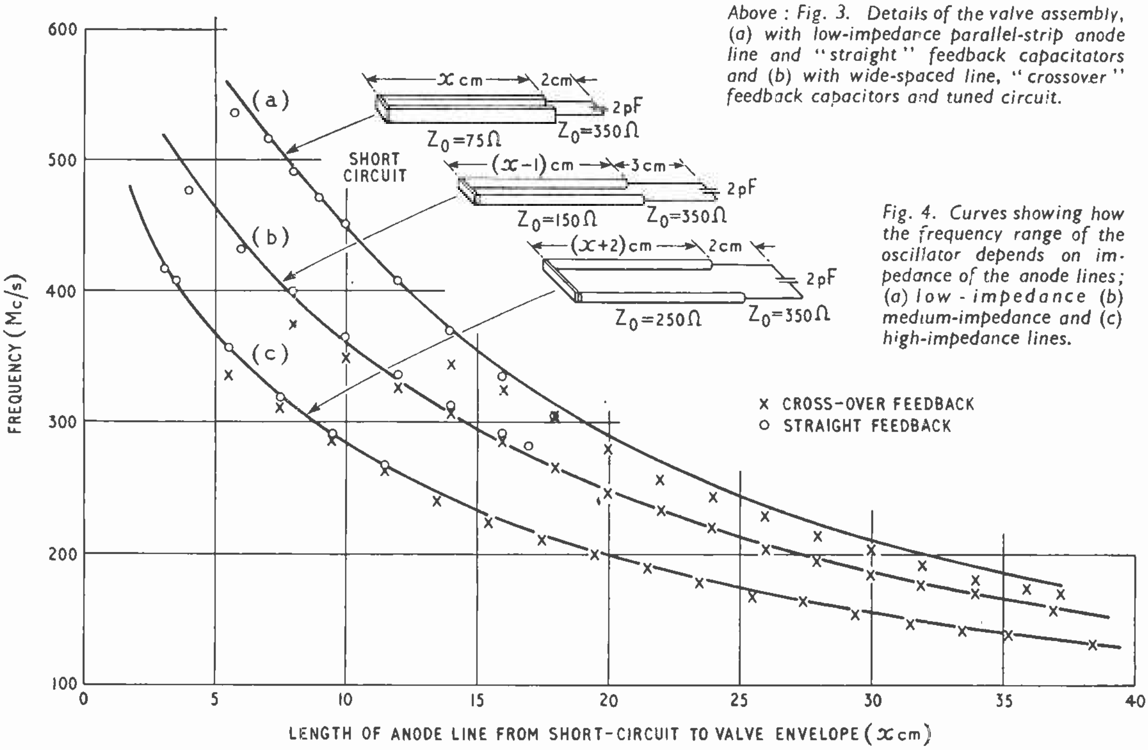


Fig. 4. Curves showing how the frequency range of the oscillator depends on impedance of the anode lines; (a) low-impedance (b) medium-impedance and (c) high-impedance lines.

capacitance gave 5.2pF and an estimate of the inductance of the leads can be obtained by comparing them with a loop of wire 1in in diameter and 0.02in thick. The inductance of such a loop is shown[2] to be 0.1μH. Another estimate can be found by joining the grid terminals on the valve base and by adjusting the frequency of the oscillator for minimum anode current (indicating that the grid circuit is resonant). The frequency at which this occurs is 230Mc/s and it is readily shown that 5.2pF resonates with 0.1μH at about 230Mc/s confirming the previous estimate. Having ascertained the series inductance and capacitance of that part of the grid circuit which is within the valve envelope, the magnitude of the external reactance which must be added at any particular frequency can be computed. A few values are given in the table:—

Mc/s	120	150	180	200	Mc/s	250	300	350	400	450	500
μH	0.238	0.116	0.050	0.022	pF	18.3	6.11	3.44	2.27	1.65	1.25

In order to provide the appropriate grid reactance at all frequencies a series of plug-in capacitor units are employed, some of which are ordinary variable air capacitors and others have parallel coils as well. These can be seen, marked N, in Figs. 1(b), 2 and 3.

Power Generation.—A limited amount of time was spent in studying the power output and efficiency of the oscillator with a view to becoming more familiar with the behaviour of the apparatus. The most important feature which soon became apparent was that the efficiency increased when more power was drawn from the circuit. At the higher frequencies it is very much more difficult to couple an external circuit sufficiently strongly to the anode line to extract the necessary power. For one thing, the anode line becomes a smaller proportion of the anode resonant circuit at the higher frequencies and there is an appreciable voltage drop along the anode pins. Also lower impedance lines have to be used in order to reach the higher frequencies and these are intrinsically more compact and less easy to couple to. Finally, the need for avoiding power losses by skin effect, by poor contacts, by radiation and by absorption in extraneous parts of the circuit, such as the heater circuit, becomes more important at the higher frequencies. Fig. 5 summarises a number of measurements of power and efficiency which were made with the oscillator. These do not represent the optimum values which can be obtained with the valve; in fact it is known[3] that 60 watts can be drawn from an oscillator incorporating this valve and operating at the fixed frequency of 500Mc/s.

Two methods of power transfer and measurement have been used and these are illustrated in Fig. 6 (a) and (b). In the method (a) power is drawn from the anode line by means of an output coupling loop located above the line. It is found that the best results follow from long loops made of copper strip about ½in wide, the separation of the two sides of the loop being about the same as that of the conductors of the anode line. The load resistance consists of a series-parallel combination of 12 cracked-carbon resistors connected as shown in Fig. 6 (a) and giving a terminating resistance of 68 ohms to the coaxial cable from the output coupling loop. The six 0.001-μF capacitors decouple the "earthy" ends of the resistors to the outer conductor of the cable at the radio frequencies while presenting a high impedance path to the 50c/s a.c. calibration circuit. The centre conductor of the coaxial cable from the output coupling loop is joined to a brass tube which forms the common connection of the 12 carbon resistors; the brass tube also acts as a screened holder for a thermometer (L in Fig. 2) which records its temperature. From the view of the load resistance J and part of the calibration circuit K shown in Fig. 2, it can be seen that all r.f. connections are as short as possible to avoid stray inductances. The method of tuning the output coupling circuit has been explained in the literature[4] where a full description may be found. In practice the variable length coaxial line shown in Fig. 6 (a), (M in Fig. 2), is adjusted until a maximum temperature is recorded by the thermometer. The oscillator is then switched off and the a.c. calibration voltage is increased until the same steady temperature is recorded by the thermometer. Invariably the maximum power is obtained when the coupling loop is near the short-circuited end of the anode line and, usually, as the output power is increased the grid circuit requires slight adjustment.

The slowness of the thermometer method of measuring power makes the adjustment for maximum power difficult and tedious, particularly at the higher frequencies. A good idea of the vigour of the oscillations under any particular conditions can be acquired by holding a small neon lamp near the high-voltage end of the anode line, or near a corresponding part of the output circuit, but this does not provide a quantitative measurement. The combination of a standard, 40-watt, 230-volt lmap and a normal photographic light meter provides a quick and reasonably accurate meas-

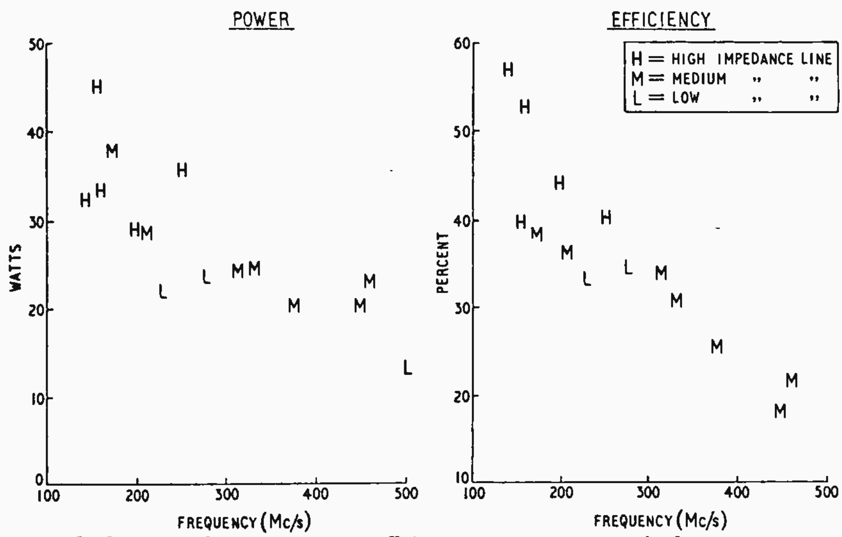
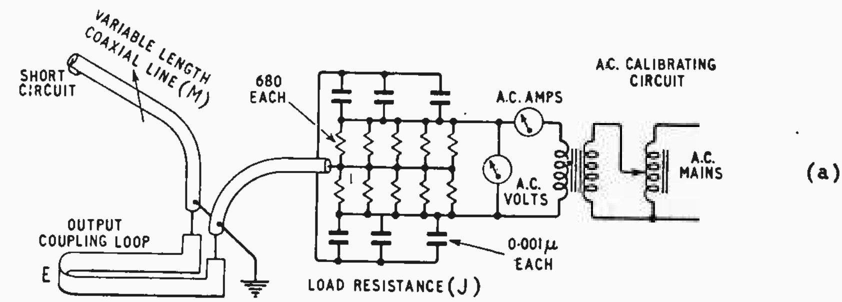
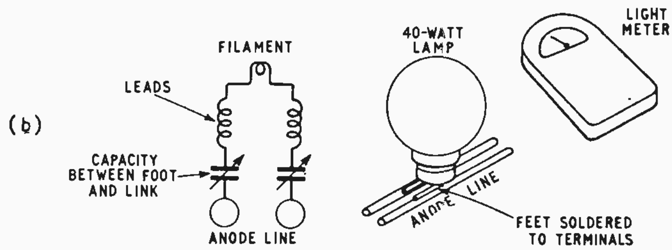


Fig. 5. Summary of power output and efficiency measurements over the frequency range covered by the oscillator.

Fig. 6. Two methods of measuring the power output, (a) by means of a coupling loop and a resistance load of known value and (b) by means of a lamp and light meter.



urement of the power available from the oscillator, as illustrated in Fig. 6 (b). Two short thick wires (feet) are soldered to the terminals of the lamp and the latter is supported just above the anode line. The light meter is fixed near the lamp by the same support which holds the lamp so that the two can be moved together. Power is transferred from the high voltage end of the anode line to the lamp *via* the series resonant circuits formed by the inductances of the leads to the filament within the lamp and the capacitances between the feet and the anode line. By moving the lamp and light meter support the capacitances can be adjusted for maximum reading of the light meter, *i.e.*, maximum power from the lamp. Without disturbing the relative positions of the lamp and the light meter the same reading can be obtained with the a.c. calibration circuit (Fig. 6 (a)) connected to the feet of the lamp. The product of current and voltage gives the power



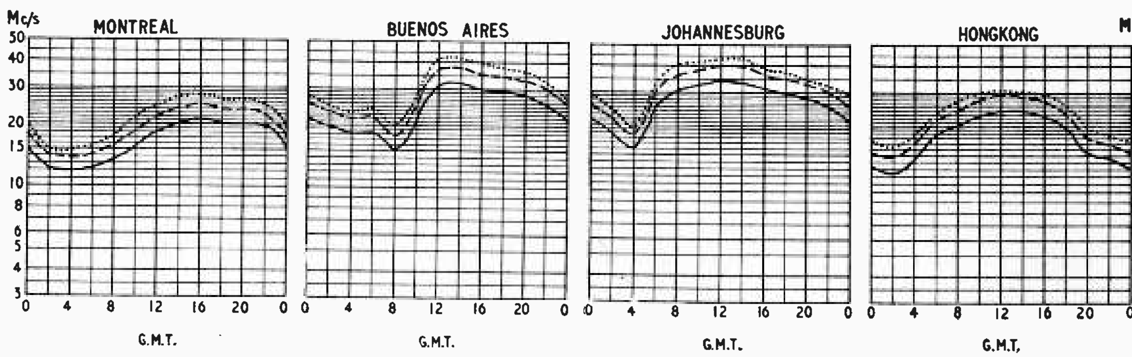
At the lower frequencies it is not feasible to resonate the inductance of the lamp leads with the capacitance between the feet of the lamp and the anode line, but the lamp may be used in place of the load resistance of Fig. 6 (a). The a.c. calibration circuit can be applied, after the oscillator has been switched off, to the end of the variable length of coaxial line in place of the short-circuit. However, it should be noted that the load resistance provides a resistive termination of prescribed value, while the lamp does not.

REFERENCES

[1] Schelkunoff, S. A., "Electromagnetic Waves," p. 243. (D. Van Nostrand, 1947.)
[2] Terman, F. E., "Radio Engineer's Handbook," p. 52. (McGraw-Hill, 1943.)
[3] Private communication from Mullard, Ltd.
[4] Harvard University Radio Research Staff, "Very High Frequency Techniques," p. 380. (McGraw-Hill, 1947.)

SHORT-WAVE CONDITIONS

Prediction for April



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

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

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

— — — PREDICTED AVERAGE MAXIMUM USABLE FREQUENCY

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

Magnetism in Materials

(Concluded from p. 131 of previous issue)

4. Rectangular Hysteresis Loop Materials : Permanent Magnets

By D. H. MARTIN, Ph.D.

THE use of ferromagnetic cores as storage elements in computers and similar devices has created a demand for a rather new kind of material. This must have a coercivity no greater than about 1 oersted, and a hysteresis loop which is as nearly rectangular as possible. A core made of such a material has, in the absence of a magnetic field, two stable states, i.e. the two possible directions of the remanent magnetization. In a digital computer these two states are respectively used to indicate the storage of a "0" or a "1."

An example of the use of cores of this kind is the computer memory, or store, shown in Fig. 22. Information in the form of a series of pulses, representing a "1" when positive and a "0" when negative, is fed into the memory and stored there until required again later in the computation. The method of "writing" a "1" into, say, the core in the third column and second row (labelled 3.2 in Fig. 22) is to pass simultaneous pulses of current through the third vertical wire and the second horizontal wire. Each pulse produces a field which is only slightly larger than half the coercive force, and so only core 3.2, at which *both* pulses appear, is acted upon by a field large enough to reverse its polarization, thereby storing a "1." In order to "read" this "1" at a later time current pulses are again passed through the wires in the third column and the second row but this time in the opposite directions. The polarization of core 3.2 is then reversed and an inductive pulse of e.m.f. is produced in the output winding which threads all the cores, and this indicates that a "1" had in fact been stored there.

The desirability of a rectangular loop will now be clear. If a "0" is stored in a particular core no output pulse is desired when reading, but in practice a small unwanted pulse is produced by the small change in induction from B_r to B_{max}. Small unwanted pulses are also produced, during reading, by all the other cores which are subjected to single current pulses (half H_c). The unwanted signals are smaller the larger the ratio of B_r to B_{max} and only materials for which this ratio is greater than 90% can usefully be employed.

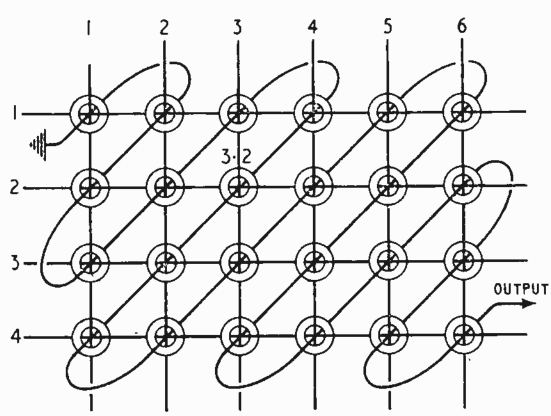


Fig. 22. Schematic illustration of a ferrite core matrix used as a store or memory.

Rectangular-loop materials are also used in the units which perform the arithmetical operations in some computers, in shift registers, magnetic amplifiers and a number of other applications.

The materials most commonly used for the computer applications are certain ferrites which switch in times of the order of 1 microsecond. Short reversal times are attainable with ferrites because their high electrical resistivities mean that eddy current damping of the reversal processes is very small. Ferroxcube D is a commercial magnesium-manganese ferrite having suitable rectangular-loop properties. Some nickel-iron alloys have rectangular loops, as I have described in an article in this series. They are likely to find increasing application in the computer field in the form of ultra-thin films, of the order 10^{-4} cm. thick or less, when they have reversal times less than 1.0 microsecond.

The reasons for high remanence have been discussed earlier. The squareness of the demagnetization quadrants of rectangular hysteresis loops is governed by factors which are less well understood. In this part of the magnetization cycle reverse domains appear for the first time and studies of their nucleation have only recently been made.

Permanent Magnet Materials

Improvements in hard magnetic materials for permanent magnets during the last 60 years have been no less remarkable than those in soft materials. A magnet designed to produce a given field over a specified volume would have to be roughly 20 times heavier if made of an early magnet steel than if constructed using the materials now available. A good hard material will clearly have a large coercivity H_c, and a large remanence B_r. A very useful figure of merit is the maximum value of the product B × H attained in the demagnetization quadrant of the hysteresis loop. It can be shown that this maximum, BH_m, known as the energy product, is proportional to the square of the field which a well-designed magnet of a given volume can produce in the pole gap. Modern materials exhibit values for B_r, H_c and BH_m, in the ranges 5,000-13,000 gauss, 500-1,000 oersteds and 1.5-4.0 × 10^6 gauss-oersteds respectively, compared with 9,500 gauss, 50 oersteds and 0.2 × 10^6 gauss-oersteds for the high-carbon steels available 50 years ago. Many present-day applications in loudspeakers and microphones, in electrical instruments of many kinds, in radar microwave generators, in motors, magnetos, and so on, have been made possible only by the development of the highly efficient alloys now available.

