Wireless World

ELECTRONICS, RADIO, TELEVISION

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Canutes of the Air

AT a meeting of the International Civil Aviation Organization (ICAO) last month in Montreal it was decided by a majority vote to recommend that the existing standard short-distance air navigation aid VOR (v.h.f. omni-directional radio range) should be supplemented by DMET (distance measuring equipment). Further, that "protection" for the combined system should extend to January 1st, 1975; in other words, wherever VOR/DMET is installed no change should require replacement of the equipment before that date. A strong case was made by the U.K. delegation with the full backing of the Ministry of Transport and Civil Aviation for the adoption of the Decca Navigator on grounds of greater accuracy and flexibility, but arguments based on technical merit failed to shake the resolve of the U.S., and other countries already heavily committed to VOR, to make do with the system on which so much capital has already been invested.

In principle VOR/DMET is simple; it is easy to understand and to use. It is a "rho/theta" system in which the radial distance (ρ) from a fixed beacon and the bearing angle (θ) are continuously presented to the pilot as dial readings. With this simple equipment the American pilot flies from one beacon to the next with the confidence of a mariner in a well-buoyed channel or of a late reveller finding his way home from lamp-post to lamp-post. Maximum deviations from course are liable to occur at points midway between beacons.

Decca is more sophisticated. Synchronized signals from a group (chain) of stations lay down a network of intersecting hyperbolic lines of constant phase difference which gives sustained accuracy of location up to about five times the distance possible with VOR/DMET. Thus greater flexibility for diversion and "holding" procedures is possible at times of bad visibility and congestion; movement is not constrained by reference to fixed points as in the case of omni-directional beacons. Another great advantage of the hyperbolic system is that, unlike "rho/theta" it can and has been adapted to automatic course plotting, which shows the pilot, by a glance at a chart, his present position and the effect of wind on the "holding pattern" he may be trying to sustain. Not only does this give the pilot confidence, but, since he can be relied upon to execute air traffic control instructions accurately, the controller and his overworked radiotelephone channels are relieved of the necessity of providing radar assistance and can concentrate on their proper functions of overall supervision and the control of movement in anticipation of troubles such as those which might arise from any incipient irregularities in flight schedules.

With traffic at times already filling the airspace available with existing standards of longitudinal and vertical spacing in a single airway, the only room for expansion is laterally, i.e., two flight paths in each airway instead of the single path available with the accuracy of existing range beacon methods of navigation. The Decca system can easily define a flight path to within ± 2 nautical miles at distances up to 150 miles from the centre of the chain so that in an 11-mile wide airway two flight paths with this tolerance would still have a 3-mile buffer zone between them. The opening up of new parallel flight paths would enable some of these to be allocated to jet aircraft, which must have an uninterrupted climb to and descent from their optimum height in the vital interest of fuel economy.

Such possibilities of immediate relief must, however, remain pipe dreams if the Montreal recommendations are subsequently endorsed by the Air Navigation Commission and ratified by a two-thirds majority of the 21 member states of ICAO. Although BOAC and BEA pilots are already enjoying the benefits of accurate visual tracking and could fly the additional lanes if these were sanctioned, it would be folly to extend the capacity of the system while foreign planes with less accurate aids have access to the air lanes. While the U.K. is a member of ICAO it will honour its obligations to provide VOR facilities and has in fact already ordered an extension of VOR coverage for airline operators who choose to rely on this system. There is, of course, nothing except initial cost and payload to prevent any aircraft from carrying both these short-range aids, together with Doppler and possibly inertial systems, to be used as circumstances dictate.

In the air the pilots will decide which system or systems serve them best in remaining masters of all navigational eventualities. On the ground air traffic control must continue to cut its cloth according to the performance of the less well-equipped aircraft. This in turn must set a limit on the expansion of air transport until such time as more precise flying is possible. When that day arrives the developments now taking place in the application of data processing and computers will have reached the stage when they can handle the increased volume of traffic that can be released. We have a feeling that present disappointments over the latest ICAO recommendations will have been forgotten long before 1975.

Elements of Electronic Circuits

1.—TIME CONSTANT AND DIFFERENTIATION

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

When studying the operation of complete electronic equipments we sometimes find gaps in our knowledge of the basic electronic circuits, or "building bricks," of which the equipments are composed. This series of articles reviews some of the more common circuit "bricks" and explains the principles of operation of devices which are often simply dismissed by functional names such as "amplitude limiter," "clamp," "differentiator" and "integrator." The articles are written in a non-mathematical way and give emphasis to physical explanations.

LET us first consider a simple series circuit made up of a capacitor C and a resistor R, as shown in Fig. 1. If we apply a sudden voltage, V, to the input terminals, the voltage across the resistor will follow at once as shown in Fig. 2. If the input

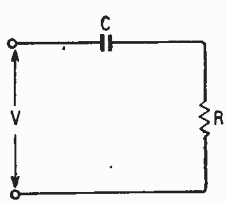


Fig. 1

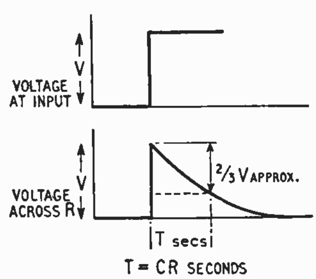


Fig. 2

voltage is maintained at a steady value the voltage across the resistor will drop as the capacitor C discharges through R. This rate of leakage through the resistor depends on the values of C and R; the greater the values of C and R the longer will this time be.

It can be shown from theory that about two-thirds of the charge on C will leak away in a time equal to CR seconds, if C is measured in farads and R is measured in ohms (alternatively C in microfarads and R in megohms). The product CR is known as the time constant of the circuit.

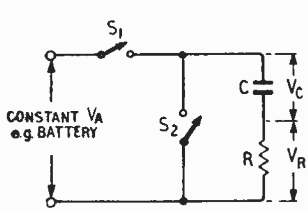


Fig. 3

Now let us consider the sequence of operations in the circuit shown in Fig. 3. With switch S_1 closed and switch S_2 open, V_A is applied to C and R. The capacitor therefore charges up and V_C grows. At the instant of closing S_1 the total V_A appears across R. This, however, decays in an exponential fashion, the sum of V_C and V_R being equal to V_A.

We now open S_1 and close S_2. As a result V_C is immediately applied in the opposite sense across R. Then V_R decays from a negative maximum to zero. V_C, on the other hand, decays from a positive maximum to zero.