Up to 1920 the best hard materials were the cobalt-steels containing up to 35% cobalt. As the fraction of cobalt is increased the coercivity rises from about 50 oersteds to 250 oersteds, and the BH_m from 0.2 to 0.95×10^6 gauss-oersteds. Magnet steels contain about 1.0% carbon and small quantities of other metals. The carbon is distributed through the steel in the form of sub-microscopic islands of carbon compounds, and these impede the motion of domain walls and lead to high coercivities. These types of magnet steels are still fairly widely used.

About 1935, alloys based upon the aluminium-nickel-cobalt-iron system became available. These are known as diffusion-hardening alloys, and their permanent-magnet properties are developed by annealing at about 600°C after they have been quenched, i.e. rapidly cooled, from about 1,250°C. At 1,200°C these alloys are single-phase, the atoms of each metal being distributed uniformly through the material. When they are rapidly cooled in air or in an oil-bath this uniformity is frozen-in and remains. During the subsequent tempering at about 600°C, however, the atoms slowly diffuse and the alloy begins to separate out into two phases, minute submicroscopic islands of nearly pure iron forming throughout the lattice. This is an ideal situation, according to domain theory, if high coercivities and low permeabilities are required, since, not only is the lattice severely and very non-uniformly strained but the intensity of spontaneous magnetization varies from point to point because the composition of the material is non-uniform. Domain walls are therefore severely impeded. The hardest properties are obtained when the tempering has gone on just long enough for the islands to be in a very early stage of development. They are then so minute and are separated by such small distances that the magnetization processes are sometimes discussed in terms of single-domain particle concept described in the section dealing with the theory of magnetization processes. In fact, the process of a domain wall moving through a very inhomogeneous material of this type is very much the same thing as the progressive reversal of single-domain particles which are so close to one another that there is pronounced magnetic interaction between them. The two models, domain wall movement and single-domain rotation, approach the same problem from different directions, and it is satisfactory that both are capable of explaining the high order of coercivity found in diffusion-hardened materials.

Alloys of this kind are known commercially as the Alnicos and are made up of roughly $\frac{1}{2}$ iron and $\frac{1}{6}$ each of aluminium, nickel and cobalt, there being some variation among the several alloys which come under this name. They have coercivities in the range 700-1,000 oersteds, remanences between 5,000 and 8,000 gauss, and energy products from 1.0 to 2.0×10^6 gauss-oersteds.

An important development came with the discovery in 1938 that diffusion-hardening alloys responded to the application of a field of some 1,000 oersteds during the quenching operation. The coercivity was not changed, but the remanence in the direction in which the field had been applied was increased considerably, as was the magnitude of BH_m. In the perpendicular direction these properties were reduced. Alloys thus treated are known as Alcomax, Ticonal, Alnico V and VI, and Hycomax, depending on the country of origin. They have roughly the composition 8% aluminium, 13% nickel, 25% cobalt, 3% copper and the rest iron. Their remanences and BH_m are 10,000-12,000 gauss and $3\text{-}5.5 \times 10^6$ gauss-oersteds respectively, and most good-quality magnets are nowadays made from these materials. The effect of the field applied during cooling is to orient the nuclei of the new phase, which are formed at this stage. The precipitate islands, which grow in the form of plates during tempering, are therefore aligned close to the field direction, making that a preferred direction of domain magnetization. This leads, as in the domain-oriented nickel-irons, to an increased remanence.

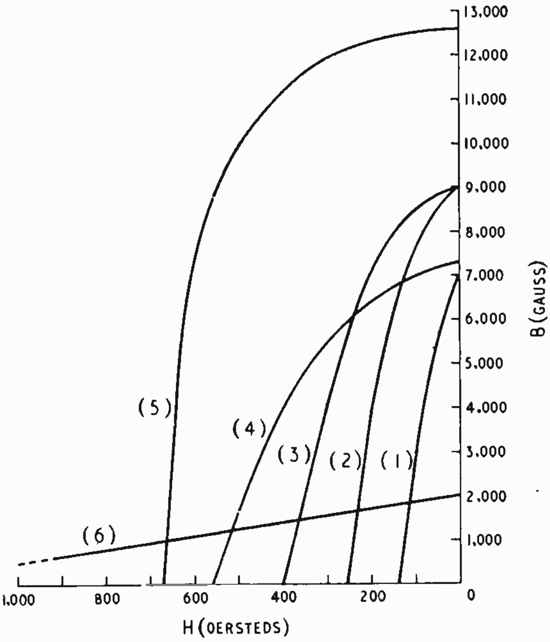


Fig. 23. Demagnetization quadrants of some permanent magnet materials. (1) 3% cobalt steel. (2) 35% cobalt steel. (3) Finely powdered cobalt-iron alloy (single-domains). (4) Alnico. (5) Alcomax III. (6) Permanent magnet ferrite (Hc 1,500 oersteds).

Fig. 23 illustrates the properties of the three kinds of permanent magnet materials discussed above. Alnico and Alcomax alloys are brittle and difficult to machine. They are normally cast in their final shape, and may be ground to size. Some precipitation-hardened alloys are machinable, such as Remalloy, Cunico and Cunife, but they are not greatly superior to cobalt-steels and are only rarely used in this country.

In recent years there have been two important new developments in hard materials. First, a ferrite suitable for use in permanent magnets has been discovered. This is a cobalt ferrite and is produced under such names as Vectolite and Feroxdure. It can have H_c as high as 1,200 oersteds, but its remanence is low at about 2,000 gauss. Its lightness, high resistivity, and especially high coercivity, fit it for a number of special applications.

A permanent magnet barium ferrite is also available under the name Magnadur. The crystal grains in these ferrites are not much larger than the critical size for single-domain behaviour, and their properties have been interpreted in terms of their high anisotropy constant K and low B_s.

The second recent advance in permanent magnet materials is the production of powdered alloys in which the particles are sufficiently small to be genuine single-domains as discussed in the section on domain processes. Powder magnets are available which are made of iron or iron-cobalt alloys having particle sizes of about 2×10^{-6} cm. Spherical single-domain particles have maximum theoretical coercivities of $2K/I_s$. For iron this is about 600 oersteds. If the particles are elongated, however, the theoretical maximum coercivity is of the order $2\pi I_s$, that is about 10,000 oersteds for needle-shaped oriented particles of iron. Powdered iron pressed into a compact mass and available under the name Gecalloy, can have H_c greater than 500 oersteds, and iron-cobalt powders have H_c greater than 650 oersteds. The particle size of 2×10^{-6} cm diameter is about 100 times smaller than the powders used to reduce eddy current effects in radio-frequency coil cores. Powder magnets are comparable to the Alnico alloys in their properties. They are lighter, however, and contain no expensive materials, and their B_r and H_c can be tailored to specification by adjusting the density of packing. An indication of what may be achieved using fine powders is given by the magnets fabricated from powdered manganese-bismuth. This material has a remarkably high anisotropy constant, K, and therefore has an H_c as large as 3,400 oersteds.

Fine powders of iron oxide have been widely used recently for magnetic recording tape. In order that the magnetic pattern on the tape be permanent a low ratio of B_r to H_c is required, since the self-demagnetizing effect is proportional to B_r. The ferrites are therefore especially suitable having very high H_c and comparatively small B_r. The particles may be produced in needle form.

Conclusions

My aim has been to illustrate how the extraordinary variety of behaviour to be found among ferromagnetic alloys and compounds can be interpreted by the simple ideas of domain theory. There remain, of course, many interesting effects which have yet to be satisfactorily explained, but the difficulties are often those of choosing between two or more possible domain interpretations. To the engineer the importance of domain theory lies in its ability to suggest in which ways a material might be improved and the limits beyond which no advance could be made.

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Books Received

Fun with Radio, by Gilbert Davey. Radio correspondent of *Boys Own Paper* gives detailed practical constructional details for fifteen circuits, including crystal sets, a number of portable receivers, a superhet and single-ended amplifier with negative feedback. Pp. 64; Figs. 34. Price 10s 6d. Edmund Ward (Publishers), Ltd., 194-200, Bishopsgate, London, E.C.2.

Fernsehröhren, Eigenshaften and Anwendung, by H. Hönger and C. Reuber, covers general use of valves (including c.r.t.'s) in television receivers; followed by characteristics of particular valve types with practical examples of their use. Pp. 160; Figs. 270. Price 15DM. Regelien's Verlag, 16 Hubertusbader Strasse, Berlin-Grunewald.

Repairing Hi-Fi Systems, by David Fidelman, gives general principles of correct operation and common types of fault for amplifiers, a.m. and f.m. tuners, record players (with pickups), loudspeakers and tape recorders; and also discusses typical test equipment. Pp. 203; Figs. 98. Price 3 dollars 90 cents. John F. Rider, Inc., 116 W. 14 Street, New York 11. Obtainable in this country from Modern Book Co., 19-23, Praed Street, London, W.2. Price 23s.

Elements of Tape Recorder Circuits, by Herman Burstein and Henry C. Pollak. Besides equalization, bias and erase, and level indicating circuits, also discusses general aspects of tape recording, including head and tape characteristics and methods of reducing hum and noise. Pp. 223; Figs. 144. Price 2 dollars 90 cents with soft cover, or 5 dollars hard cover edition. Obtainable in this country from Modern Book Co., 19-23, Praed Street, London, W.2. Price 23s (soft cover) or 40s (hard cover).

Industrial Television, by H. A. McGhee. General section discusses pick-up tubes and circuit design of associated equipment. Applications described include underwater and airborne television, use with microscopes and telescopes, and in atomic research. Pp. 120; Figs. 104. Price 15s. George Newnes, Ltd., Southampton Street, Strand, London, W.C.2.

Problems in Radio Engineering, by E. T. A. Rapson. Seventh edition has more numerical problems from examination papers (with solutions); and additional material on negative feedback, the valve as a reactor, and frequency discriminators, following the previous pattern of introductory notes and formulæ. Pp. 177. Price 15s. Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, London, W.C.2.

New Equipment and Methods for the Evaluation of the Performance of Lenses for Television, by W. N. Sproson, M.A., B.B.C. Engineering Monograph No. 15, describes photoelectric optical bench used to measure loss of contrast for various numbers of bars per mm on a pattern, and discusses a suitable single index for evaluating lens performance for television. Pp. 16; Figs. 19. Price 5s. B.B.C. Publications, 35, Marylebone High Street, London, W.1.

Pulse Counter F.M. Receiver

By M. G. SCROGGIE, B.Sc., M.I.E.E.

SUPPLEMENTARY NOTES, INCLUDING PARTICULARS OF CONVERSION TO CRYSTAL CONTROL

SINCE details of the "Unconventional F. M. Receiver" were published in the June 1956 issue the prototype has been in continuous domestic use for a year; also a number of readers have written to report on their experiences with receivers made to the same design or modifications of it.

The original design provided switch tuning to the three B.B.C. v.h.f. programmes, and yielded an a.f. output of about 0.8 V max. It comprised one r.f. stage, a diode frequency changer with triode oscillator, two resistance-coupled i.f. stages working at 150 kc/s or thereabouts, a pentode limiter and a two-diode pulse-counter discriminator with output filter and de-emphasizer. The second triode in the same bulb as the oscillator was used to stabilize the oscillator frequency by varying the magnetization of the miniature ferrite core on which the oscillator coil was wound. This type of receiver has the considerable advantages—especially for home constructors—of needing no i.f. or discriminator alignment or special instruments, and of being capable of lower distortion than the ratio discriminator or even the Foster-Seeley.

In the simple form described, its sensitivity is relatively low. This renders it unsuitable for fringe areas, and necessitates an outdoor aerial in some of those areas where more conventional f.m. receivers would manage on an indoor aerial, or a full-sized indoor aerial where they would manage with something inside the cabinet. So it is interesting that the several readers who reported experience with more sensitive modified versions of their own were all very pleased with the results. Mr. W. O'D. Whish, of Truro, using a preliminary conventional frequency conversion to 10.7 Mc/s, described extremely satisfactory performance at 85 miles from the local station over hilly country. He could not understand why there was not more enthusiasm about what seemed to him the ideal receiving system. An interesting point about this and other extensively modified designs was the latitude as regards types of valves, apparently no difficulty being encountered in substituting EF50, etc., for those specified.

Mr. D. Birt, of Oxted, carried out careful direct comparisons between discriminators of the pulse-counter and ratio types, using a 10.7 Mc/s-to-125 kc/s frequency changer between the input to the ratio discriminator and the limiter preceding the pulse counter, and equalizing the a.f. outputs to enable the same a.f. equipment to be used for either by a switch-over. The consensus of opinion among listeners to it was clearly in favour of the pulse counter, the improvement in quality being especially noticeable with speech and vocal music and less so with heavy orchestral music. The pulse counter showed up a loss of bass in the ratio discriminator until its usual 8μF capacitance had been increased to 25μF.

A letter from Mr. L. D. Stuart, published in the August 1956 issue, while generally favourable, seemed doubtful about the a.f.c. system—the experimental saturable-ferrite arrangement, in which the anode current of a triode controlled by the z.f. component of the discriminator output is passed through the coil of a P.O. relay modified to take the oscillator tuning coil core between its pole pieces. It is true that, as stated in the original description, the magnetic circuit of this system is rather susceptible to stray magnetic fields and ought to be enclosed in a Mumetal screen if a really low hum level is to be achieved. Subject to this, however, the system was very effective, and only once during its year of service—in the exceptional heat wave of last June—did it need any re-adjustment. (For that matter, no other part of the receiver needed any attention at all in a year of daily use.) With that exception, the a.f.c. invariably pulled the oscillator frequency within the necessary tolerance (about ±0.04%), notwithstanding that no frequency-stability precautions whatsoever were taken in the simple switch tuning circuit.

The only real shortcoming of the receiver has been the perceptible amount of hum, due to the unscreened a.f.c. coil and (to some extent) the 2-ft. high-impedance lead from output to a.f. amplifier. The first cause could be overcome by a screen and the second by a cathode follower.

However, since several readers (no doubt with the "Crystal-Controlled F.M. Receiver" of Mr. D. N. Corfield before them in the following issue) inquired about crystal control as an alternative, this has been tried—unfortunately after a longer interval than had been hoped. Crystal control offers this type of receiver an undoubted combination of advantages:

(1) The channel frequencies and intermediate frequency are automatically set up without calibrated signal generator or guesswork.

(2) They are maintained positively under all conditions.

(3) They are maintained within closer limits, enabling the i.f. to be designed closer to the optimum value, and ensuring uniformity of the corresponding high standard of performance.

(4) The triode released from a.f.c. duties is available for an output cathode follower; both potential causes of hum are thus removed, and if necessary a longer output lead can be used.

(5) One pre-set adjustment (a.f.c.) is eliminated.

(6) There is more latitude in the design of the oscillator tuning circuit, which can also be more readily screened to prevent radiation.

Against these must be set the cost of one crystal per channel, which is not negligible, especially if the owner is obliged to move from one part of the country to another where different f.m. frequencies are used.

The conversion proved even easier than expected. The first type of oscillator circuit tried, though slightly different from that of Mr. Corfield, being closely similar to the original one, worked perfectly. Fig. 1 shows the relevant parts of the circuit: (a) as originally, and (b) converted to crystal control.

The third-harmonic system is still used, to avoid the interference with viewers of the B.B.C. London television programmes that might occur if the oscillator frequency were chosen so that its second harmonic beat with the Wrotham signals. The crystal frequencies are therefore as follows:

Programme	Wrotham frequency Mc/s		Oscillator 3rd harmonic Mc/s	Oscillator fundamental (crystal) frequency Mc/s
Light ...	89.1	120 kc/s	88.98	29.660
Third ...	91.3		91.18	30.393
Home ...	93.5		93.38	31.127

As a Midland reader pointed out, however, the reverse situation obtains in that region, for second-harmonic working puts the oscillator frequency well clear of the local Band I television channel (4), whereas the second harmonic of an oscillator for third-harmonic working would clash with it. It seems unlikely that a harmonic of the oscillator would in any case interfere appreciably with television reception, except perhaps in unusual circumstances, but one might as well be on the safe side. Mr. David Deacon who (in the August, 1956, issue) manifested alarm on behalf of the amateur 10-metre band, would no doubt support any advice tending to restrict the number of oscillators in or near that band. But in view of the complete absence of a single reported case of interference of any kind by this type of f.m. receiver, a more substantial reason for preferring second-harmonic working (outside Channel 1 areas) is that it gives about 50% greater sensitivity.

It will be noticed that the i.f., previously a nominal 150 kc/s, is now 120 kc/s. With the closer frequency control, this allows sufficient margin for deviation downwards, and is nearer the centre of the flat response band of the i.f. amplifier.

The method of altering the oscillator tuning capacitance by the programme selector switch in Fig. 1 (b) may look like a retrograde step, for it is the one whose disadvantages were given as a reason for introducing the improved method shown in (a). As it happens, the change was necessary in order to enable the crystals to be switched, without having to substitute a different type of switch. It proved not to be really retrograde, since adjustment of the capacitance for each channel is much less critical. Fig. 2 shows the arrangement of trimmers, extemporized from terminal heads; the performance varies little over most of their range of adjustment.