The effect of switching S_1 and S_2 in a regular sequence is to apply a voltage square wave to C and R, and Fig. 4 illustrates the resultant growing and decaying of voltages V_C and V_R. When the CR circuit (with a CR value small compared with the time taken by other changes in the circuit) is

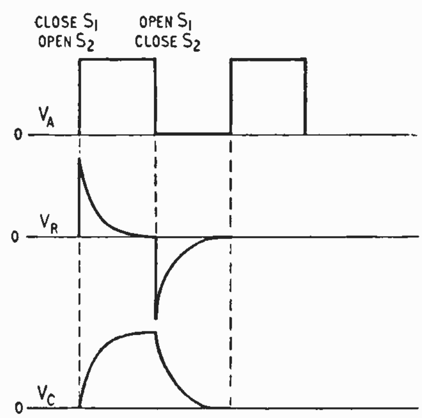


Fig. 4

used in this way it is called a differentiating circuit and the original square pulse is said to be differentiated when the voltage V_R is selected as the output.

Let us now consider the effect of different CR values on a square pulse. In the following illustrations, Figs. 5 and 6, the square wave V_A is assumed to be all positive. First of all there is the case where the CR time constant is very much greater than the period of the applied square-wave voltage. Referring to Fig. 6, it is important to note that the voltage V_R always equals $V_A - V_C$. V_C gradually builds up to a voltage which varies slightly about $V_A/2$, while V_R ultimately becomes symmetrical about zero with its positive and negative peaks fluctuating about $V_A/2$ in a complementary manner to V_C.

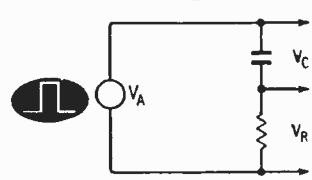


Fig. 5

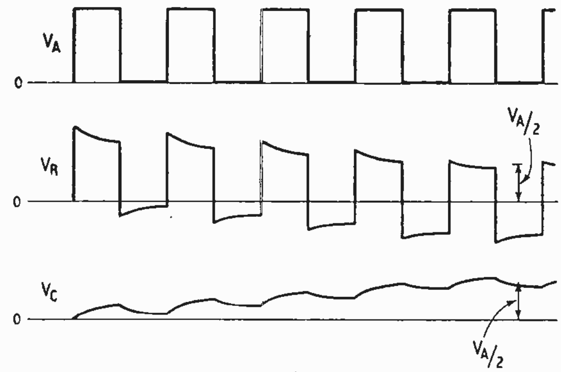


Fig.6

V_R tends, therefore, to become almost a square wave oscillating about zero volts. It is also important to note that the slope of the charge/discharge portions of the waveforms depends on the magnitude of the applied voltage V_A.

Secondly there is the case where the CR time constant is equal to the period of the applied square wave voltage. Here, as shown in Fig. 7, V_C becomes more ripply, and more distortion occurs in V_R which is now much less like the square wave in Fig. 6.

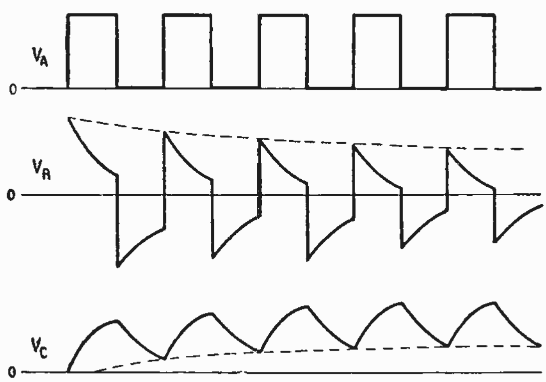


Fig. 7

Thirdly we have the case where the CR time constant is very much less than the period of the applied square wave voltage. V_C now approximates to the input square waveform, as shown in Fig. 8,

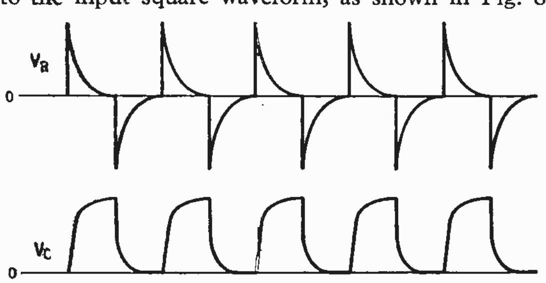


Fig. 8

while V_R consists of a series of very short pulses or "spikes," i.e. approaching a true differentiated square wave from a mathematical point of view.

Next we will look at the effect of different CR values on a linear voltage. Fig. 9 depicts a voltage

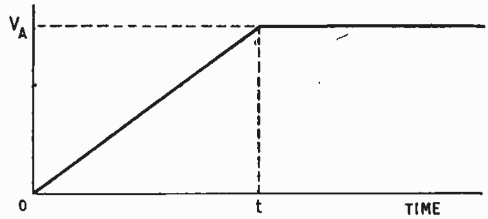


Fig. 9

which rises linearly from zero to a value V_A in time t. We will examine what happens when we apply this rising voltage to CR circuits (Fig. 10) of widely different time constants.

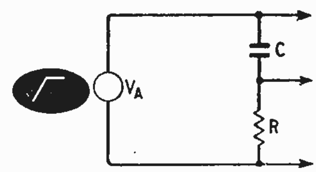


Fig. 10

First, the case where the CR time constant is greater than the period t. Referring to Fig. 11, V_A is the applied wave. C charges and V_C grows along AB. V_R is represented by AC so that the

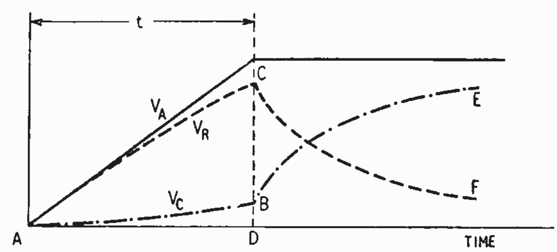


Fig. 11

linear edge of the waveform is only slightly distorted. After a period t, the capacitor C charges normally and V_C grows in accordance with BE whilst V_R drops according to the path CF.