"Setting up" consists in adjusting the main capacitor C_8, with the switch at "H," to give maximum oscillator voltage at the cathode (not less than about 6V) if a

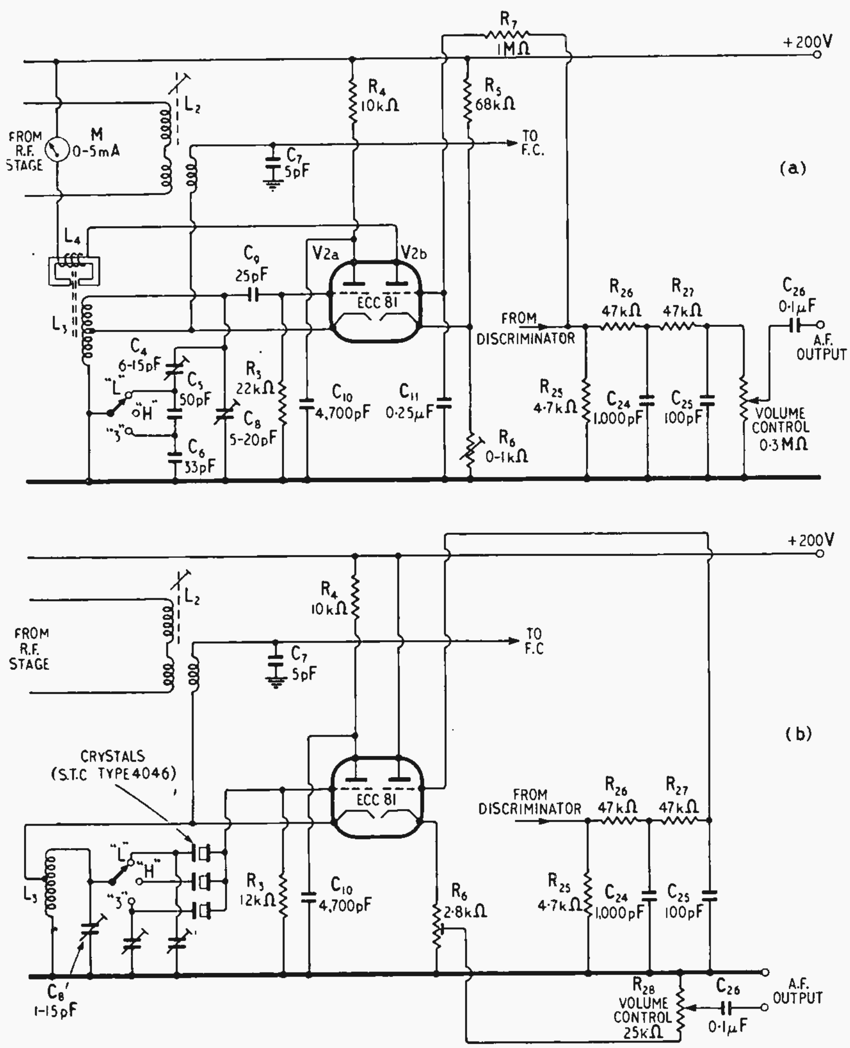

Fig. 1. Oscillator and output parts of circuit diagram: (a) as originally published, and (b) converted to crystal control. The former a.f.c. triode is used as an output cathode follower.

suitable valve voltmeter is available to measure it. If not, a 0-1 mA meter should be interposed between the grid leak R_3 and the earth line and set to maximum by C_8. It is not absolutely essential to use any meter at all, actually; all that needs to be done is to set C_8 to nearly the maximum value at which oscillation is obtained (on "H") and then at the other two positions of the switch adjust the trimmers so that similar conditions exist.

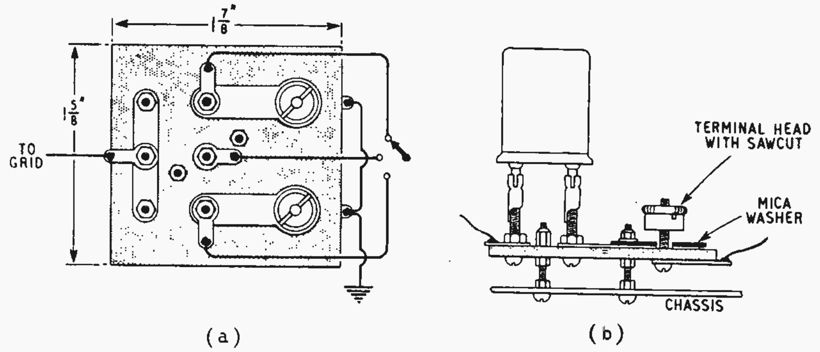

Fig. 2. Plan (a) and side view (b) of crystal holder and trimmer panel assembled from odd parts.

The oscillator coil, L_3, consists of nine turns of 22 s.w.g. wound on 1 cm. dia. polystyrene tube and tapped five turns from earth for the cathode. For second-harmonic working, presumably six or seven turns tapped at four would do, in conjunction with crystals of appropriate frequencies.

It should be noted that the specified frequencies of the crystals are the third harmonics of their fundamental frequencies of vibration, and that oscillation is possible at the fundamental and other odd harmonic frequencies. Only the desired frequency is obtainable within the range of the tuning circuit described, but the possibility of oscillation at an incorrect frequency should be borne in mind, especially in connection with modified designs.

R_6 is pre-set to give the desired range of volume control on R_{28} but if this is considered an unnecessary refinement R_6 can, of course, be adopted as the volume control and R_{28} omitted.

One may tend to assume that because all three transmissions are received from transmitters of equal power at the same site, on closely spaced frequencies, the signals obtained in a receiving aerial will not differ widely in strength. That is possibly a fair assumption if the aerial is erected well in the clear, free from reflections comparable in strength with the direct ray. It was unexpectedly wide of the mark in relation to the indoor aerial. Although only about 15 miles from Wrotham, the receiving site is screened by high ground, and indoors on the ground floor a full half-wave dipole is needed. It was quite easy to find a position giving 10 V or more to the limiter from one transmitter or even two, but moving the aerial a few inches to raise the third from an inadequate volt or so had the effect of bringing down one or both of the others catastrophically. Only one position in the room could be found that gave satisfactory signal strength from all three, and, of course, that was nowhere near parallel to the polarization! If the reflections were from a distance of several miles, such conditions would favour the kind of distortion discussed in the December, 1956, issue, but it appears that they are due mainly to metalwork in the house. This experience is mentioned here because the possibility of widely different signal strengths from transmitters in the same group of three does not seem to have been given much publicity in advice on the installation of v.h.f. aerials.

A feature of the pulse-counter type of f.m. receiver which should interest transistor enthusiasts is the fact that except for the preselector stage and the oscillator—perhaps not even the oscillator nowadays—all stages can be worked with transistors of readily obtainable types. At present the first stage at least might have to use one of the low-voltage pentodes designed for running in team with transistors off a car battery or its equivalent.

AUDIO FAIR

ALL but four of the 65 exhibitors (see below) at the London Audio Fair, which opens at the Waldorf Hotel, Aldwych, London, W.C.2, on April 18th, will be making use of private demonstration rooms in addition to having stands in the main exhibition.

The fair will be open to the trade only until 4.0 on the first day, but on the three following days (Saturday, Sunday and Monday) it will be open to ticket holders from 11.0 to 9.0. Tickets, dated for specific days, are obtainable free from exhibitors, audio dealers or by post from this office. Applications stating day of proposed visit (and, if possible, an alternative) must be accompanied by a stamped addressed envelope (6in by 3½in).

Although originally announced for five days, the Fair will close on Monday, April 21st.

A.K.G.
Acoustical Mftg. Co.
Altobass
Armstrong
Associated Electronic Engrs.
B.B.C.
B.S.R.A.
Beam-Echo
Brenell Engineering
Burne-Jones
Champion Electric
Chapman (Reproducers)
Collaro
Cosmocord
Dulci
Dynatron
E.A.P. (Tape Recorders)
E.M.I. Sales & Service
Electronic Reproducers
G.E.C.
Garrard
Goldring
Goodmans
Goodsell
Gramophone Record Review
Grampian
Grundig
Harting, Wilhelm
Hi-Fi News
Jason Motor & Electronic
Kolster-Brandes
Leak, H. J.
Lowther
Lustraphone
Minnesota Mining & Mftg.
M.S.S. Recording
Mullard
Multimusic
Pamphonic
Philco
Pilot
Pye Group Records
Pye
RCA Great Britain
R.G.D.
Rogers Developments
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Trix Electrical
Truvox
Vitavox
Vortexion
Westrex
Wharfedale
Whiteley
Wireless World and *Electronic & Radio Engineer*
W. & N. Electronics
Wright & Weaire

Stabilized E.H.T. Unit

Design of a Compact Equipment for Anode Supplies

By ***D. J. COLLINS,**** *B.Sc.(Eng.), A.M.I.E.E., and* ***J. EDWARD SMITH,**** *B.Sc.*

IN analogue computing work, multipliers and function generators of the electron beam type are often used. The authors, when considering the design of a multiplier, were faced with the problem of maintaining tight control of the sensitivity of the cathode-ray tube. It became necessary to provide an e.h.t. unit with the following performance:

(a) The unit was to provide an e.h.t. voltage variable from 1350V to 1500V and of negative polarity.

(b) It was to provide a current of 450μA.

(c) The ripple content of the supply was not to exceed 150 millivolts peak-to-peak.

(d) Load changes of ±2% were to produce less than ±0.1% variations in output voltage.

(e) Changes in output voltage due to supply variations of ±10% were not to exceed ±0.5% of the nominal output voltage.

In addition, since this unit was to form only part of a computing unit assembly, it had to be compact and light and capable of operation from conventional computer supply lines. In view of this, the possibility of generating the e.h.t. from 50-c/s mains was ruled out, and the best approach appeared to be in using a high frequency e.h.t. oscillator which was stabilised with some form of control loop.

Basically, the e.h.t. was derived from the secondary of a transformer via a hard valve rectifier and filter circuit. The primary of the transformer formed the anode coil of a Class-C oscillator operating at 20 kc/s. The output level of this oscillator was controlled by varying the screen volts of the oscillator valve. The stabilizing control loop was provided by controlling this screen voltage indirectly from the e.h.t. output voltage. In general design of stabilized e.h.t. supply units where several e.h.t. voltages can be required, it is customary to obtain the feedback voltage from an independent winding of the e.h.t. transformer. The effect of the loop is then to stabilize the flux in the transformer. In this case, however, it was convenient to use the bleeder chain of the cathode-ray tube as one arm of the feedback network. This system has the same loop gain penalty as the independent winding, but provides a component saving of rectifiers and smoothing circuitry. The bleeder chain is external to the unit, and it is the poor stability of this chain, together with tube current variations, which produces the load current changes. The circuit diagram of the unit is shown in Fig. 1.

The detailed design was tackled in the following sequence:—

The Output Section.—The basic filter system was designed for the specified figure, since it was apparent from the circuit configuration that the control loop would exert very little effect on any 20-kc/s components on the e.h.t. supply. A hard valve rectifier was used in preference to a pencil type, because of its smaller physical size and lower stray capacitance. An initial assumption was made that the oscillator frequency was 20 kc/s, and a filter reservoir capacitance of 0.005μF was chosen. This value of capacitance did not present a size problem, and was considered adequate for the basic 20-kc/s components.

The subsequent filtering was to provide an attenuation of some 6,000:1, and it was felt that a single filter would assist in loop stability by limiting the phase shift in the filter to that of one time constant. The largest convenient filter capacitor had a value of 0.1μF, necessitating a filter resistor of 470kΩ.

* Solartron Research & Development.

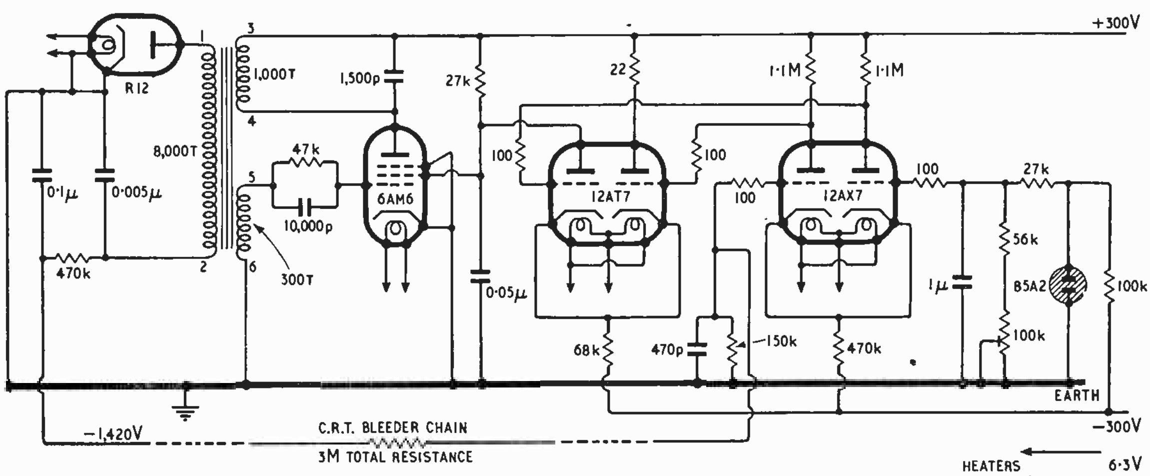


Fig. 1. Complete circuit diagram of the stabilized e.h.t. unit.

The nominal output voltage of 1,420V fixed the reservoir voltage at 1,630V d.c., which required a voltage of approximately 1,200V r.m.s. at the secondary of the e.h.t. transformer.

The secondary loading was of the order of one watt, and the obvious core choice was a ferrite material, although a suitable core form was difficult to find. Eventually, a pair of Mullard FX1315 cores was chosen. The cores have a round centre limb and adequate volume.[1]

It was considered that a Class-C oscillator used in this condition would give a swing of about 150V r.m.s. into the primary of the e.h.t. transformer. Using a maximum flux density of 1,000 gauss, the primary turns were calculated from the expression

$$N = \frac{0.225 \times 10^8 E}{f B_{max} A}$$

where A = cross-sectional area of the core

B_{max} = 1000 gauss

E = r.m.s. voltage across the coil.

This expression fixed the primary at 1,000 turns, corresponding to 6.7 turns per volt.

In oscillators of this type, an optimum anode-to-grid winding ratio has been found to be approximately 3:1 and, in view of this, the grid winding was set at 300 turns.

The secondary winding, consisting of 8,000 turns, was split into three sections (see Fig. 2), each section being pile wound into adjacent "windows" of a four-window Perspex former. This former fitted over the centre limb of the core, and the fourth window contained the primary winding. The sectioning of the e.h.t. winding reduced the possibility of voltage breakdown in the winding and also reduced self-capacitance. To complete the oscillator coil, the grid winding was wound over the centre section of the secondary. The core was gapped, and the two halves were mechanically clamped by synthetic resin-bonded paper cheeks which carried the winding terminations.

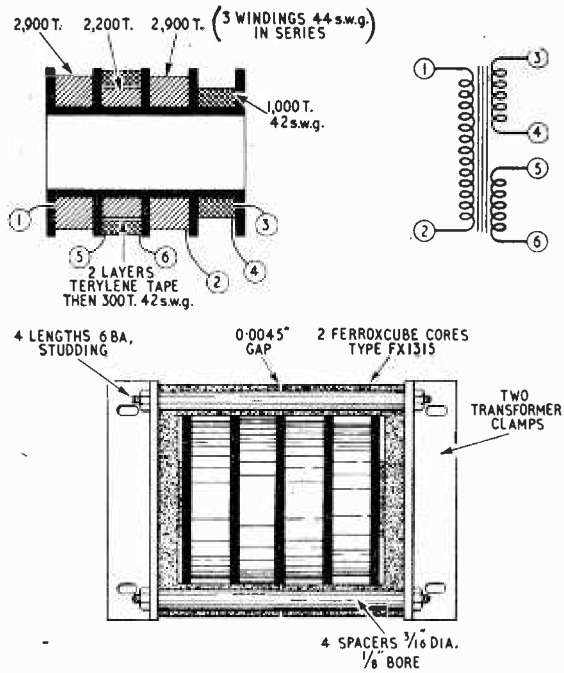


Fig. 2. Winding details of the e.h.t. transformer.

The Oscillator.—This used an EF91 pentode and was of conventional form. In circuits of this type, it has been found that there are two basic modes of oscillation. One is based on the main primary parameters and is usually of low frequency, while the other, attributed to a leakage reactance effect, is a mode of higher frequency. Invariably the higher frequency mode gives a better efficiency, and it is possible to select this higher mode by reversing the primary winding. The frequency of oscillation is adjusted by tuning the primary with extra capacitance. The angular period for which the valve conducts is controlled by the grid time constant and was adjusted in this case to be of the order of 80°. In this condition the peak pulse current was about 50 milliamps. The e.h.t. level was controlled by varying the screen grid voltage of the EF91, and when the e.h.t. was adjusted to its nominal value the screen grid voltage was about 150V.

While the e.h.t. oscillator was running on open loop, i.e., with no control voltage applied to the screen, it was found that heater voltage variations had little effect on the e.h.t. output. This suggested that the valve was working well within its capacity. On open loop, 10% variations in the h.t. line potential caused 10% changes in e.h.t., and 10% load variations had a similar effect. This indicated the need for a stabilizing loop.

The D.C. Amplifier.—The feedback information was applied to one grid of a long-tailed pair, the other grid having a reference voltage applied to it. There were several advantages of using a long-tailed pair as an input stage. The circuit gave a first-order reduction in contact potential drift, and

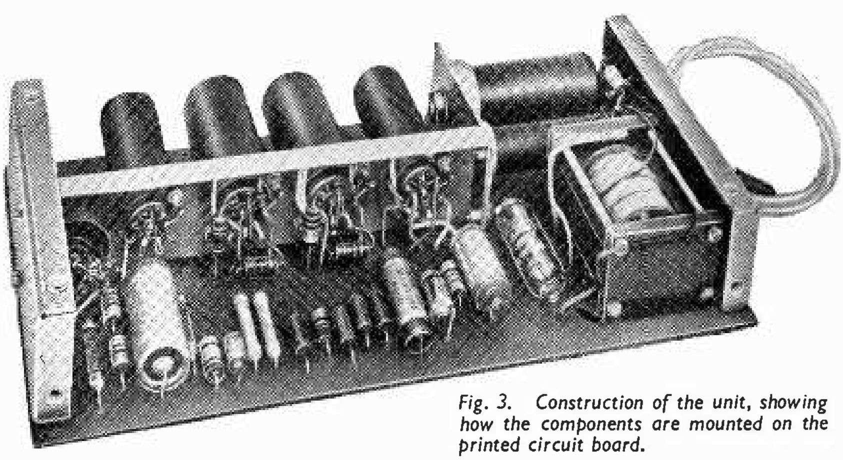


Fig. 3. Construction of the unit, showing how the components are mounted on the printed circuit board.

[1] See Mullard Ferroxcube Handbook.

presented a high impedance to the reference voltage source. The grids of this stage were quiescent at −68V, and variations of the output were obtained by variation of the reference voltage. The anodes of the long-tailed pair were directly connected to a cathode-coupled pair. The first half of the cathode-coupled pair acted as a cathode follower, and the anode of the other half section was d.c.-coupled to the screen of the oscillator valve.

The d.c. forward gain from the input grid to the e.h.t. output was of the order of 52dB. In the closed-loop condition, the feedback network had a loss of 27dB, reducing the loop gain to 25dB. This was adequate, however, to meet the specification. An important point to note was that the long-term stability of the output was not to a first order dependent on the supply stability, since there is a built-in reference source.

Construction.—The unit has been developed into computer "module" form, having overall dimensions 9½in deep, 1⅜in wide, and 5⅛in high (see Fig. 3). The majority of the wiring is carried on a printed board which also serves as a mounting chassis. The power supplies are fed in via a printed board connector, and the e.h.t. output is a flying lead. The unit has an overall screening cover (not shown in Fig. 3).

Finally, it must be pointed out that the design procedure of such a unit is by no means clear cut. Nevertheless, this design meets the specification required, and does so with relatively low power consumption. The power supplies required are: +300V, 16mA; −300V, 8mA; and 6.3V a.c., 1 amp.

R.E.C.M.F. EXHIBITION

Record Number of Exhibitors

THIS year's components show, the fifteenth organized by the Radio and Electronic Component Manufacturers' Federation, will have the record number of 168 exhibitors (listed below). It will again be held at Grosvenor House and Park Lane House, Park Lane, London, W.1, and will be open from 10.0 to 6.0 daily from April 14th to 17th.

Admission is by invitation ticket obtainable from the R.E.C.M.F., 21, Tothill Street, London, S.W.1, by engineers and technicians in the "user" industries, research, Government departments and the Services.

A.B. Metal Products
A.K. Fans
Aero Research
Air Control Installations
Allan, Richard, Radio
Anderton Springs
Anglo-American Vulcanized Fibre
Antiference
Ardente Acoustic Laboratories
Associated Electronic Engrs.

Bakelite
Belling & Lee
Bird, Sydney S., & Sons
Bray, Geo., & Co.
Brayhead (Ascot)
Brayhead Products
Brimar
British Communications & Electronics
British Electric Resistance
B.I. Callender's Cables
British Physical Laboratories
Bulgin

Carr Fastener
Cathodeon Crystals
Clarke and Co. (Manchester)
Collaro
Colvern
Connollys (Blackley)
Cosmocord
Creators

D.S.I.R.
Daly (Condensers)
Darwins
Diamond H Switches
Dubilier
Duratube and Wire

E.M.I. Sales & Service
Eddystone
Egen Electric
Ekco Plastics
Electro Acoustic Industries
Electro Methods
Electronic Components
Electronic Engineering
Electrothermal Engineering
Enalon Plastics
English Electric
Enthoven Solders
Erie Resistor
Ever Ready

Ferranti
Fine Wires
Formica
Fortiphone

Garrard
Goldring
Goodmans
Gresham Transformers
Guest, Keen & Nettlefold

Haddon Transformers
Hallam, Sleigh & Cheston
Harwin Engineers
Hassett and Harper
Hellermann
Henley's
Henry & Thomas
Hinchley Engineering Co.
Hunt (Capacitors)

Imhof
Instrument Review
Insulating Components and Materials

Jackson Bros.

J. Beam Aerials

K.L.G. Sparking Plugs

Langley London
Linton and Hirst
Lion Electronic Developments
London Electrical Mfg. Co.
London Electric Wire Co.
Long and Hambly
Lustraphone

M-O Valve Co.
Magnetic and Electrical Alloys
Magnetic Devices
Mallory Batteries
Mansol (Great Britain)
Marrison and Catherall
McMurdo Instrument Co.
Measuring Instruments
Mica and Micanite Supplies
Micanite and Insulators Co.
Minnesota Mining & Mfg.
Morganite Resistors
Mullard
Mullard Overseas
Multicore Solders
Murex
Mycalex and T.I.M.

N.S.F.
Neill, James, and Co.
Newmarket Transistor Co.

Oliver Pell Control

Painton
Parmeko
Partridge Transformers
Permanoid
Plannair
Plessey Co.
Plessey International
Power Controls

Radio Instruments
Reliance Mfg.
Reproducers & Amplifiers
Reslosound
Rola Celestion
Ross Courtney & Co.

S.T.C.
Salford Electrical
Salter, Geo., and Co.
Scott, Geo. L., and Co.
Shell Chemical Co.
Siemens Edison Swan
Siemens Ediswan (Valves)
Simmonds Aerocessories
Simon Equipment
Sims, F. D.
Spear Engineering Co.
Stability Capacitors
Standard Insulator Co.
Static Condenser Co.
Steatite and Porcelain Products
Stocko (Metal Works)
Suflex
Supply, Ministry of
Swift Levick and Sons
Symons, H. D., and Co.

T.C.C.
Taylor Electrical
Technical Ceramics
Technograph Electronic Products
Telcon Magnetic Cores
Telegraph Construction & Maintenance
Telephone Manufacturing
Texas Instruments
Thermo-Plastics
Thorn Electrical Industries
Truvox
Tucker, Geo., Eyelet Co.
Tufnol

Vacite Wire Co.
Victoria Instruments
Vitavox

Walter Instruments
Wandleside Cable Works
Waveforms
Wego Condenser Co.
Welwyn Electrical Labs.
Westinghouse
Weymouth Radio
Whiteley Electrical
Wiggin, Henry, and Co.
Wimbledon Engineering Co.
Wingrove and Rogers
Wireless Telephone Co.
Wireless World and Electronic & Radio Engineer
Woden Transformer Co.
Wolsey Electronics

Zenith Electric Co.

LETTERS TO THE EDITOR

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

Forward Scatter

I WAS very interested in the ionospheric forward scatter propagation section of your report in the March issue on the Symposium held at the Institution of Electrical Engineers in January.

Ever since the appearance, in *Physical Review* in 1952, of the paper "A New Kind of Radio Propagation at Very High Frequencies Observable Over Long Distances" by D. K. Bailey *et al*, the feeling, in this country, has been one of pessimism towards the possibilities of this form of propagation. Much emphasis has been placed here on the difficulties facing ionospheric forward scatter, in particular its interference potential and its own susceptibility to interference and multipath from back scatter.

I was therefore very glad to see in your summary of the I.E.E. Symposium the statement that "It is only fair to add that, despite the difficulties, the U.S. Authorities are using several such links upon an operational basis."

I had the privilege, on February 20th of being at the meeting of the Armed Forces Communications and Electronics Association when Major General Alvin L. Pachynski, Director of Communications-Electronics, U.S.A.F. and Mr. Richard Kirby of the National Bureau of Standards, Colorado, read papers on the operational reliability and the technical characteristics of the various scatter circuits in use by the U.S.A.F. Their optimism and dynamic approach was in complete contrast to the conservatism seen here. These were people who had, for several years, operated thousands of miles of traffic-carrying scatter systems and who overcame the difficulties as they arose. The great bogy raised in the U.K., namely, the susceptibility of ionospheric forward scatter systems to back scatter, has been resolutely tackled by the U.S., and Richard Kirby expressed the view that back scatter would shortly cease to be a significant factor. In particular, reference was made to the use of ARQ* and to the frequency translator system† developed by the Page Corporation of America. The latter, on the routes on which it has been tried, has reduced "outages" from back scatter to near negligible proportions. Both speakers pointed to the very low reliability of conventional H/F radio circuits across and within the North Atlantic and showed the far greater reliability of their scatter systems in the area. (Mention was made of the excellent performance of the ionospheric forward scatter links during the very severe ionospheric storm of February 11th when conventional North Atlantic H/F circuits were out for many hours.)

Surely it is time we in the U.K. accepted the unique properties of ionospheric forward scatter and at least appreciated its value to areas where conventional H/F can be unreliable. Further, we should bear in mind that, so far, the U.K. has tested only two experimental links and has never been called on to use its ingenuity, mechanically or electrically, to overcome the difficulties of actual traffic transmission. Whereas we have only aired these difficulties here the U.S. have gone a very long way towards solving them.

Weybridge. R. J. HITCHCOCK.

Aerial Measurements

THE article by Mr. F. R. W. Strafford in the February 1958 issue on conditions to achieve accurate results in measuring TV aerial performance has been read with considerable interest. The method described has been used for a number of years on a variety of frequencies and no difficulty has been encountered in obtaining consistant agreement between measured and calculated polar diagrams of dipoles used for checking purposes. This agreement has generally been within ±1 dB, but on the few occasions when this tolerance has been exceeded, the cause has been located and remedied. Moisture absorption in the wooden supports near the aerial under test has been the chief offender, and has been found to cause disturbances of 2 to 3 dB.

With regard to horizontal polarization, while it is agreed that there is not a critical Brewster angle such as occurs with vertical polarization, experience here is that the interference pattern due to ground reflection with horizontal polarization dies out at about the same distance as with vertical polarization. It has been assumed that this is due to the increasing losses incurred by scattering and absorption at small angles of incidence. These experiments were carried out on an open expanse of grass, and resulted in a choice of height and working distance of 8ft and 120ft respectively, agreeing exactly with Mr. Strafford's ratio of 15. It is, however, recommended that this ratio should be adhered to also for horizontal polarization, as experience here is that the distance could not be "safely halved" as suggested in the article. C. O. TITLEY,

Sir W. G. Armstrong Whitworth Aircraft Ltd.

Baginton, nr. Coventry.

Valve Failures

IN my work as a service engineer I have had to replace, during the last few years, many hundreds of valves which have failed prematurely. Probably half of these failed within the guarantee period, but far too many of these have failed after the end of the 90 days allowed by most manufacturers as the free replacement period.

Valve failures, with the expense of a new valve and purchase tax, plus the charge for a service visit, are a source of great dismay to owners of new television sets. Some owners, if they are really unlucky, have to buy two or three valves in less than a year.

There seems to be two main causes of these premature failures. In some cases, set manufacturers are to blame for overrunning or overdriving a valve in a new circuit. This happens very often in the first few months after the introduction of a new design, and service engineers could tell of lots of cases where a particular model has always burnt up its first overrun valve within the first six months. The same valve, in another circuit, has had no serious failures, and proves that the valve is quite a good type if properly used. A new triode/output pentode, with 300-mA heater, has had quite a chequered life up to now in one very popular set, and in another model the failure has always been a new type high voltage rectifier.

But a more common occurrence is valve failure due to new types having been released before they have been properly tested, or at least before the production department has really got tolerances worked out. We can all think of valve types, up to a score of them, which when first introduced were a constant source of trouble. Now, after the production has got down to it, they are as trouble-free as valves can be, thus proving that the early ones were at fault either electrically or mechanically. To go back many years, there was a period a few years after the war when so many failures had occurred with a new type 300-mA multiple rectifier that sets had to be laid up, as the makers could not supply the demand for replacements. This same valve type is now a good old stager, never gives more than a very occasional demand for a spare.

* Automatic repetition of obliterated characters.

† The frequency is changed after the forward scatter signal has been received and before the back scatter arrives.—Ed.

There are lots more examples, right up to the present day. The triode/r.f.-pentode frequency changer introduced a couple of years ago was a very bad offender for over a year, but now it is dependable. But a six-volt booster diode introduced six years ago is still on the unreliable list. Its weakness has always been intermittent heater, I have changed about a hundred myself, nearly always at the customer's expense.

I wonder why set manufacturers, when they find they have sent out a model with an overrun stage, do not contact the users to offer to reimburse them when the inevitable expense crops up? And valve makers, could they not extend the guarantee for an indefinite period when it becomes apparent that one of a new range is proving unreliable? If these concessions were allowed, the servicing industry could free itself from the bad reputation it has often been awarded, for charges which should really be borne by the makers of the sets or valves.

London, N.8. J. SPENCER.

Solid (Deprived?) Sound

WITH reference to "Free Grid's" item "Ni-Fi Stereophony" appearing in the March issue of your magazine I would like to draw your attention to the fact that the word "stereo(n)," the Greek adjective (στερεότ), means "solid"; apropos, there is no doubt about the happy choice of the word stereophonic to convey the desired meaning in English, because a "solid" sound is "three-dimensional" sound, which after all is the generally accepted interpretation.

On the other hand the Greek word for "I rob," or "deprive of" is "stero" (στερῶ), a verb.

London, S.W.7. ANTONIOS SIMONIS.

Tape Speeds

"FREE GRID'S" proposal of a unit for tape speed would be helpful if the unit were by definition reciprocal. Otherwise we might in time be sorry we had not made the unit smaller, or be reduced to something like a deci-Stille (or deci-Poulsen?).

Let us rather take an example from television, where we speak of Band III and Channel 9 and nobody worries about odd fractions of a megacycle.

Therefore, let 30 in/sec be Speed One.

Then, Speed N would be $\left(\frac{2}{2^N} \times 30\right)$ inches per second.

Thus, $1\frac{7}{8}$ in/sec is Speed 5, $\frac{15}{16}$ in/sec is Speed 6 and so on.

London, S.W.3. RICHARD SWETTENHAM.
Argo Record Company, Ltd.

LET us have x stilles $= \frac{30 \text{ in/sec}}{\text{actual speed (in/sec)}}$ which will permit further 2:1 reductions in speed during tape development and yet allows the use of a whole number when the actual speed is expressed in this new unit.

On the matter of what to call this unit, I think that "Free Grid's" suggestion is excellent. Is not the tape speed slowing down and may eventually become "still"? (I here creep out of the back door, having suddenly realized that 1500 "stills" sounds like a gallop.)

Newnham, Glos. R. S. BOUGHTON.

Optical Noise Filter

WHEN the diaphragm of a camera lens is made smaller the cone of light from lens to film (corresponding to a point on the object) becomes slimmer and the angle at the apex is smaller. This allows greater latitude in image distance or, if this is fixed, object distance (depth of focus) for an acceptable standard of sharpness. The more a lens is "stopped down" the greater latitude is obtained until at an aperture of $f/100$ one has virtually a pin-hole camera and the lens might just as well be thrown away. At no point does the angle of view become narrower.

The human eye, with its automatic focusing, has no use for such a variable stop. Only when the lens is not functioning correctly does the need for spectacles arise. Without them the cone of light from each point is either too short or too long and the effect of viewing through a small hole is the same as in a photographic camera. The narrower angle of view in this case is only incidental and is due to the fact that the hole is at a considerable distance in front of the eye's own iris instead of being at the centre of the lens as it should be in a perfect camera. From this it is obvious that for a person of normal eyesight the pin-hole effect does not work.

May I finish by drawing attention to another interesting aspect? This is the pin-hole microscope. Tiny objects placed about 5 cm in front of an eye cannot be seen clearly, but the use of a pin-hole between object and eye produces a sharp image. The closeness of the object is the cause of the apparent magnification.

London, N.6. J. E. AMPHLETT.

I THINK the explanation of the increase in definition in objects viewed through a hole between the fingers lies in the diffraction of light around obstacles.

I, myself, am short-sighted. If a short-sighted person views a cross at a distance through the linear slit between two straight-edged objects, held close to the eyes, he will notice an increase in definition only in lines of the cross parallel to the slit. Any person doing this simple experiment will notice also dark lines running parallel to the slit, and which move with the slit, if the field of view is altered. These are interference fringes.

If a short-sighted person views distant objects past the edge of another object held about 2 inches from the eye, he will observe an increase in definition of the far objects appearing very close to the edge of the near object, and again only in lines parallel to the edge.

The hole between fingers allows light to diffract around the edges. It thus acts as a concave lens, and this is the type of lens used to correct short sight.

The slit between two straight, close objects acts as a cylindrical lens, and hence only corrects the sight in the plane of the slit.

Oxford. D. HERBISON EVANS.

"Do It Yourself" Interference

ALTHOUGH I feel that the four months which have elapsed since the end of my Studio "E" "One-valve Set" series have proved the point I made in my earlier letter, and no National Interference Crisis has arisen, I must ask again to be allowed to make one or two points in reply to Mr. Douglas Walters' letter in the March issue.