Now referring to Fig. 12, we have the case where the CR time constant is less than the period t. V_A is the applied wave. C charges and V_C grows along AHG, after which the slope of GB is the same as that of the applied voltage. $V_R = V_A - V_C$, giving the curve AJG subsequently remaining

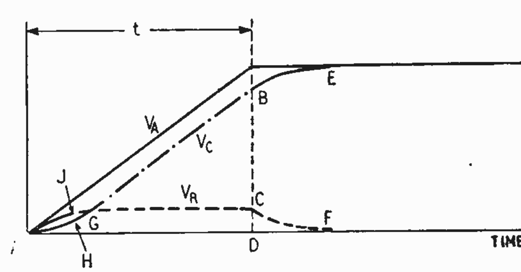


Fig. 12

constant at GC. Note that the value of the steady voltage CD = mCR, where m is the slope of V_A in volts/second.

Finally, let us look at the effect of different CR values on a recurring linear voltage—a sawtooth wave. The response of a CR circuit as in Fig. 10 to a succession of sawtooth pulses V_A is shown in Fig. 13, the voltage V_R only being considered. It is seen that for a circuit time constant very much greater than the period of the applied wave, V_R is not very distorted and the linear rise of voltage is little affected. With the circuit time constant less than the period t, V_R is very distorted. Therefore if distortion is to be avoided in CR coupling circuits they must be designed with long time constants compared with the period of the recurrent waveform.

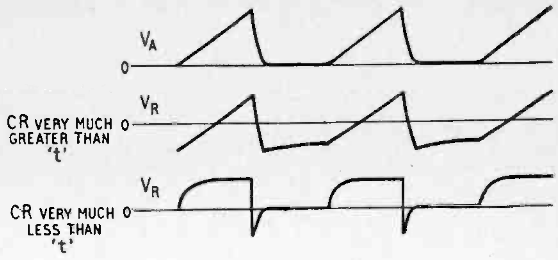


Fig. 13

Television Society's Exhibition

ONE might have expected the Television Society's Exhibition this year to say something significant about the topical subjects of new frequency bands, new standards and perhaps colour. But the threatened arrival of the Television Advisory Committee's report must have frozen everyone into silence, for very little was revealed of any recent technical investigations in these fields.

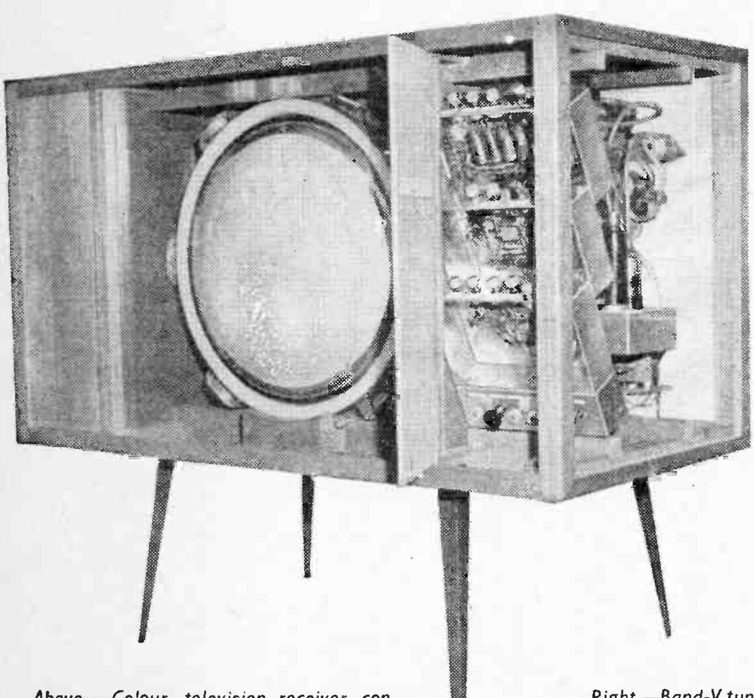
The problems of reception in Band V have already been discussed in *Wireless World** and types of tuners have been described. B.R.E.M.A. summarized the situation to date by showing examples of these tuners which they have provided to assist the T.A.C. in its deliberations. The so-called Group 1 type is a simple continuous tuner (see picture) consisting of an EC93 oscillator and a crystal mixer. This is intended to be clipped on to an existing Band-I/Band-III tuner, the valves of which are used as i.f. amplifiers. Such units have been used for some time in W. Germany for reception of u.h.f. television transmissions.

* "Reception on Band V," January, 1958, issue.

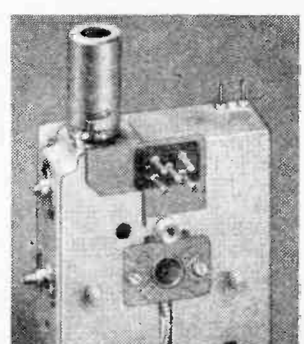
What is known as a Group 4 tuner is a Band-I/Band-III turret with special u.h.f. coil inserts. A double superheterodyne principle is used. A harmonic of the local oscillator is selected for the first frequency changing operation, which is achieved in a germanium diode mixer. The i.f. is amplified by the existing cascode valve in the tuner and then frequency converted again, using the oscillator fundamental and the existing pentode mixer valve. (See *Wireless World*, January, 1958, issue, p. 14.)

The third tuner shown by B.R.E.M.A. is called a Group 5 type and is a high-performance circuit incorporating an r.f. amplifier valve (A2521) to improve the noise factor. After the crystal diode mixer comes a cascode double-triode i.f. amplifier and then two further pentode i.f. amplifier stages. (See *Wireless World*, May, 1958, p. 244.) Nobody would suggest that this expensive circuit is a commercial possibility for domestic receivers, but it has been developed to achieve the level of performance which will probably be obtained from simpler tuners in the future.

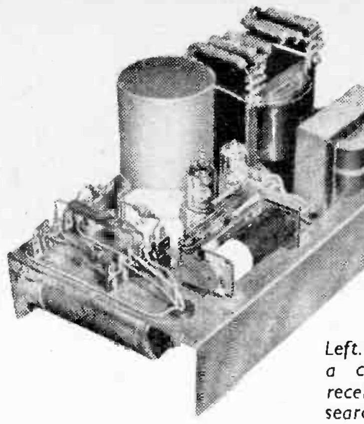
Bush Radio demonstrated an all-electronic test pattern generator for 625-line C.C.I.R. standards. It was notable for the range of video information made available—actually comparable with Test Card C. As well as giving a linearity grating surrounded by a frame of black and white blocks, the pattern incorporates definition check bars of 1, 2, 3, 4 and 5 Mc/s and a five step "gamma



Above.—Colour television receiver constructed by John Ware, showing arrangement of chassis.



Right.—Band-V tuner unit for attachment to an existing tuner (B.R.E.M.A.).