First, one does not casually go along to Lime Grove and produce the design before the cameras. It is endlessly probed for weeks beforehand by every possible B.B.C. department, including several branches of the Engineers. I personally discussed the receiver with the latter on four occasions, particularly with regard to the interference question. Incidentally I was rewarded by a most fascinating tour of one of their experimental labs. as a result.

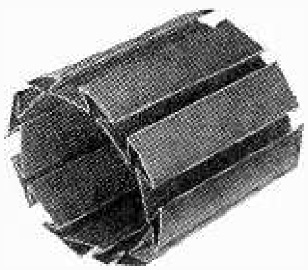
As Radio Correspondent for "B.O.P." for many years I have discovered (or evolved!) the special technique in writing about radio for boys. Designs must be simple and not require complicated lining-up. They must get results anywhere in the country and need not be too modern in outlook (there is usually some old junk in the attic). The chief thing is low initial cost and low running cost. Mr. Walters would calmly double the cost of the receiver and the battery consumption when, as I did, reducing the value of the reaction capacitor achieves the same result. Besides which the selectivity problem is not solved by adding an untuned r.f. stage (not to mention the thousands of letters I should get commencing "My Dad says it would be better to tune the first stage. . . ").

I am grateful to Mr. Peter Tansley for the support given in his letter in the February issue.

Kenton, Middlesex. GILBERT DAVEY.

Technical Notebook

Lower Valve Temperatures, reducing the chances of glass envelope failures, become possible with a new kind of metal insert for use between the valve and its screening can. It is a cylindrical device in which the metal is folded into something like the box pleats used in kilts and skirts (see illustration). This gives almost continuous contact between the valve envelope and the screening can and consequently a high degree of thermal conduction. Made by the Atlas E-E Corporation in America, the insert has the additional advantages that it takes up variations in valve



and screening-can diameters and provides cushioning for the valve against shock and vibration.

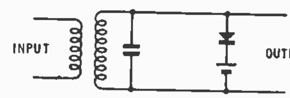
Higher Speed Digital Computers for "real time" operation, with digit pulse rates probably in the region of 10 Mc/s, are the subject of preliminary investigations now being made by the National Research Development Corporation. It is possible that transistors may prove more satisfactory components than valves in this p.r.f. region. Although the transistor cannot be made to operate so easily at high frequencies because of the slowness of the current carriers, it is inherently a low-impedance device, and therefore has the advantage of reducing the effect of circuit capacitances on fast rise and fall times. The micro-alloy transistor has been designed specially for this type of work and will operate at pulse frequencies in excess of 20 Mc/s. It is similar to the surface barrier transistor, with an etched-away base region of controlled thickness (about 0.1 mil), but has in addition an extremely thin alloyed junction (about 0.001 mil) which leads to better current amplification than in the surface barrier type. Transistors of this kind will probably become available in Britain later in the year.

Residual C.R.T. Gases can never be entirely removed because in practice it is not possible to evacuate a picture tube below a pressure of about 10^{-6}mm of mercury and there is always a certain amount of gas liberated after the tube is sealed. Such gases can, of course, shorten the life of the tube by poisoning the cathode. If precautions are to be taken to reduce their generation, it is necessary to know what gases are present in existing tubes and from which components they originate. Philips in Holland have been doing analyses on this question by means of a mass spectrograph called an omegatron, which might be described roughly as a small cyclotron. The principal residual gases found by this method are methane and argon. It seems that the methane pressure falls with the passage of electrons in the tube, but rises again during periods of rest. The argon is present only after vaporization of the getter. What other gases are found depends on the method of manufacture and materials used, but hydrogen, carbon monoxide and carbon dioxide are common. It appears that carbon monoxide and carbon dioxide can be expected in tubes with aluminized screens. The work is described in *Philips Technical Review*, Vol. 19, No. 7-8. It is hoped to obtain quantitative analyses later.

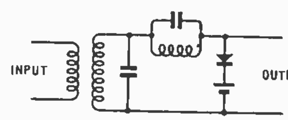
Vacuum Ultrasonic Cleaning technique for metal parts developed by Technochemie of Switzerland is said to offer advantages because of the removal of air from the solvent. Cavitation is claimed to be far more effective, while the removal of air pockets from any intricate component undergoing treatment gives better contact between the solvent and the metal surface. Impacted dirt or other unwanted material in small blind holes in the metal can also be removed by the technique. The equipment, which is available in this country from the Electro-Chemical Engineering Co., uses barium titanate transducers and works on frequencies of 40kc/s and 400kc/s. The process normally includes the additional operations of cleaning before the ultrasonic treatment and rinsing, degreasing and drying afterwards.

X-Raying Miniature Components is being done at the Battelle Institute, on things like diodes, transistors, capacitors and resistors, as a preliminary check on the causes of component failures. Photographic enlargements of the X-ray images about 2½ inches long are made, and are said to yield useful information in 75 per cent of the cases. This technique avoids the risk of destroying the evidence by damage which is possible if the component is opened for inspection. For good resolution a small focal-spot X-ray tube is desirable at a focal-spot-to-object distance of at least 6ft. This tends to collimate the X-ray beam so that after passing through the object it will produce as small a penumbral shadow as possible. A high-contrast, fine-grain film is also desirable for the work.

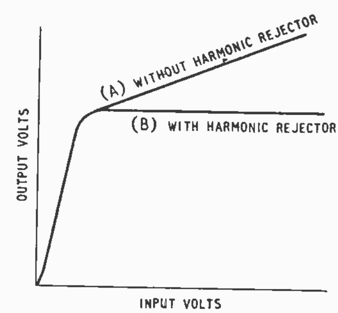
Tuned F.M. Limiter.—A simple form of limiter suitable for use in f.m. receivers, shown at (a), consists of a diode biased in the reverse direction. As soon as the peak inverse voltage exceeds the bias voltage a large current flows and damps the tuned circuit heavily. The limiting obtained is not, however, perfect, and a typical input-output



(a)



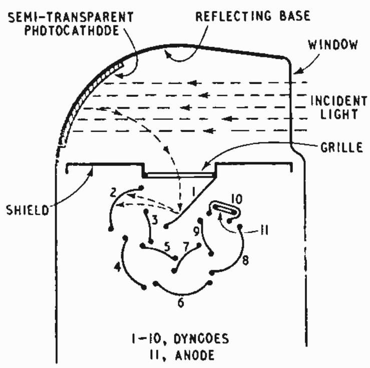
(b)



characteristic is shown by curve A in the lower diagram. The circuit has been analysed by C. G. Mayo and J. W. Head, who, in the March issue of *Electronic and Radio Engineer*, describe a simple modification which results in almost perfect limiting. The modification, shown in (b), consists of putting a rejector circuit, tuned to the third harmonic of the input frequency, in series with the limiter diode. The kind of performance obtained is indicated by curve B. The authors discuss the problem of combining the limiter with a discriminator and propose a new variety of

Foster-Seeley discriminator which takes advantage of the low output impedance of this type of limiter. The calculated harmonic distortion in the audio output is very small.

Dormer Window is a distinguishing feature of a new photo-multiplier tube, the type 7029, recently introduced by RCA. The light enters as shown in the sketch and falls on a semi-transparent photo-cathode with reflecting material underneath. Electrons emitted from the photo-cathode pass into the 10-dynode electron



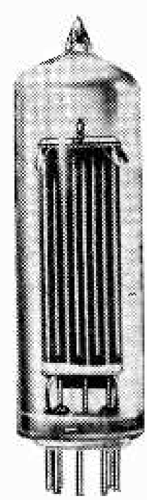
multiplier. This has an arrangement, common to other RCA tubes, whereby the last dynode, No. 10, is shaped so as to partially enclose the anode. It serves as a shield to prevent the fluctuating potential of the anode from interfering with the electron focusing between the other dynodes. (The anode is actually a grating which allows the electrons to pass through it.) As a result, the output current is substantially independent of the instantaneous positive anode voltage over a wide range, and the photo-multiplier can be used with practically any load impedance. The tube is intended mainly for detection of low-level light signals in the presence of relatively high background illumination.

Radar Mapping System, a new form of aerial photography, has been developed by Texas Instruments for the U.S. Air Force. It produces a strip photograph of the picture appearing on the airborne radar screen covering a broad corridor of the terrain below. The system has been called "side looking radar" because the mapped corridor extends out on each side of the aircraft's path.

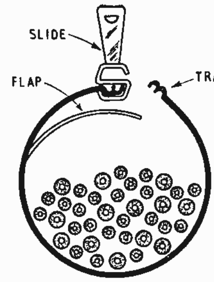
Three-Colour Storage Tube, similar to the shadow-mask colour television c.r.t. in mode of operation but having a long screen persistence of about 1 minute, is described by C. D. Beintema, L. L. Vant-Hull and S. T. Smith in D.S.I.R. unpublished report PB121815*. There are three "writing" electron guns and the perforated shadow mask is arranged so that the electron rays from each gun impinge on a particular set of colour phosphor dots on the screen. In this way it is possible to store electrical signals independently in adjacent colour areas. The tube has 75 colour phosphor dots to the inch and gives a brightness of 8 foot-lamberts.

Simple Diode Fluxmeter described by W. Fulop in the February, 1958, *Journal of Scientific Instruments* is based on the magnetron effect which occurs in the electron trajectories of a diode valve when it is placed in a magnetic field. This reduces the anode current according to the strength of the field. A subminiature diode is rotated in the field on two mutually perpendicular axes until minimum anode current is obtained. The angular co-ordinates of the diode then provide a relative measure of magnetic flux and can be calibrated against a standard.

Low-R Photoconductive Cell of the cadmium sulphide type just introduced by Mullard's will give sufficient current to operate a relay directly with only a low applied voltage. The low resistance is achieved by an interdigital pattern of copper strips on the cadmium sulphide element, as shown in the illustration. Cadmium sulphide cells have only recently become available in commercial form and are notable for their high sensitivity compared with photo-emissive cells and other photoconductive types. They are slower in response than photo-emissive devices, but this particular cell will perform switching operations at speeds up to about 50 per second. With illumination of 5 foot-lamberts, at a colour temperature of 1500°K (reddish yellow light), the cell will give about 20mA for an applied voltage of 10V. From the same illumination but at a colour temperature of 2700°K (yellowish white) the current is approximately 6mA. Doubling the applied voltage gives a four-fold increase of current within the permissible power dissipation, which is 1 watt at 25°C or 200mW at 75°C. The dark current is only 2.5μA (at 25°C) with 300V applied to the cell. Spectral response covers the entire visible spectrum and extends nearly into the infra-red region.



Zip-Fastener Cable Harness made of p.v.c. is a new idea from America for grouping together assorted wires into one main cable. Manufactured by the Aphlex Tubing Division of Alpha Wire, the "zipper tubing" is available in sizes ranging from ½ inch to 4 inches in diameter (closed) and lengths from 10ft to 1000ft. The two interlocking parts are in the form of continuous mouldings—like the modern plastic slide fasteners used for toilet bags, etc. A flap is incorporated to contain the wires while the tube is being closed up by the slider.



Thermal Image Pick-up Tube, with sufficient sensitivity to detect objects differing by as little as one degree from background temperature, seems a possible outcome of development work described by J. Burns in D.S.I.R. unpublished report PB124111*. It is thought that the tube should be capable of giving a picture of substantially television quality.

Video Tape Splicing method has been developed by Ampex in the U.S.A. for their television magnetic tape recording machines (in which the signals are recorded in transverse tracks across a 2-inch wide tape, see September 1957 issue, p. 445). The splicing is done along the frame sync pulse lines to give a smooth transition during playback. The position of the frame pulse lines on the tape is found by applying a suspension of carbonyl iron particles to the recorded surface. The iron particles align themselves with the recorded magnetic lines of force, so as to make them easily visible after the rapid evaporation of the suspension medium. Finding the correct lines for splicing is further simplified by identification pulses provided by the recorder. These protrude right to the lower edge of the tape, so that only this part of the surface need be coated with the carbonyl iron.

Feedback in Magnetic Amplifiers is being investigated as a new technique by Remington Rand in the U.S.A. The power gain of the amplifier can be increased, but there remains a finite rise-time limiting the speed of response. Tests made on magnetic amplifiers excited by a sine-wave carrier are described in D.S.I.R. unpublished report PB123403*.

* Obtainable from the Lending Library Unit of the D.S.I.R., 20 Chester Terrace, Regent's Park, London, N.W.1.

Transmission-Line Calculator

Device for Finding the Length of Terminated Lines at Specific Frequencies

By J. H. ANDREAE, Ph.D.*

THIS device has been found useful for calculations on low-loss resonant transmission lines in the course of ultrasonic research above 50Mc/s. It is based on the well-known formula for the reactance X at a distance x from a short-circuit along a line of characteristic impedance Z_0:—

$$X = Z_0 \tan(2\pi x/\lambda) \quad \ldots \quad (1)$$

where λ is the wavelength.

The multiplication of Z_0 by $\tan(2\pi x/\lambda)$ is effected by the slide-rule principle, in fact, by adding their logarithms:—

$$\log_{10}X = \log_{10}Z_0 + \log_{10}\tan(2\pi x/\lambda) \quad \ldots \quad (2)$$

The characteristic impedance Z_0 is set on a sliding logarithmic scale (A in the illustration), while $\tan(2\pi x/\lambda)$ is given by the curve B engraved on the Perspex disc D. This curve is a polar plot of the function $\log_{10}\tan(\theta/2)$ against the angle θ. $\theta/2$ represents $2\pi x/\lambda$ so one complete rotation of the disc ($\theta = 0$ to 2π) corresponds to a change in x of $\lambda/2$, or half a wavelength.

The disc D is 12in in diameter and $\frac{3}{16}$in thick and has a reference circle E engraved on it at a radius of 4in. The radial scale for the polar curve of $\log_{10}\tan(\theta/2)$ is identical with that for the $\log_{10} Z_0$ scale (a decade extending over 2in) and the curve B is measured from the reference circle so that a radius r measured from the centre of the disc to the curve is given by:—

$$r = 4 + 2\log_{10}\tan(\theta/2) \text{ inches} \quad \ldots \quad (3)$$

Since the reactance at a point on the transmission line is usually required in terms of an inductance L or a capacitance C, a second rule F is provided for converting the reactance in ohms directly into an inductance in microhenries, or a capacitance in picofarads. Taking logarithms of the formulae:—

$$X = 2\pi fL \quad \ldots \quad (4a)$$

and

$$X = 1/2\pi fC \quad \ldots \quad (4b)$$

we find that

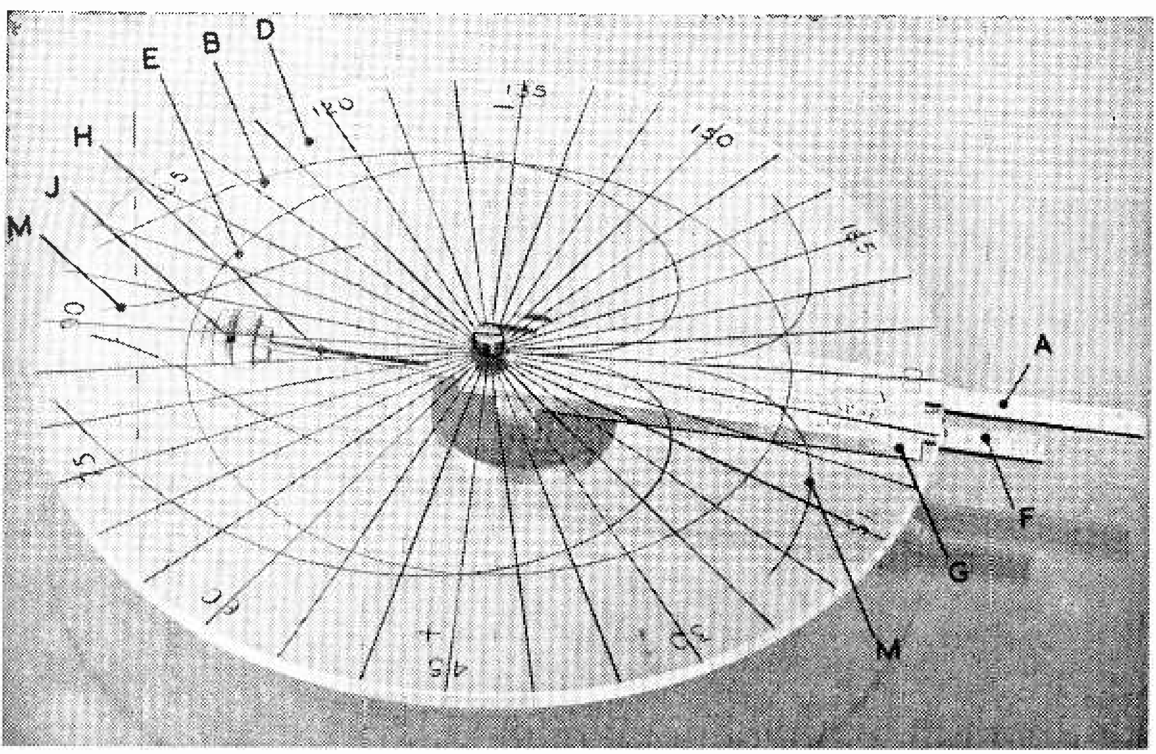
$$\log_{10}X = \log_{10}2\pi + \log_{10}f + \log_{10}L \quad \ldots \quad (5a)$$

and

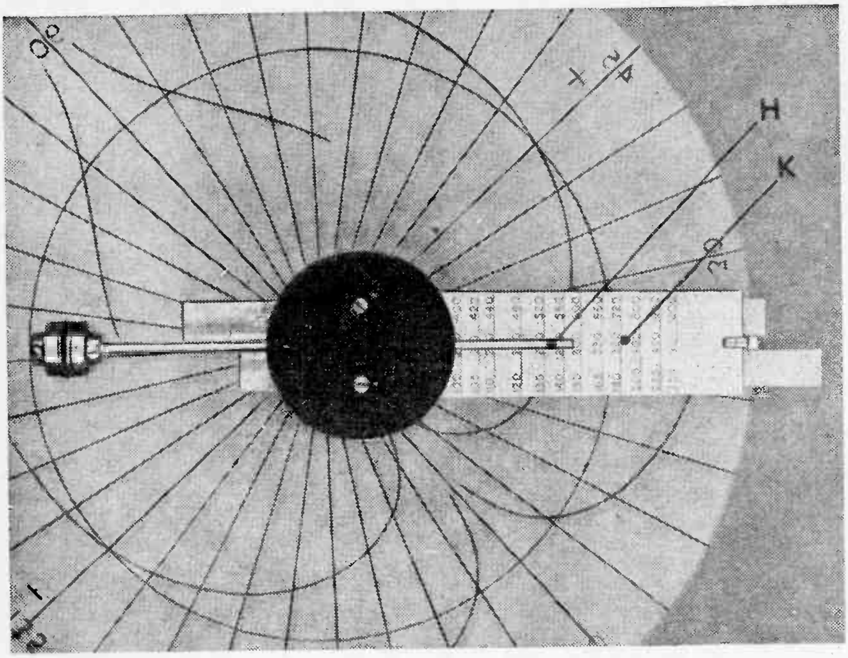
$$-\log_{10}X = \log_{10}2\pi + \log_{10}f + \log_{10}C \quad \ldots \quad (5b)$$

The rule F is graduated with two scales in opposition, one giving the frequency f and the other giving the inductance or capacitance. The two scales are displaced by the amount $\log_{10} 2\pi$ and, because of the

*Imperial Chemical Industries Ltd., Research Department.



Top view of calculator showing the engraved Perspex disc with the "slide-rule" unit mounted underneath it.



Underside of calculator showing base rest and reverse of "slide-rule" unit.

of x in formula (1) by one centimetre and is divided into tenths. The 6-division scale is employed for air-dielectric transmission lines and the 4-division scale is used for lines with a polythene dielectric. Polythene has a dielectric constant of $\epsilon = 2.3$, so $\sqrt{\epsilon} = 1.5$ and 6/4 is a good approximation to the ratio of the wavelengths in air and polythene. (When other dielectric media are encountered a separate frequency scale K may be provided, or the number of divisions "rolled out" by the wheel on the 6-division scale can be divided by $\sqrt{\epsilon}$.) When the pointer end of the arm H is moved to the required frequency on the scale K and the disc is rotated through 360°, the appropriate wheel scale should roll out the distance x to one half wavelength in centimetres.

negative sign in equation (5b), the rule is reversed when capacitance, rather than inductance, is being measured. The rule is reversed by pulling it out and inserting the other end first.

In order to change ohms into microhenries, the frequency end of the rule F is inserted into the rule case G and the appropriate frequency is lined up against the mark L on the rule F. (The mark L is placed at 1,000 ohms and this allows for the conversion of henries to microhenries.) Now the inductance in microhenries can be read off the rule F for any value of the reactance in ohms on the rule A. Similarly, for conversion to picofarads the rule F is reversed and the frequency is set against the mark C which corresponds, conveniently, to the end of the rule.

In addition to the rules A and F the rule case G carries the arm H, on one end of which runs the wheel J. The other end of the arm acts as a pointer on the frequency scale K, which is engraved on the under side of the rule case. The rubber-tyred wheel J rolls on the disc D at a radius which is determined by the position of the other end of the arm H on the frequency scale K. For one complete rotation of the disc (*i.e.* one half wavelength) the wheel performs:—

$$n = R/r \quad \ldots \quad (6)$$

revolutions, where R is the radius of the circle on which the wheel rolls and r is the radius of the wheel. The scale K is calculated from equation (6), the length of the arm H, the number of graduations on the wheel and the formula:—

$$\lambda = \frac{3.10^{10}}{f\sqrt{\epsilon}} \text{ cm} \quad \ldots \quad (7)$$

where ϵ is the dielectric constant of the medium separating the conductors of the transmission line. For the device shown, a wheel of 1cm radius is used and two scales are engraved on it, one giving 6 divisions per revolution and the other 4 divisions per revolution. Each division corresponds to an increase

So far it has been tacitly assumed that the transmission line is terminated in a short-circuit. When the line is terminated in a reactance X_T, this termination is imagined to be replaced by a length of short-circuited line showing the reactance X_T at its open end. Then, instead of setting the calculator to the short-circuit position and rolling out the length of the line, we start from the angular position of the disc at which the curve B indicates the reactance X_T on the Z_0-rule A.

The calculator has been designed for anti-clockwise operation and that half of the curve B which passes over the rules immediately after the short-circuit position 0° is marked positive, the other half negative. The sign of the reactance changes both at the short-circuit position and also at the open-circuit position 90°.

To extend the curve B near the short-circuit and open-circuit positions, additional curves M are provided which represent parts of the curve B multiplied by 10 and divided by 10, respectively. When using these extension curves the values indicated by the scales on the rules A and F should be increased or decreased by a decade as appropriate.

A Problem.—The scope of the calculator may be illustrated by describing the procedure for solving a particular problem. A push-pull, resonant line oscillator was constructed for operation between 150 and 500Mc/s using a double-tetrode valve type QQVO6-40 and described elsewhere in this issue. Three anode lines of characteristic impedance 75 ohms, 150 ohms and 250 ohms, respectively, were employed. The inter-anode capacity of the valve was measured and found to be 2pF and the characteristic impedance of the line formed by the anode pins was calculated to be 350 ohms. We shall consider the case of the 75-ohm line only since a similar procedure applies to lines of other impedance. The problem is to calculate the length, in centimetres, of the anode line over the frequency range from 150 to 500Mc/s on the assumption that it is short-circuited at one end and terminated at the other end by a 2-cm length of 350-ohm line and a 2-pF capacitance. The procedure is as follows:—

(i) Set the pointer on the frequency scale K to, say, 200Mc/s.

(ii) Set the Z_0-rule to 350 ohms on the reference circle.

(iii) Set the frequency, 200Mc/s, on the rule F against the mark C on the rule A.

(iv) Rotate the disc until a point on the negative half of the curve B indicates 2pF on the rule F.

(v) Set the wheel J so that the zero graduation is visible just under the disc D.

(vi) Rotate the disc until the graduation 2 appears just under the disc. The reactance −330 ohms, indicated now by the curve B on the Z_0-scale, is that at the junction point between the 350-ohm and 75-ohm lines, looking into the 350-ohm line.

(vii) Set the Z_0-rule to 75 ohms on the reference circle.

(viii) Rotate the disc until the curve B again reads −330 ohms on the Z_0-scale.

(ix) Set the wheel to zero as in (v).

(x) Rotate the disc to the short-circuit position, counting the number of centimetres rolled out by the wheel on the 6-division scale (x = 32cm.).

(xi) Repeat for other frequencies between 150 and 500Mc/s until a smooth curve can be plotted. The whole curve can be evaluated in about 30 minutes.

This problem illustrates the ease with which the operator can change from one characteristic impedance to another, while working directly in megacycles per second, centimetres, picofarads and microhenries.

A more complicated version of the calculator, capable of dealing with resistive terminations and with lossy transmission lines, has been described before†. In practice, these elaborations have been seldom used and they were omitted when the calculator was reconstructed in its present, improved form.

† J. H. Andreae, Ph.D. thesis, London, 1955.

Exponential Horn Dimensions

Calculations for Ribbon Loudspeakers

By J. R. G. TWISLETON, B.Sc., A.M.I.E.E.

SOME time ago when the writer constructed a pair of exponential horns for a ribbon loudspeaker, for which a design has previously been given in *Wireless World*[1], it was found convenient to calculate the dimensions of the sides of the horn rather than use the geometrical method of development suggested in the article. This enables the outline of the sides to be marked directly on the material to be fabricated, or, alternatively, on to suitable templates for the sides.

The calculation is given for horns of rectangular cross-sections[2], and the nomenclature used is that of the previous article[1]. Thus, the throat dimensions of the horn are a and b, and the corresponding dimensions at an axial distance x from the throat are $a_x = ae^{m_a x}$ and $b_x = be^{m_b x}$. It is clear that at the point x, where the width of one side of the horn is a_x, the length of the side is not x but the distance along the curve $b/2 \times e^{m_b x}$. Similarly at the point where the width of the adjacent side is b_x, the length of that side is the distance along the curve $a/2 \times e^{m_a x}$.

The length of these curves can be readily obtained by integration[3], when it is found that for the side of width a_x the developed length b'_x corresponding to an axial length x is given by

$$b'_x = \frac{1}{2m_b}\left\{\log_e\left[\frac{(\eta - 1)}{(\eta + 1)}\left(\frac{\eta_0 + 1}{\eta_0 - 1}\right)\right] + 2(\eta - \eta_0)\right\} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

$$\text{where } \eta = \left[1 + \left(\frac{bm_b}{2} e^{m_b x}\right)^2\right]^{\frac{1}{2}},$$

$$\text{and } \eta_0 = \left[1 + \left(\frac{bm_b}{2}\right)^2\right]^{\frac{1}{2}} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

Equations (1) and (2) also give the developed length a'_x of the side of width b_x if for b'_x, b and m_b are substituted a'_x, a and m_a respectively.

Practical Example.—Consider a horn having a cut off frequency of 900 c/s, and throat dimensions a = 1.375 in and b = 0.375 in. The exponent $m_a + m_b$, which is equal to $4\pi f_c/13{,}500$ where f_c is the cut off frequency, is 0.84 per in. Thus, choosing $m_a = 0.36$ and $m_b = 0.48$, the mouth dimensions are 9.25in and 5.0in for an axial length of 5.25in. The dimensions of the sides in inches, calculated from the formulae using a slide rule, are given in the following table, η_0 being the value of η where $x = 0$, i.e. the first value of η given in the table.

x	0	0.75	1.5	2.25	3.0	3.75	4.25	5.0	5.75
a_x	1.375	1.80	2.36	3.10	4.06	5.36	6.38	8.38	11.0
η	1.004	1 008	1.016	1.035	1 072	1.138	1.2	1.41	1.785
b'_x	0	0.8	1.52	2.30	3.12	3.91	4.43	5.21	6.7
b_x	0.375	0.54	0.74	1.10	1.60	2.27	2.76	3.70	5.92
η	1.031	1 052	1.086	1.147	1.24	1.39	1.53	1.82	2.23
a'_x	0	0.76	1.52	2.39	3.28	4.28	5.0	6.25	7.78

In the calculation no allowance is made for any flaps to hold the sides together, but this can be taken care of when the sides are marked out.

It may be noted that if the horn is to be subdivided into cells, the dimensions of the internal partitions required may be calculated in the same way as for the sides by using the appropriate values for a and b.

[1] P. L. Taylor, Ribbon Loudspeaker, *Wireless World*, Vol. 57, No. 1, p. 7 (Jan. 1951).

[2] A treatment for exponential horns of square cross section has been given by G. H. Logan in *Electronics*, Vol. 12, No. 2, p. 33 (Feb. 1939).

[3] See for example, Toft and McKay, "Practical Mathematics," Ch. XI (Pitman 1942).

Re-charging Primary Cells

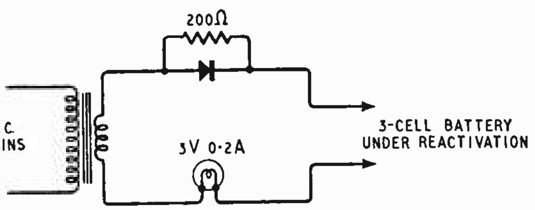
Further Notes, Including Results with Leakproof Units

By R. W. HALLOWS, M.A. (Cantab), M.I.E.E.

FOR a good many years now the investigation of the possibility of reactivating the dry Leclanché cell has been one of my spare-time diversions. The chemical reactions which take place inside such a cell are actually considerably more complex than the simple equations given in many text books suggest. But the key reaction is the chemical conversion of zinc abstracted from the inner walls of the can and ammonium chloride into zinc chloride and ammonia, and since this is the exact opposite of an electroplating process, it seemed more than likely that it should be possible to reverse the reaction successfully—if only one could find out how to do it.

Experiments in which reverse d.c. was passed through partly discharged cells were to some extent successful*; but one very serious snag was encountered. Zinc was certainly redeposited on the inner walls of the can, but not always in a satisfactory way. Instead of being hard, smooth and evenly distributed, it was inclined to be soft, lumpy and uneven. The inevitable result was that after a varying number of reactivations thin spots developed and eventually puncturing, or even bursting of the can occurred.

The big trouble was that it was quite impossible to predict the life of such reactivated cells. One



might be in perfectly good shape after fifteen or even twenty reactivations; occasional cells, though, would fail through puncturing after as few as three or four. Clearly, no reactivating process could be of much practical value unless its products were reliable. It certainly costs far less to reactivate a cell than to buy one; but it is a much more economical business to throw run-down cells away and invest in new ones than to have expensive apparatus ruined by the horrible mess which exudes from a punctured can!

Results showing a distinct improvement were obtained when a trickle charger with no smoothing circuit was used for the d.c. supply. But here another trouble was apt to arise: unless one was very careful cells under charge became far too hot and there was evaporation of moisture from the electrolyte. Still, there was an improvement in the quality of the redeposited zinc. This was undoubtedly due to the roughness of the d.c. and I have kicked myself not a few times since for having failed to try the effect of a little superimposed a.c.

Then in 1954 a Dutch engineer, Mynheer Beer, was kind enough to send me particulars of a device developed by him and known as the "Electrophoor" which was extensively used in the Netherlands. The inventor was also kind enough to let me have an "Elektrophoor" suitable for dealing with three cells of the Eveready U2 or Vidor Monocell size. The apparatus was described in *Wireless World*†. In case any readers have not access to that issue (and to save others the bother of turning up the reference!) the circuit diagram is reproduced on this page.

It will be seen that the rectifier is shunted by a 200-250 Ω resistor which allows a certain amount of a.c. to pass. The input to the cells under treatment resembles, as I wrote originally, "very dirty d.c." The waveform, as shown by the oscilloscope, consists of a shortish peaky positive "half-cycle," followed by a shallow negative trough of longer duration. It is, in fact, as correspondents showed‡, very similar to those used in the periodic reverse (P.R.) system of electro-plating, by which even deposits of metal up to 0.5 inch in thickness can be obtained. One's biggest surprise on opening the can of a cell which has been many times discharged and subsequently reactivated by the "Elektrophoor" is to find as a rule no trace of lumpy or spongy deposits, but a hard, even inner surface.

The superimposed a.c. not only produces this most desirable result, but also speeds up the process of depolarization and makes it more complete.

The otherwise charming little town in which I live has not the best of street lighting; and I make a great deal of use of a 3-cell flashlamp after sunset during the darker months of the year, that is between mid-September and mid-April. One set of cells lasted me right through what I call the flashlamp season of 1954-55. They were thrown away in April, not because they were in poor condition—the e.m.f. and internal resistance could still be brought back by reactivation to something very close to their original values—but because I was afraid that I might forget to give them an occasional "pep-up" and that there might in consequence be a regrettable incident.

The same thing took place in 1955-56 and 1956-57 and these experiences have already shown that, for seven months on end, at any rate, the dry Leclanché cell can be used precisely and exactly as if it were a secondary cell.

Last autumn, leakproof cells were once more available. Three of these (LPU2's) have been in regular use since last September and it seems likely that they may continue to give good service from

* See "Reactivating the Dry Cell." R. W. Hallows, *Wireless World*, August, 1953, p. 344.

† "Dry-cell Reactivator." R. W. Hallows, *Wireless World*, October, 1955, p. 503.

‡ A. F. Standing and George E. Smythe, *Wireless World*, December, 1955, p. 606.

year to year. That rather depends on just how far a leakproof cell *is* leakproof. Wanting to find out, I have deliberately bullied some of them in an almost brutal way—without, so far as can be detected, any untoward results. Some have been grossly over-charged for 36 hours or more on end. Others have been baked in the oven for three hours until they were much too hot to be handled with bare fingers. But they always seem to come up smiling again after such ordeals and quickly settle down to working as well as ever.

I calculate that during the 200-odd days between the middle of September and the middle of April when they are in regular use the flashlamp cells are under discharge for a total of not less than 150-160 hours. The load being 0.25A, that comes to 37½-40 ampere-hours, with the cells apparently still in excellent condition. This, you must admit, is no mean performance.

Since these experiences extend at the moment of writing over the autumns, winters and springs of just on four years, one feels that the method of re-activation by d.c. with superimposed a.c. has amply proved its value.

It has been suggested by correspondents connected with the electro-plating industry that even better results might be obtainable if the source of the reactivating current were something different from 50 c/s mains a.c. It might be preferable, they think, to use a current of less rapid periodicity and in particular to make the negative troughs applied to cells under charge shallower and of much longer duration.