Left.—Power unit for a colour television receiver (G.E.C. Research Laboratories)

wedge." The video signal is intended for distribution on an r.f. carrier (together with the associated f.m. sound carrier) throughout a factory in which 625-line receivers are manufactured.

Colour receiver development—very much in the background at the moment—was represented by an example of size-reduction in power supplies. We have already reported, in our July and August, 1958, issues, how G.E.C. Research Laboratories have achieved a reasonable size of experimental colour receiver by the use of a.c./d.c. technique in power supplies. A selenium rectifier voltage doubler has been used to get the 450-V h.t. supply from mains voltage. Now the Laboratories have produced an even smaller power unit (see picture) by the use of silicon diodes for rectification and voltage doubling. It measures about 9in × 6in × 5in and gives 400V at 400mA, 200V at 250mA and −150V stabilized. A thermal-delay relay system is incorporated to allow the receiver's heaters to warm up before the h.t. is applied.

Colour television of the N.T.S.C. variety has so far been quite out of reach of the average amateur constructor, partly because of its frightening complexity but mainly because of the impossibility of obtaining three-colour c.r. tubes and other special components. Not, however, out of the reach of John Ware, an architect, who demonstrated a complete, working 19-inch receiver for picking up the B.B.C.'s colour test transmissions. Although the circuit was based directly on H. A. Fairhurst's design (published in *Journal of the Television Society*, Vol. 8, and in *Wireless World* in March and April, 1956), Mr. Ware must be congratulated, not only on his ability in getting such a complex apparatus to work (no reflection on Fairhurst!) but on his enterprise in getting hold of the colour tube (a British experimental all-glass type). The layout, too, showed a rather original approach, being based on several small chassis arranged in echelon (see picture) to give easy accessibility to components and control knobs.

One way of dispensing with fine tuning controls in domestic television receivers is to have automatic frequency control of the local oscillator. G.E.C. Research Laboratories demonstrated how this could be done by using the variable capacitance properties of a semiconductor junction diode. The Colpitts oscillator of an ordinary commercial television set incorporated a reverse-biased EW76 silicon diode as a variable-capacitance tuning element. The capacitance of the diode varied in proportion to a control voltage which was derived from the sound i.f. signal via a double-diode frequency discriminator. The self-adjusting action of this servo loop was such that the control voltage altered the oscillator tuning to bring the sound i.f. signal to the correct frequency.

The suggestion that television signals might be relayed by tropospheric scatter over relatively long-distance links, instead of the usual line-of-sight links, emerged from another demonstration on the G.E.C. stand. This was a tape recording of speech transmitted over a 180-mile tropospheric scatter link between Coventry and Start Point. The frequency was 2,600Mc/s and a 1-kW transmitter was used with 12-ft diameter paraboloid aerials arranged for space diversity operation. The bandwidth was sufficient for five telephone channels, but by decreasing the range or increasing the power it was considered possible that a television channel could be accommodated.

Cathode-ray tubes on show included two new types on the Mullard stand for 110° scanning. These were the 21-inch type AW53-88, which is 5 inches shorter than an equivalent 90° tube, and the 17-inch type AW43-88, which is 3 inches shorter than the equivalent 90° tube. Both are electrostatically focused and have straight electron guns, using no ion-trap magnets.

When it is already difficult to generate sufficient power to scan these 110° tubes one has to avoid anything which allows a dissipation of this power. A demonstration on the Pye stand pointed out that an absorption of power can be caused by any aluminizing in the c.r.t. envelope near the scanning coils. A set of scanning coils connected to a Q-meter was placed first on a 110° tube with, and secondly on one without, aluminizing at the critical region, to show that a reduction of power loss is obtained in the second case.

AUDIO FAIR EXHIBITORS

TICKETS for the London Audio Fair which opens for four days at the Hotel Russell, Russell Square, W.C.1, on April 2nd, can be obtained free from exhibitors listed below and audio dealers. Some 60 of the 69 manufacturers who are exhibiting at this year's show will have private demonstration rooms in addition to space in the main exhibition. The show opens each day, including Sunday, at 11 and closes at 9. Admission on the first day is limited to the trade until 5.30.

Dated tickets are available from this office. Applicants should enclose a stamped addressed envelope and state the day for which the tickets are required.

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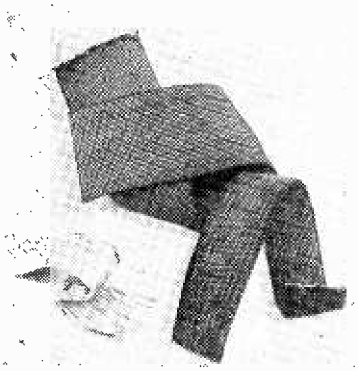
Vitavox
Vortexion
Walters (Sales)
Wharfedale
Whiteley
Wireless & Electrical Trader
Wireless World and *Electronic & Radio Engineer*

Technical Notebook

Flexible Ribbon Cable, suitable for applications where motion is involved, consists of parallel wires woven with Teflon and other yarns into a flat ribbon, as shown in the picture. Known as Tempbraid, the

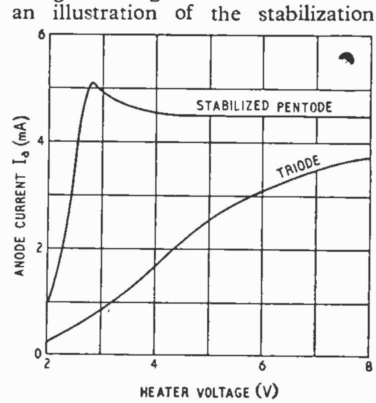


cable is manufactured in widths from $\frac{1}{4}$in to 3in by the American firm Hitemp Wires. The ribbon can be slit along its length if the yarns are first impregnated. With square or rectangular channels for cables, the ribbon type of construction allows a greater number of conductors to be packed in, since the cable harness builds up to a square or rectangular section instead of being circular. Also introduced by this firm is a flexible ceramic type of insulation on a new range of wires for operation at high temperatures. It is a vitreous enamel film, which is firmly bonded to the nickel-clad copper conductor, and is rated for continuous operating temperatures of at least 1000°F and up to 1500°F for short periods. The insulation is said to show no visible evidence of cracking when the wire is wrapped around a rod of five times its own diameter. High abrasion resistance is claimed and the material is resistant to oils, solvents and thinners, organic materials and water. At extremely high temperatures (about 2000°F) it starts to melt but does not burn.

Simulation of Doppler Effect for use in the testing of Doppler radar equipment (or in radar system simulators) presents some unusual problems—mainly the construction of an oscillator which is extremely stable and yet can have its frequency altered at a high rate to simulate "target" or observer movement. A solution to this problem is suggested in *Electronic Design* for 26th November, 1958, in an article by J. E. Tofler. The proposed system employs controlled variation of the time intervals between successive cycles of the output of a very stable oscillator. This controlled variation is achieved by a variable delay circuit external to the oscillator, which stays at a constant frequency. For the "at rest" condition for both target and observer the time delay is constant; to synthesize a target moving with constant speed a linear rate-of-change of delay is introduced, thereby "squashing-up" or "opening-out" the cycles from the oscillator in a manner corresponding to that of the actual Doppler phenomenon. Acceleration of the target (or observer) is synthesized by controlling the delay time in a square-law fashion (or in a more complex way to simulate increasing or decreasing acceleration). It is suggested that existing monostable circuits capable of producing a delay proportional to an applied potential are suitable (examples given are the phantastron and cathode-coupled multivibrator). Simple checking for correct operation is achieved easily, too: a sinusoidal variation of delay is employed, the total displacement (relative to the undelayed oscillator output) is displayed on a c.r.o., this being equal to the integration of frequency shift and the differential of velocity. An example given quotes an acceleration of ±400g, period 2 seconds. This corresponds to a displacement of $10.6\mu s$ and an apparent velocity of 5,600 m.p.h.

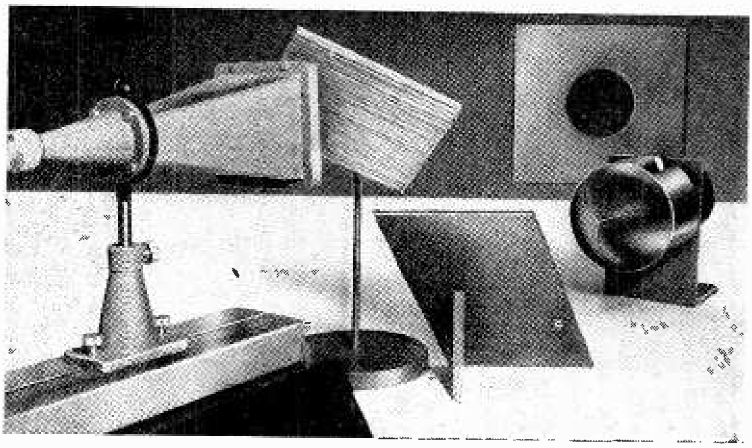
Compensating Compass for measuring the direction of the earth's field in the presence of a freely rotatable disturbing dipole is an interesting recent development by the Fighting Vehicles Research and Development Establishment. Such a disturbing dipole could be produced, for example, in a magnetic vehicle by induction due to the earth's field. Two points are chosen such that the ratio of the disturbing fields at them is known and is about two. At each point is placed a set of three flux-gate field measurement devices spaced at 120° intervals in a horizontal plane. Each flux gate feeds a different stator on two synchros, each set of three flux gates feeding the same synchro. The synchro rotors are locked together and the output of that associated with the greater disturbing field reduced in the known ratio of the two disturbing fields. A servomotor drives the rotor system until the difference between the two synchro outputs is reduced to zero. In this case, since owing to the different synchro sensitivities the outputs due to the two disturbing fields cancel, the outputs due to the earth's field must also cancel to give an overall cancelled output. Since the earth's field is the same at both points, the outputs due to this can only cancel if each is zero, i.e., if the rotors become aligned at right angles to the earth's field.

Simple Emission Stabilization to offset drift caused by variations in heater supply voltages in d.c. amplifiers is described by B. C. Cox in the December, 1958, issue of the *Journal of Scientific Instruments*. It has been applied to a 6K7 pentode used as a triode, with the suppressor connected to the anode and the screen grid acting as the control grid. A 220-kΩ resistor is connected from the 225-V h.t. supply to the control grid. If the heater causes the cathode temperature to fall and the emission is reduced there is a consequent decrease of grid current. This decrease of grid current produces an increase of grid voltage (because the voltage drop across the 220-kΩ resistor is reduced) which restores the emission to practically its original value. Conversely, an increase of cathode temperature causes the grid voltage to be reduced. As an illustration of the stabilization



performance, the curves of anode current against heater voltage compare the stabilized triode-connected 6K7 pentode with an unstabilized and normally connected 6J5 triode.

Mechanical Microwave Frequency Shifting by means of a rotating 90°-corner reflector was demonstrated recently by Hilger and Watts. Q-band radiation (around 8mm) propagated in waveguide in the H_{01} mode is first transformed into a collimated vertically polarized beam using a square pyramidal horn.



A plano-convex polystyrene lens in the mouth of the horn equalizes the effective path lengths to all points in the horn mouth. The plane lens surface is "bloomed," i.e., horizontal grooves are cut in it to give a path length of $\lambda/4$ and an effective dielectric constant of the square root of that for the polystyrene lens material. This matches the lens to the air and avoids reflections. Such blooming is not necessary at the curved portion of the lens where for reflected radiation the path length differences cause considerable cancellation. The plane-polarized beam impinges on a flat metal reflector with a number of parallel protruding fins attached to it, this reflector being angled in such a way that the electric field has components both parallel and at right angles to the fins. The latter component is unaffected by the fins and is reflected with 180° phase change from their flat backing. The former component parallel to the fins effectively sees a portion of waveguide with a width equal to the spacing of the fins which is arranged to be beyond cut-off for Q-band. This component is thus reflected at the fins with a certain phase change. The resultant phase change between the two components (which includes that produced by their path length difference of twice the fin height) is arranged to be 90° so as to produce a circularly polarized beam. After straightforward reflection from a flat metal plane this beam impinges on a rotating 90°-corner reflector. Rotation of such a reflector through a certain angle rotates a plane polarized wave through twice this angle. Since the circularly polarized beam can be regarded as a plane-polarized beam rotating at the signal frequency, the rotating corner reflector alters the frequency of the circularly polarized beam by twice the reflector rotation frequency. This changed frequency radiation re-traverses the system undergoing similar transformations in the reverse order. A portion of the outgoing and incoming radiation in the waveguide is extracted, using a magic T, and the beat frequency produced on detection used to drive a loudspeaker.