If any reader feels so minded and has the necessary facilities available, here is an interesting field for experiment. Myself, though, I fancy I shall remain content with the results obtained with the 50 c/s a.c. so conveniently supplied by the mains.

Valves Galore

—And Some Notes (Mostly Sour) on Series-Heater Circuits

By JACK DARR*

Although series-heater radio receivers are common in America, the low mains supply voltage has until recently prevented the use of this technique for TV receivers. Now that suitable power rectifiers and capacitors are available (voltage-doubling for the h.t. line is universal) series-heater TV receivers are becoming common. This article deals with some of the servicing problems that Americans are meeting for the first time.

AMONG some of the more entrancing features of Life In These United (more or less) States is the opportunity of repairing some of the weird circuits used in the manufacture of radio and TV receivers. Probably the principal factor in the design of much of our mass-produced equipment is economy of construction. This accounts for the Printed Circuit, anathema to most service technicians, but beloved of the development men and accounting departments because of their cheapness of manufacture. Another is the Series Heater Circuit.

This arrangement, identical with that used in the older strings of Christmas-tree lights, was developed to eliminate the need for a mains transformer. Of late, it has resulted in the introduction of some of the most weird heater-voltages imaginable! The technician comfortably puttering around in a new set, accustomed to such sensible types as the 6BQ6GT (a very popular line-scan output tube), now finds himself staring in horror at such cute little numbers as 12BQ6GT, 14BQ6GT, 17BQ6GT, 19BQ6GT, and even a 25BQ6GT. These are accompanied by such items as the 12AX4 and 19AU4 for dampers (efficiency or boost diodes). Perhaps because of its retiring disposition, always hiding shyly in the box screening the line-scan output transformer, the EHT rectifier has somehow escaped notice, and remains the old and faithful 1B3! It is quite heartening to the technician to find at least *one* valve (tube to us!) in the set with a number he has seen before! (and is likely to find in his tube-kit!).

In other parts of the set, the same confusion prevails. I.F. stages, in the Good Old Days, used such types as the 6AU6, a sharp-cut-off pentode, with perhaps a 6CB6 in the first stage, for a.g.c. purposes. Now, upon lifting the screens from the i.f. tubes, we find a group of such Little Monsters as 3CB6, 4BZ6, 5AU6, 7AU7 *etc.* Oops! Pardon me. I'm a bit confused; the 7AU7 is not found there, but is a replacement for our old familiar friend, the 6SN7. It has a large family, too; 14AU7 *etc. etc.*

Sync separators, clippers *etc* are inhabited by another strange tribe; 5U8's, 5AN8's, 7AW8's, 3BN6's, while audio output and other chores are handled by 5AQ5 and 5BK5. Vertical oscillators find themselves crowded into one bulb with the output triode in the 6CM7. This novelty combines one 6J5 and one 6SN7, or half of it, all in one tiny bottle!

In the tuner, to use a native expression, they have gone simply "hawg-wild!" Replacing the old, familiar and highly efficient 6BQ7-6BK7 *et al*, we find, if I may be permitted an atrocious pun, a perfect "cascade of cascodes"; 3BQ7, 4BK7, 5BZ8, 5CL8, 5AT8, 4BS8, 5CG8, on and on *ad infinitum* until one

* Ouachita Radio-TV Service, Mena, Arkansas.

wonders where they get all the new letter combinations! Also prominent among such types are the new triodes—the 2BN4 is one. This is employed in a new type of tuner which is the only tuner giving less snow when the r.f. tube is removed from the socket! A 2AF4 is used in u.h.f. tuners and was the source of much grief during its formative years; later production changes have ironed out some of the bugs, and they work very well now.

Mixer-oscillators, beginning with the old faithful 6J6, have changed to a triode-pentode combination, using a 6U8 in the beginning: these were soon replaced by 5U8, 5AT8, 5CG8, 5BS8 *et al.*

The Reason For The Change:—There was actually a bit of good reasoning behind the development of these odd-numbered valves. They do have two things in common; their filament current and their "warm-up" time. These are 600 mA and 11 seconds, respectively. This was done intentionally; the picture tubes all have 6-volt heaters, with 600-mA current and (now) an 11-second warm-up time. (How they've overlooked them in the stampede to make odd-voltage tubes, I shall never know!) When used with the remaining tubes, this created quite a few rather unseemly series-parallel heater circuits. For instance, many sets used a dual-string arrangement, with 300 mA tubes in each branch, meeting at the c.r.t. heater for the first time, where the currents flowed together through its heater back to earth.

The difference in warm-up time created quite a bit of confusion and service difficulties in the older sets. Older tubes were quite individualistic about this parameter; they arrived at their operating temperature when and if they jolly well got ready, regardless of what was going on in other parts of the circuit. For instance, if the line-scan output tube got ready to go a bit early, no drive was available from the oscillator, if that worthy happened to be a bit slow in waking. This resulted in a severe overload in the anode circuit with occasional failures of fuses and much puzzling on the part of the service technician as to just what had caused the fuse to let go.

The first corrective measure applied to this problem was the inclusion of a special resistor in series with the heater string. This blob of thyrites had a negative temperature coefficient, which gave it a whacking great resistance when cold, up into hundreds of ohms, dropping to a quite low resistance when heated up. This unit was called an NTC resistor by the trade and several mouth-filling names by the advertising gentry ("Magic Tube Saver," *etc*). It caused a delay in the warm-up time by limiting the current which could be drawn initially. This eliminated one very bad feature, the unequal loading, which caused some valves to suffer as much as a 400% overload while others were underheating, resulting in amazingly short tube lives!

By making all of the tubes with identical current drains and warm-up times, the designers were able to string them all together like a tremendous Christmas-tree light string.

This "controlled warm-up" feature eliminated not only the resistor, but also speeded up the overall time required to get the thing into action. Using large NTC resistors it often required a minute and a half to get a picture on the screen; the new types will start the set to work within about 30 seconds. This makes the customer much happier; with the old types he often missed the opening commercial!

The "Line-Connected" Chassis and Shock Hazards:—Another feature of the series-connected set is the need for using what is known among the setmakers as a "line-connected" chassis and among servicemen a "Death-trap." Instead of the familiar mains transformer and rectifier tube, we now find all sorts of arrangements, mainly using selenium or silicon rectifiers in half-wave and full-wave voltage doubler circuitry. The most charming feature of these arrangements is that they seem to require that one side of the circuit be connected directly to the a.c. mains (line). The inevitable result of this arrangement is that if the line plug is inserted a certain way, the full line voltage is present between the chassis and the nearest grounded object (which is generally the serviceman, but may be, on occasion, the *customer!*)

One delectable version of this was encountered recently by the writer while servicing one of these chassis. Touching the earthed antenna lead and the chassis gave a vicious shock. After reading a few appropriate verses from the Koran *etc*, the luckless wight reversed the plug and returned to his task, only to be unceremoniously removed from his stool and deposited on the shop floor when he again managed to complete the circuit between the chassis and antenna, this time with the elbow! Investigation (using a voltmeter) resulted in the shocking (oh!) disclosure that this little gem was hot—with the full line voltage to ground—in *both* positions of the plug!

All levity laid aside for the moment, a very serious problem does exist. This applies not only to the technician but also to the user. For economy again some of these sets have been housed in metal cabinets. Of course, in compliance with the Underwriters' regulations, insulation is provided between chassis and cabinet. However there are some models in which this insulation seems to be entirely inadequate. Careless service procedure, owner tinkering *etc* can nullify even this slight degree of protection by allowing self-tapping screws, stray bits of metal or any other conductor to fall into the small spaces between chassis and cabinet, causing a short-circuit. Insulation which breaks up or fails when the chassis is removed and replaced, can cause the same trouble. Several accidents, including two deaths of set users, have resulted from this cause.

The serviceman shares to some degree the manufacturers' responsibility for prevention of possibly fatal shocks, both by checking insulation when the set is serviced, and by warning the set-user of the dangers inherent in use of the apparatus on damp concrete floors, or out in the yard, on damp ground, near grounded metal cabinets such as sinks or bath fixtures, *etc*. It is to be hoped sincerely that some safe solution to this hazard can be worked out very soon; after all, good customers are hard to find and we cannot afford to lose very many of them!

The "Needle-in-the-Haystack" Feature:—There is one unmistakable characteristic of the series-heater set, displayed when a valve happens to reach the end of its useful life, and passes to its ancestors. *Everything* goes dead! No sound, no picture, no raster, no pilot light, "no nuthin." Of course, as a few unwary souls have discovered, there remains a nice unloaded potential of a few

(*Continued on page* 197)

hundred volts of "B+," floating about in the circuit. This is usually quite accessible at such points as the scanning yoke, the (exposed) rectifiers and especially at the new type of fuse used in most sets; all these are installed in the chassis with the hot end out! "Werry Handy," as Sam Weller would say. Aside from this a silence and darkness, as of the grave, prevails.

This brings up a knotty problem. From past experience the technician knows that one of the valves has passed to that bourne from which none returneth, but the problem is "Which One?" With the old faithful parallel-heater sets, this was the simplest of operations; the extinct item was advertised by its absence of illumination. Even a faulty metal tube could be located in a moment or two by touching it; the dead one was cold.

No such bed of roses for our modern technician! His the task of isolating one dead tube from a string of possibly 18-20, all equally cold and silent. Of course, there is always the dogged method of beginning at one end of the string and testing each in turn until the dead one is located. This inevitably results in it being found at the *other* end of the string, no matter at which end tests were started. (Some technicians have tried a method of random selection, hoping to catch the bad one by surprise, as it were; this gives the same result.) This is a time-consuming process, and considering the almost entirely inaccessible locations of many tubes, a difficult one. Incidentally there is a firm belief current among American technicians that the egg-heads at each factory have a special department, known as the "Dirty-Trick" section, which specializes in unlikely and inaccessible locations for tube sockets! They love such didoes as locating the audio output stage just below the bell of the c.r.t., so close that the bottle must be bent sidewise to remove it. Between this and the back of the set is the exposed e.h.t. rectifier and line-scan output tube which must be reached over to gain access to the a.f. output. These are either very hot or very charged, with results which may be left to the imagination. Undisputed champions in this category are the designers of a famous 1952 model, which had the e.h.t. rectifier and both tubes in the tuner *under* the chassis, so that the chassis had to be removed from the cabinet to gain access to them. They are getting some stiff competition, however, from the designers of some of the new sets and almost lost the cup last year to the genius who mounted his tuner upside down, far up in the front of the cabinet, with the tubes hanging downward, accessible only through a very small square hole in the vertical chassis. He lost out at the last moment due to lack of co-ordination with his associates; someone carelessly mounted the tuner with only two small screws, so that it could be removed bodily and pulled out of the chassis, giving easy access to the tubes! (It is generally believed that next year this oversight will be remedied by riveting the tuner firmly to the chassis!)

This divertissement out of the way, we remain with the problem of locating the unknown dead tube! Some devices have been brought out in recent years which are very helpful. Chief among these is a wee "Black Box" provided with tube sockets to match each type used in the set: 7-pin and 9-pin miniatures, octal *etc.* On the end, a c.r.t. receptacle is provided. Inside, a small battery and pilot lamp are wired up to the heater terminals of each valve-holder so that the lamp glows when a good tube, or one at least having a reasonable degree of continuity, is inserted in the holder. An a.c.-powered version includes a socket into which the cheater cord† is plugged, and a small neon lamp with series limiting resistor, to give the same results.

Some thoughtful makers are pasting a "heater-string layout" on the back of the cabinet or chassis. This shows a sketch of the chassis, with each tube indicated, and connecting lines showing just which tube is connected to what, *etc.* This is absolutely invaluable; by removing a tube in the centre of the string and measuring to each side of the line-plug with an ohmmeter, the dead half of the string may be located. Further tests will narrow the number of suspects down until the culprit is found. One bewildered technician removed a tube, and took the measurements mentioned; much to his surprise each half showed continuity. Upon replacing the tube, the set still refused to light up. Repeating the tests gave the same result. After a little while, it dawned upon him that he had removed the dead tube (dammit) on the first try, and was holding it while he measured the resistance of the remaining perfectly good tubes. The next day, he encountered seemingly the same situation. "Ah-ha!" he cried, checking the tube he had pulled out. To his chagrin, it was also good. Some little time later he discovered that the maker had thoughtfully included an autotransformer in the design, so that he had continuity back to the line, no matter which side of the string he measured! He finally located the extinct unit by the old method of testing each one in turn. (What? Certainly it was the last one he tested! What did you expect?)

Aside from the difficulties of locating dead tubes, another utterly charming feature of the series-heater sets lies in the inability of the technician to disable easily any given stage, by pulling the tube. For instance, if the local oscillator is to be disabled while aligning a set, a duplicate tube with its anode pin clipped off must be inserted in the socket, to make up continuity for the heater string. To follow this procedure for the whole set would imply the destruction of a complete set of good tubes. Of course, the next set coming along would have different types, so there goes another set of perfectly good tubes!

Actually, although the writer may sound rather acidulous about the whole thing, and the schematic of the set may look as if someone had dipped a very active inchworm (measuring-worm?) in the inkpot and released it on the page, these little sets are marvellously efficient, and not *too* difficult to service. (With exceptions, of course.) In fact, we have grown rather used to the contrary little monsters, and don't mind them so much. With the proper techniques and equipment, one will, in time, become able to check them out almost as fast as the older types. The points about the shock-hazard still remain, however, and must be watched very carefully. All in all, it is rather like the old story about the man who hit himself on the head with a hammer, because it felt so good when he stopped! We rather enjoy it, because it feels so good when we stop. Cheers.

† Cheater-cord—a cable and fittings used to bypass the devices disconnecting the a.c. mains supply on removal of the receiver back.—ED.

Manufacturers' Products

Decorative Television Masks

A NEW development in the production of decorative surrounds for television tubes is announced by Iridon, Ltd., 1, Avery Row, Grosvenor Street, London, W.1. High-impact polystyrene is used and the printed pattern providing the decorative effect is sunk below the surface of the plastic in such a way that it is completely protected and cannot be scratched, chipped or marred by abrasion. Designs at present available include mambo, blue fleck, filigree, pebbledash and woodgrain.

New Unspillable Accumulator

A RECENT addition to the Exide range of 6-volt accumulators for use in portable radio and electronic equipment is the Model 3EN5 known as the Silver Exide and weighing only $3\frac{1}{4}$lb. It is completely unspillable in any position and is contained in a moulded translucent high-impact polystyrene case which is capable of withstanding mechanical abuse either in transit or in use. The level of the acid can be seen through the translucent case and maximum and minimum levels are indicated by two red lines seen in the illustration.

Terminals are cadmium plated and located as far as possible from the filling plugs and gas vents as a protection to corrosion. Intercell connections are made internally through the partitions, thereby reducing the path length and contributing to the low weight. Porvic and glass wool are used for separators.

The accumulator measures $3\frac{11}{16}$in $\times$ $3\frac{9}{16}$in $\times$ 5in high and has a capacity of 5 amp hr at the 20-hr rate of discharge.

The makers are Chloride Batteries, Ltd., Exide Works, Clifton Junction, Manchester.

Wide Band Attenuator

AN attenuation range from 0 to 61.5 dB in 0.5 dB steps at frequencies up to 60 Mc/s is available in the Wayne Kerr Q251 75-ohm π-section attenuator. Using the correction curves provided, the maximum error up to 20 Mc/s is 0.1 dB rising to 0.3 dB at 60 Mc/s. The zero-setting insertion loss is less than 0.05 dB up to 20 Mc/s, rising to 0.55 dB at 60 Mc/s. Power inputs up to one watt can be accepted. The attenuator costs £30, and is made by Wayne Kerr Laboratories, Ltd., Roebuck Road, Chessington, Surrey.

Multi-way Coaxial Switch

TO facilitate the rapid selection of v.h.f. transmitting or receiving aerials fed by coaxial cables without disturbing the nominal impedance of the system Racal Engineering, Ltd., Western Road, Bracknell, Berks, have introduced a 12-way rotary-type coaxial switch. It is ruggedly constructed from a cylindrical aluminium casting with 12 coaxial sockets around the periphery and one (inlet or outlet according to method of operation) placed at the back. A central rotor contacts each peripheral socket in succession. Stationary and moving contacts are made of rhodium-plated beryllium copper and mounted on polystyrene, the combination ensuring low-contact resistance, long life and low loss at high frequencies.

The switch can be motor operated as the torque is less than 3lb/in. Other features of the switch are:—working frequency up to 250Mc/s, impedance 52 ohms or as required by special order, 1kW power handling, adjacent contact isolation better than 80dB. The diameter of the switch is $4\frac{1}{16}$in, its depth is $4\frac{9}{16}$in and it weighs 2lb.

R.F. Power Meter

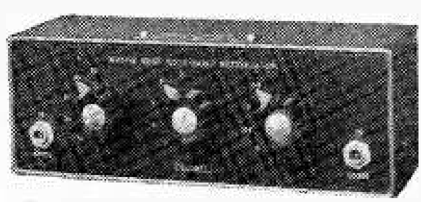
THE illustration shows a 500-watt r.f. power meter which is believed to be the first of its kind produced commercially in this country. It is the Type TF1205 and provides direct measurement of r.f. power from zero frequency to 500Mc/s.