Magnetic Xerographic Printing machine for reproducing books, magazines and newspapers has been built in prototype form at the Lithuanian Research Institute of Electrography, according to a recent report in *Soviet News*. It does away with conventional type and type-setting and uses instead a continuous belt of ferromagnetic tape on to which the printing pigment has been attracted. This is unlike the American and British xerographic system, in which the printing powder is attracted *electrostatically* to a charged selenium layer (see *W.W.*, January, 1959, issue, p. 20). Here the electrostatic charge patterns are formed by optically focusing the images of characters on to the uniformly charged selenium. In the Lithuanian system the images of characters are converted photoelectrically into electrical signals, which drive magnetic recording heads to impress corresponding magnetic patterns on the tape. The printing pigment, after being attracted to these magnetic patterns, is transferred to the paper by an electric field, as in the American and British system.

Heater-Circuit R.F. Chokes wound on cylindrical ceramic capacitors are described in an article on subminiature radar i.f. amplifiers by W. H. Kumm in *Electronic Equipment Engineering* for December, 1958. It is claimed that this form of construction produces a small self-resonant (i.f. 30Mc/s) choke with a very low resistance.

Cooling Crystal Mixer Diodes is often suggested as a means of improving receiver noise factor. However, recent noise factor determinations carried out by L. K. Anderson and A. Hendry on seventeen 1N263 mixer diodes at 9375Mc/s (X-band) both at 27°C and −196°C indicate that no worth-while improvement is obtained—in fact, some crystals gave an even slightly worse performance. This is reported (*I.R.E. Transactions on Microwave Theory and Techniques*, October, 1958) to be due to an increase in the noise temperature of the crystal as it is cooled. It is suggested that this indicates that flicker noise* in germanium crystals may be a significant factor at the i.f. used (30 Mc/s) and also that it is a temperature-dependent effect.

* Flicker noise is noise which occurs in semiconductors (and valves) in excess of the Schottky and thermal noise. It is thought to be due to holes meeting annihilation by electrons in a "trap," and it is normally considered only to be a problem at low frequencies because the spectral distribution of the noise energy is proportional to $1/f$.

Stereo Pickup Vertical Compliance should not be too great otherwise the stylus will not track the downward halves of high-acceleration vertical modulations. This is because in such half-modulations the stylus is no longer driven by the record groove but by gravity and the vertical stiffness of its suspension. This principle has been pointed out by Decca.

Electrolytic Polishing is being used on metal parts of complex shape which could not easily be polished by mechanical methods. The process developed by Electropol Processing at the Trading Estate, Farnham, Surrey, is intended for stainless steel, and the polishing is achieved by removing electrolytically a controlled amount of metal evenly from all surfaces of the article. For this the metal part is jigged then immersed in a chemical bath and subjected to an electric current to give a "de-plating" action. Usually the thickness of metal removed is of the order of half a thou'. The process is claimed to give a high degree of corrosion resistance to stainless steel because, unlike mechanical polishing, it removes certain metallic and non-metallic inclusions which have been introduced into the surface of the steel at the rolling-mill stage of manufacture. Greater resistance to surface adhesion of liquids or solids is also claimed. In the radio industry the process is being applied to the electron guns of cathode-ray tubes, and here a particular purpose is to remove unwanted burrs which would interfere with the correct electron-optical structure. For this the normal process has to be given a selective action so that more metal is removed at the burrs than elsewhere.

Compact Microwave Delay Lines constructed by spirally winding waveguide are described in *Electronics (Engineering Edition)* for October 24, 1958, by R. R. Palmisano and A. Sherman. A 40-ft long coil of half-size (internal dimensions of 0.2in by 0.9in) X-band waveguide can be wound in a diameter of only 15in. The attenuation increase due to the coiling is less than 1dB for this length of guide.

Loudspeaker Enclosure Calculations

USE OF A SIMPLE ANALOGUE COMPUTER

By *M. V. CALLENDAR**

THE basis of the computer is an electrical analogue circuit. This circuit is chosen in such a way that the differential equations which govern it are the same as those governing the acoustic system of which the performance is to be investigated.

In the computer an analogue network of this type is arranged on a panel bearing a number of control knobs labelled "Size of box", "Stiffness of loudspeaker suspension" and so forth. The necessary information is fed into the computer in the form of settings of these controls.

As shown in the block diagram of Fig. 1, the network is supplied from an oscillator which sweeps from 100 kc/s to 1 Mc/s. The output from the network is applied to an oscilloscope which exhibits it as a function of frequency. The network is so proportioned that the electrical response curve shown on the oscilloscope represents the acoustic response at frequencies between 20 and 200 c/s of an acoustic system having parameters as set up on the controls. The effect of varying any parameter is thus quickly seen.

Alternatively, a pulse generator can be substituted for the sweeping oscillator, in which case the transient acoustic response is shown by the oscilloscope. Fig. 2 shows typical c.w. and pulse responses for a bass reflex system, as seen on the oscilloscope.

The merit of this computer, as with others, is that problems requiring hours or days for solution by normal methods can be solved in a few minutes. In particular, the normal methods for solution of equations involving transient (or pulse) waveforms—classical or operational methods, or Laplace transforms—are all exceedingly laborious. And direct acoustic measurements, although no doubt the ultimate criterion, are time-consuming, and prone to increasing errors (due to wall reflections) as the frequency is lowered.

The network is designed on the basis of the electrical mechanical acoustic analogue principle†. We use the "acoustic impedance analogue" in preference to the "acoustic mobility analogue" and so we have the following table of analogues:—

Electrical		Mechanical		Acoustic
Inductance	L	Mass	m	Ac. mass m/A^2
Capacitance	C	Compliance	C	Ac. compliance A^2C
Current	I	Velocity	u	Ac. velocity $U=uA$
Voltage	V	Force	F	Ac. pressure $p=F/A$

* E. K. Cole Ltd.
† See, for example "Acoustics" by L. L. Beranek (McGraw-Hill)

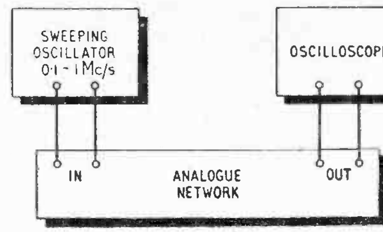


Fig. 1. Block diagram of computer.

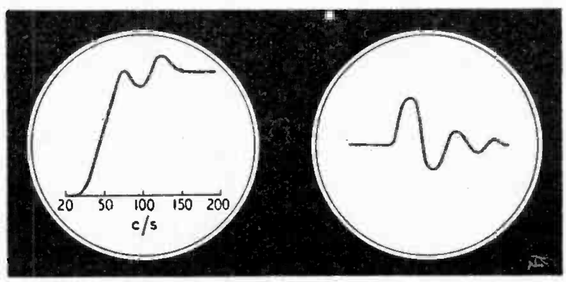


Fig. 2. Typical c.w. (left) and pulse (right) responses of a bass reflex cabinet.

Here A is the effective cross-sectional area of the acoustic circuit (e.g. A can be the area of the cone of the loudspeaker) and "compliance" is the reciprocal of stiffness (e.g. of the cone suspension).

There is no reason why the analogue network should operate at the same frequency as the acoustic circuit, provided that the elements are suitably scaled in value, and in fact a frequency 5000 times higher was found convenient.

Fig. 3 shows a simple analogue network suitable for computing and displaying the bass response of a moving coil loudspeaker in an enclosure with or without a vent. The output from the cone and from the vent can also be seen separately if required. The circuit can be modified if necessary to show the effect of other resonances of the air in the box, and of special shapes of box or positions of the vent. It is assumed that the cone moves as a rigid piston (this is usually true up to over 200 c/s) and that the walls of the enclosure are rigid. Voice-coil inductance and directional effects in sound radiation can be neglected in the low-frequency range under consideration. The m.k.s. system of units is used throughout.

As to the individual elements comprising the network shewn in Fig. 3:—

(a) The electromagnetic damping is the chief controlling factor at the loudspeaker bass resonance and is dependent upon the magnet flux and electrical source impedance (i.e. the negative or positive feed back ratio). This is represented by an *acoustic* resistance $R_X = B^2l^2/A_L^2(R+R_A)$, where B is the magnet flux, A_L the effective area of the cone and l the length of wire in the voice coil which has a resistance R and is fed from a source of effective resistance R_A. Other acoustic series resistances, except those intentionally introduced by added damping material, are usually much smaller than R_X.

(b) The loudspeaker itself is represented by the capacity $A^2_LC_L$ in series with the inductance m_L/A_L^2 where C_L is the compliance of the suspension and m_L the mass of the coil and cone.

(c) Under dynamic conditions, the mass of the loudspeaker cone is augmented by that of the "adherent" or "driven" air which is represented by the inductance m_a. Under many conditions we may put $m_a \approx 1/\sqrt{A_L}$.

(d) If the box is closed, the major effect of it is to increase the apparent stiffness of the loudspeaker suspension. It can therefore be represented by a series capacity C_B, the magnitude of which is given by $C_B = 0.7 \times 10^{-5} V_B$ where V_B is the volume of air in the box.

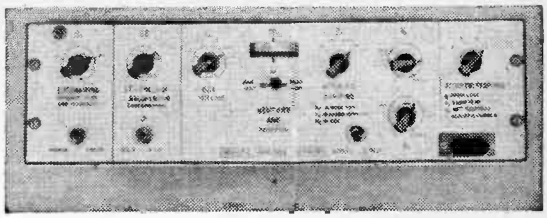
(e) If damping material is used in the box, this can be represented by a resistance R_C. The magnitude of R_C is usually difficult to calculate and is better measured by an electrical impedance test at resonance.

(f) A vent in the box can be allowed for by an inductance representing the mass of air vibrating in (and near) the hole. An approximate formula is $m_V = (1/\sqrt{A_V}) + (1.2t/A_V)$ where A_V is the area and t the length of the vent hole.

(g) If damping material is used in the vent, this can be represented by a resistance R_S. An additional resistive outlet is equivalent to damping in parallel with the vent, and corresponds to a resistance R_p.

(h) The current through the network when a voltage is applied is a measure of the acoustic velocity in cubic metres per second. The voltage across a small resistance (here 47 Ω) can then be used to indicate this current. Normally, however, we require the acoustic pressure, and this, at low frequencies and at a short distance from the loudspeaker, is proportional to frequency × acoustic velocity and can be obtained from the voltage across a small inductance (here 25 μH). The acoustic velocity output U_L from the loudspeaker is then given at the terminal U_L in Fig. 3. The pressure output from the vent or from the loudspeaker alone are obtainable by switching to p_V or p_L respectively as shown, the normal response being given by the difference between the two at p_C (provided that the listener is not too near the loudspeaker). The network allows for the change of phase angle between the two waves with frequency, but assumes that the vent is placed in the front of the enclosure at a distance of the order of a foot from the loudspeaker opening.

Provided that precautions normal to electrical circuits are taken, the computer in itself has an accuracy quite adequate for any actual requirement. But this accuracy is, of course, dependent upon the exactness or otherwise of the correspondence between the acoustic circuit assumed and the actual physical loudspeaker and enclosure. The results are, therefore, subject to the same errors (which may often be considerable) as ordinary calculations on the acoustic circuit. Such errors are of the same nature as the errors in electrical circuit calculations caused by the presence of unknown stray capacities or inductances at high frequencies. As always, calculation must be used to supplement direct experiment and cannot take its place.



Variable analogue network for loudspeaker in a reflex cabinet.

The sine-wave response of a loudspeaker with enclosure has been calculated by various writers (see e.g. Beranek's "Acoustics"), but in order to avoid excessive complications, the analysis has usually been confined to two particular cases, viz., either a closed box, or a box tuned by the vent to resonate at the same frequency as the loudspeaker's natural bass resonance. With the computer one can see at once the effect of varying the tuning of the box, as well as that of other parameters (such as an acoustic resistance in parallel with the vent) which have not usually previously been taken into account. And above all, the response to a pulse or step transient (which has not, to the writer's knowledge, been previously calculated) can be seen at a glance.