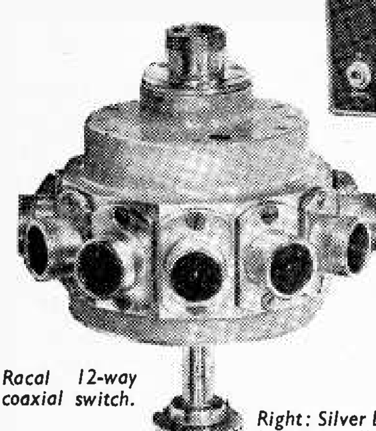
It is an absorbtion-type instrument with oil-immersed heavy-duty, power-dissipative resistance element enclosed in a finned casing for heat dissipation by free air convection. Neither water nor forced air cooling is needed.

The power measuring equipment comprises a vacuum thermocouple fed from a tapping on the load resistor and a moving-coil meter mounted in a separate case which can be located up to 6ft from the power-dissipation unit. True mean power is measured irrespective of waveform.

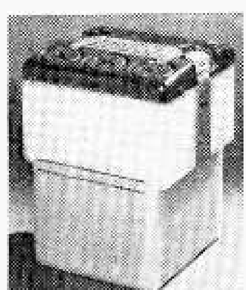
The makers are Marconi Instruments, Ltd., St. Albans, Hertfordshire.

Wayne Kerr 60 dB 75-ohm attenuator.

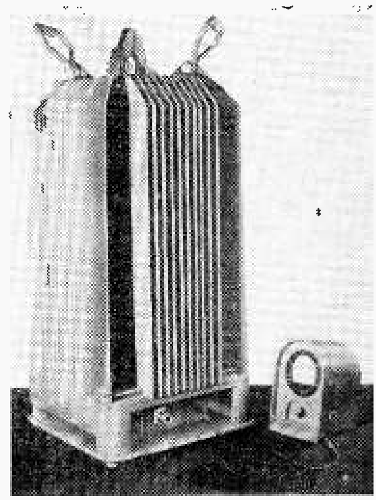




Racal 12-way coaxial switch.



Right: Silver Exide Type 3EN5 unspillable 6-volt accumulator in high-impact polystyrene case.



Marconi Instruments 500-watt r.f. power meter, Type TF1205.

APRIL MEETINGS

LONDON

9th. I.E.E.—Informal evening on "U.H.F. test transmissions" at 5.30 at Savoy Place, W.C.2.

10th. I.E.E.—"Radio observations on artificial satellites" by J. A. Ratcliffe at 5.30 at Savoy Place, W.C.2.

11th. Junior Institution of Engineers.— "Industrial applications in connection with television" by T. M. C. Lance (Cinema-Television) at 7.0 at Pepys House, 14 Rochester Row, S.W.1.

15th. I.E.E.—"A train performance computer" by Professor E. Bradshaw, M. Wagstaff and F. Cooke, "The simulation of distributed-parameter systems, with particular reference to process control problems" by J. F. Meredith and E. A. Freeman, and "A magnetic-drum store for analogue computing" by Dr. J. L. Douce and Dr. J. C. West at 5.30 at Savoy Place, W.C.2.

15th. Brit.I.R.E.—"Factors in the design of airborne doppler navigation equipment" by E. G. Walker at 6 30 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

16th. Society of Instrument Technology.—Annual general meeting followed by "Electronically operated power plant instrumentation and control" by R. E. J. Putman at 6.0 at Manson House, Portland Place, W.1.

17th. Armed Forces Communications and Electronics Association.—Visit to Wembley Studios of Associated Rediffusion.

18th. Television Society—"Transistors in television receivers" by B. Overton (Mullard) at 7.0 at the Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, W.C.2, (originally announced for March 13th.).

18th. B.S.R.A.—"Acoustics and loudspeakers" by R. A. Bull at 7.15 at the Royal Society of Arts, John Adam Street, Adelphi, W.C.2.

21st. British Computer Society.—"The use of an electronic computer in research statistics" by Dr. Frank Yates at 6.15 at York Hall, Caxton Hall, Westminster, S.W.1.

23rd. I.E.E.—"Survey of performance criteria and design considerations in high-quality monitoring loudspeakers" by D. E. L. Shorter at 5.30 at Savoy Place, W.C.2.

24th. Institution of Electronics.—"Radioastronomy and the sputniks" by Dr. F G. Smith (Mullard Radio-astronomy Observatory, Cambridge) at 7.0 in the Assembly Hall, The University of London Institute of Education, Malet Street, W.C.1.

25th. Institute of Navigation.—"The use of simulators for training navigators to use radar equipment" with contributions from the Navy, R.A.F. and Ministry of Transport and Civil Aviation at 5.15 at the Royal Geographical Society, 1 Kensington Gore, S.W.7.

28th. I.E.E.—"Economic usage of broad-band transmission systems" by R. J. Halsey at 5.30 at Savoy Place, W.C.2.

30th. British Kinematograph Society.—"An instantaneous electronic colour film analyser" by the Hazeltine Research Corp. and Pathe Laboratories Inc. at 7.15 at the Royal Society of Arts, John Adam Street, Adelphi, W.C.2.

CAMBRIDGE

22nd. I.E.E.—"Underwater television" by D. Allanson at 8.0 at the Cavendish Laboratory, Free School Lane.

CHELMSFORD

15th. I.E.E. Graduate and Student Section.—"The principles of electronic keyboard instruments" by B. Basham at 7.0 in the Public Library.

CHELTENHAM

25th. Brit.I.R.E.—"The automatic factory" by J. A. Sargrove at 7.0 at the North Gloucestershire Technical College.

EDINBURGH

7th. I.E.E. — "Broad-band slot-coupled microstrip directional couplers," "Re-entrant transmission line filter using printed conductors" and "The application of printed-circuit techniques to the design of microwave components" by J. M. C. Dukes at 7.0 at the Carlton Hotel, North Bridge.

LUTON

8th. I.E.E. Graduate and Student Section.—"Transistor amplifier circuits" by W. A. Thorpe at 7.0 in the Staff Canteen of D. Napier and Son, The Airport.

MALVERN

14th. I.E.E. — "Developments in semi-conductors" by E. G. James at 7.30 at the Winter Gardens

29th. Institute of Physics.—One-day symposium on "Some applications of solid state physics in computers and automation" in the Priory Lodge Hall, Winter Gardens.

MIDDLESBROUGH

2nd. I.E.E.—"Some transistor input stages for high-gain chopper-type d.c. amplifiers" by Dr. G. B. B. Chaplin, and A. R. Owens at 6.30 at the Cleveland Scientific and Technical Institute, Corporation Road.

NEWCASTLE

16th. Society of Instrument Technology.—"Fundamentals of electronics as applied to instruments" by A. L. Anderson at 7.0 in the King's College, Stephenson Building.

PORTSMOUTH

2nd. I.E.E.—"Junction transistors" by E. Wolfendale at 6.30 at the C.E.G.B. Offices.

STONE

14th. I.E.E. and Institution of P.O. Electrical Engineers.—"The importance of research in hearing and seeing to the future of telecommunication engineering" by Dr. E. C. Cherry at 7.0 at the Duncan Hall.

YORK

1st. I.E.E.—"The control and instrumentation of a nuclear reactor" by A. B. Gillespie at 7.0 at the Royal Station Hotel.

LATE-MARCH MEETING

28th. Institution of Production Engineers.—"The electronic control of machine tools" by D. T. N. Williamson (Ferranti) at 7.30 at the Technical College, Abbey Road, Barrow-in-Furness.

RANDOM RADIATIONS

By "DIALLIST"

V.H.F. Going Strong

THOUGH I haven't seen latest figures for the number of v.h.f. sound or television-cum-sound receivers in use, it must by now have reached a pretty big total, if the number of one's friends who have one or the other is anything to go by. I hardly ever go to a house in my district nowadays without finding v.h.f. installed and hearing its praises sung. The musical are delighted with the quality of reproduction obtainable and even the non-musical are loud in their praises on account of the freedom from interference that it gives. Interference with long-wave and medium-wave broadcasting is rather serious if you live on or near the more southerly parts of the East Coast. It's not an overstatement, in fact, to say that a concert or a play is seldom worth listening to on the a.m. bands. But with f.m. on Band II reception is normally as good and as clear as one could wish. There are, though, folk who don't give their f.m. receivers a chance. One friend who had gone in for a quite expensive set told me that it wasn't any good at all and that he was deafened by motor ignition interference. On going round to investigate I found that he was running the set in a ground-floor room, with a ramshackle aerial made of flex fixed to the picture rail! I can't think why people do such silly things; but do them they just will! Band II aerials don't cost much and they're too small (and usually too simple) to be unsightly. In that particular case a single dipole with a coaxial feeder made all the difference, and interference became a thing of the past.

TV Whistle

BY THE purest of coincidences (for they didn't know that I was writing the paragraph and I didn't know they'd written to the Editor on the subject) my note on TV whistle appeared in the same issue of *W.W.* as a letter from Peto Scott showing that their television receivers were whistle-free. I suggested, if you remember, that there were ways of obtaining e.h.t. voltage which wouldn't give rise to this nuisance. One reader took me to task, saying that he didn't believe that the whistle could be entirely eliminated. Well, Peto Scott have managed it and others should do likewise. Their letter shows that the whistle comes from the joins of the two halves of the core of a conventional auto transformer which, unless they are completely rigid, are bound to make slight movements under the magnetic effect of the alternating flux. The repetition frequency of the line scan being 10,125 c/s that gives you that infernal whistle. One of the consolations for having lost some of your h.f. hearing response is that the wretched noise becomes inaudible, or very nearly so. The fact that it is produced strongly by so many of our TV receivers is a real blot on their escutcheon and one that designers and manufacturers should take steps to remove.

Spot-Wobble, or Spot-Astigmatism?

IT'S a good many years since I first saw spot-wobble demonstrated on a 21-inch set specially made by Cintel for the B.B.C. Its possibilities made a great impression on me and I felt sure that it would be the coming thing in big-screen TV. Somehow, it doesn't seem to have caught on as one expected it to and I still don't quite know why. Its use certainly softens the picture a little and very slightly reduces the definition. But one would have thought that those things were a small price to pay for a big picture which can be viewed at quite close range owing to the absence of lininess. The demand for large sets is a growing one, even though it can't always be easy to sit far enough from the screen and near enough to the fire in the smallish living rooms of today. I wonder whether spot-astigmatism (or spot-elongation, as it's sometimes called) would furnish a more acceptable solution. Or, do some people perhaps like lininess?

Rules of Thumb

IF used with discretion rules of thumb can be most useful things. They save time by enabling you to get approximate answers to a good few radio problems in a twinkling and many of them are surprisingly accurate. One that most people know nowadays concerns the minimum eye-to-screen distance for TV viewing, if lininess is to be avoided: divide the inches of the screen's diameter (or diagonal) by two and that gives you the distance in feet. What's the maximum picture width obtainable on a screen of given size? It's five-sixths of the diameter or diagonal. There's rather a good one for frame aerials: irrespective (within reason, of course!) of size or shape you need 75 feet of wire for the medium and 250 feet for the long waves. For the quick conversion of yards into metres and *vice versa*, a metre roughly equals a yard plus 10 per cent, and a yard, a metre minus 10 per cent. A yard a second is two miles an hour. That one is pretty close, for there are 3,600 seconds in an hour and 3,520 yards in two miles. Do you know the one about the impedance of moving-coil loudspeakers? $Z \approx 1.5$ R (d.c.). And dust-cored coils: with the core at the mid position, L is about $\frac{1}{3}$ greater than that of an equivalent air-cored coil. I'm sure that readers know lots more good rules of thumb and I'll be most grateful for any you care to send in.

Safety First

AN article in a recent issue of the *I.E.E. Journal* stressed the importance of safety first with electricity. There is, however, one most undesirable though very widespread practice to which reference wasn't made. That's the use of 2-pin plugs and sockets, or lampholders with adaptors, for the connection to the mains of all manner of domestic appliances. Since the 2-pin plug or the 2-point adaptor will go in with equal ease either way round it's a pure toss-up whether or not you make those parts of the apparatus live which should not be so. Wrong connections are responsible for many accidents (and a much greater number of narrow shaves) with apparatus such as electric irons and sewing machines, to say nothing of mains-operated sound and television sets. I'd like to see the 3-pin plug and socket made compulsory. Using it, things are straightforward enough with a.c. But with d.c. there's an additional precaution needed. In some d.c. systems the positive is earthed; in others the negative; so one must make sure that all sockets are correctly wired up.

Stereo-sound

STEREOPHONIC sound and stereoscopic vision are rather mouthfuls; so why shouldn't we prune them down to stereo-sound or stereo-vision? I know that they are mongrel words; but so are many other scientific terms and anyhow neither is offensive to eye or ear. The B.B.C.'s recent experimental transmissions gave some idea of the realism sound broadcasting can provide. I hope that there'll be many more of these transmissions and that wide use will be made of two channels of a number of v.h.f. stations. That would enable pairs of owners of v.h.f. receivers to co-operate in stereo-sound reception.

UNBIASED

By FREE GRID

Super-Stereophony

IT IS strange how our boyhood interests remain the same but grow more spiritualized as we approach manhood. Thus every schoolboy is familiar with the vital statistics of a locomotive, and if a friend enthuses to him about a 4-4-2 tank engine he will at once have as clear a mental picture of it as he will of a 34-24-36 blonde about whom his friend may show equal enthusiasm in later years.

In other words his interest in vital statistics has shifted from a material and soulless plane up to a spiritual and soulful one. Late in life interest reverts to tank engines and that is why this period of existence—for can it be called life?—is known as second childhood.

I have found myself taking such an unhealthy interest in railway engines of late that I should feel really worried were it not for the fact that I still feel as strongly as ever the manhood desire to be the conductor of a great orchestra with no sign of a reversion to the original boyhood desire to be a bus conductor.

As a matter of fact I feel so strongly the desire to be an orchestral conductor that I have worked out a technical scheme whereby I can achieve my ambition without forcing Sir Malcolm Sargent into the bread line. My scheme is to provide a separate mike, amplifier and recorder (disc or tape) for every member of an orchestra. Thus there would be a separate recording of every instrument in the orchestra.

At home I should have a completely separate reproducing chain for each record, and the individual loudspeakers would be placed in the same positions as those occupied by the various instruments in the original orchestra. Each of the many separate amplifiers would have a bass boost and treble turn-up control, these all being mounted in a desk control panel situated in the same place as the conductor normally occupies.

I should therefore be able to call forth the same response from each section of the orchestra—or even from each instrument in any section—as a normal conductor can. This could have two effects. In the first place it would enable me to satisfy my ambition to be an orchestral conductor and secondly it would provide my family and friends with the same effect as though they were sitting in the Festival Hall; well, perhaps that is exaggerating a little but it would indeed provide super-stereophony.

I am fully aware of the many snags such, for instance, as the fact that my recording would bear the impress of the original conductor who presides over the orchestra at the recording session. All the same I have hopes that my one-man band will appear at the Festival Hall eventually.

My one-man band

11+ And 11×

MOMENTARY mental aberration is likely to affect all of us at times and I am grateful to Dr. Humphrey Denham for pointing out in the March issue that the e.m.f. of the Clark cell is 1.433 volts and not 1.1 so that it cannot be the basis of the fact that a multiple of 11 is used in power supply voltages. This 11× business would have ploughed me in my 11+ exam had I ever taken it.

However, I don't think that any of the other suggestions that have been put forward to explain this 11× business is the correct one. I think I have worked out the correct explanation all by myself. For what it is worth, it is as follows.

In the early days of electric lighting the only people able to enjoy the new invention were those wealthy enough to install private plants. These private installations came long before any attempt at town lighting. Very naturally such plants consisted of a battery of secondary cells and a d.c. generator to charge them. It was, of course, possible to install a generator alone but the steam engine which drove it needed stoking, and it was normal to install storage cells so that the power house could be shut down and left unattended at night time.

Obviously, therefore, the voltage of the generator had to be chosen according to the number of cells it was intended to charge. Now it so happens that the open-circuit voltage of a lead-acid cell is 2.2 and so it at once becomes obvious how the 11× complex arose. Installations were to be had with as many as 50 cells giving 110 volts. This quickly fell to 100 volts on load, and lamps of this voltage were used. But 25-cell plant was to be had and also installations using an even smaller number of cells and these were actually far more common than the plutocratic 110-volt type.

Query Corner

I OFTEN find odd gaps in my knowledge of radio and electronics which I don't seem to be able to fill by dipping into standard textbooks. Maybe you have some odd gaps too and we can get together and remedy each other's deficiencies. Here are two of my gaps for a start.

I have never been able to find out why the letter I is used as the symbol for current. The other two symbols in Ohm's law are obvious but not so I. Was it because C was already in use, and the letter I happened to be the next vacant letter available or is it the initial letter of some foreign word meaning flow. To me, it is a bit of a mystery like the use of X to denote an unknown quantity.

My next query used to worry me over thirty years ago when we all used secondary cells as our source of l.t. Now that car radio has brought back secondary cells as the prime source of both our l.t. and h.t. supplies I am worried once again. My query is simply this! Why do all lead-acid accumulator manufacturers warn us to be careful to remove the vents before connecting up to a trickle charger?

Before you all write to tell me that if this were not done the "gassing" due to the 2-amp trickle charging current, would buckle the plates and casing or something like that, let me remind you that we often bowl along on a summer day passing 10 amps through our long-suffering accumulator long after it is charged.

I have tried to get enlightenment on this point at the stands of all the leading accumulator makers—chiefly at the Motor Show, of course. I have always met with suave politeness and an indulgent smile as the young men on the stands try to blind me with science and intimate that my technical knowledge is not up to the necessary standard to enable me to understand why 10 amps on the move is less lethal than 2 amps in the garage.

I'm sure one of you know the correct answer.