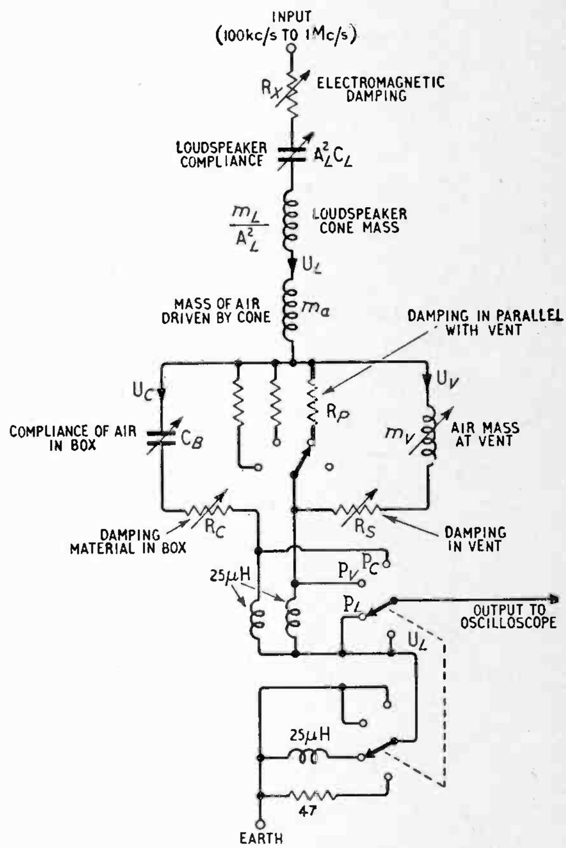


Fig. 3. Analogue network referred to acoustic output for obtaining the performance of a loudspeaker in a bass reflex cabinet.

French Components Show

THE international aspect of the components show, held recently in Paris, was emphasized by seeing, almost side-by-side, exhibits from countries as widely spaced as Hungary and America. The official title was "Deuxième Salon International," though it is in fact the twenty-second "Salon des Pièces Détachées" to be held in France. In all, about 310 organizations (excluding publishers) were represented, roughly 12% of these being "foreigners."

Sennheiser Electronic had among their range of microphones two interesting models. One was an extremely directional microphone (30° lobe-width for −3dB at 5kc/s) which is capable of a very high standard of reproduction. It consists of a split tube about 40-in long coupled to a moving-coil transducer, the split in the tube being divided up into short lengths by many small discs, mounted edge-on and at right-angles to the slot. Although the lobe-width broadens as the frequency is lowered the microphone still has a front-to-back ratio of 15dB at 200c/s. The "Mikroport" (developed by Sennheiser and Telefunken) uses a conventional cardioid moving-coil microphone whose output frequency-modulates a pocket-sized, battery-powered transistor transmitter. The transmitter centre-frequency is about 37Mc/s and this is picked up by a fairly conventional mains-powered f.m. receiver. The non-linear distortion is said to be less than 2% and ranges up to 300ft can be achieved.

Going to the other end of the sound-reproducing chain—the loudspeaker—many novel items were on show. For instance, G. Gogny were exhibiting their wide-range "Batterie Mondial" which consists of either three or six 3-in diameter units connected in series-parallel. The cones have, instead of the usual peripheral support, a repetition of the corrugated centring device mounted a short distance down the cone. This support is made from a fabric with a fairly "open" weave, the result being a very high compliance which produces a low fundamental resonance (42c/s) even with the small cone-system mass. Another loudspeaker unit, shown by Audax, uses an 18-in diameter metal ball as acoustic loading for an 8-in high-quality driver unit. To preserve a fairly resistive load on the driver the ball is divided into two resonant cavities, joined by a pipe: this unit is said to have a smooth response from 90c/s upwards.

Ferrivox market a complete set of parts for a multi-speaker system, including the output transformer and dividing filters. In the bass loudspeaker—a 12-in unit —the corrugated cone-edge support has cut in it a few narrow radial slots. This improves the compliance to the extent of reducing the fundamental resonance from 40 to 30c/s. Cabasse were showing the latest version of their 14-in bass unit—the 36IIBX—which has a nylon rear suspension, "plastic" foam at the periphery, and a magnet producing a total flux of 370,000 maxwells. Mounted in an appropriately large cabinet—for its resonance is 32c/s—the impressive bass produced drew big crowds to the stand.

Among the rather less sophisticated loudspeakers the inverted type of construction (magnet inside the cone) seems to be very popular, as do twin cone types and ferrite magnets. An example of these two latter points was the S.I.A.R.E. 7-in × 10-in elliptical unit. Also many small cone-tweeter units were on show.

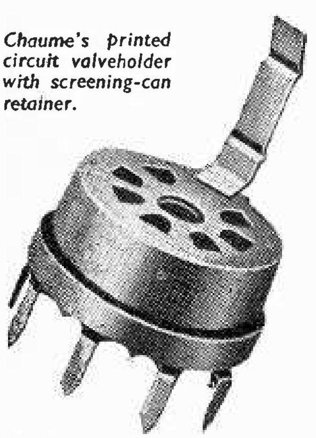
Notable among the small portable gramophones was Radio Celard's "Radio Phonocapte." This has a four-speed turntable and pickup, long-, medium- and short-wave radio, a 1.2W amplifier with bass and treble controls and loudspeaker all in a box rather like a large handbag. Eight transistors and printed circuit construction are used, the power supply being derived from torch batteries claimed to last 100 to 200 hours. Teppaz, too, were showing a neat transistor gramophone.

For stereophonic reproduction the general impresssion gained is that manufacturers feel that something better than the simplest-possible equipment is needed. It is interesting to note that some equipments have separate right and left treble controls. An example of both these trends is the Supertone "Tristan and Isolde" system whose amplifier and turntable are combined; but the loudspeakers are a pair of four-foot columns.

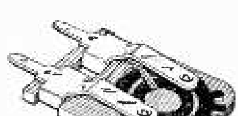
Turntables which caught one's eye were the Thorens TDK101 kit for a single-speed (33 r.p.m.) transcription unit and the Avialex, whose "works" are completely covered by a dust-proof metal shroud. Thorens, too, had a pickup arm on show with an ingenious lifting device which operates through the centre of the pivot.

A pedestal-mounted, two-speed professional tape-recorder with a signal-to-noise ratio of 58dB was shown by L. I. E. Belin. Both this model—the F12—and the portable K30 have sealed plug-in head units which are supplied with a test certificate listing their performance. Tape-threading is very simple, as there are no pressure pads and the tape path is open to view throughout its length.

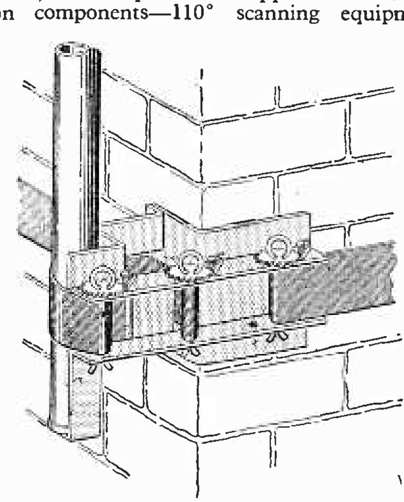
Little major development was apparent in the field of television components—110° scanning equipment is



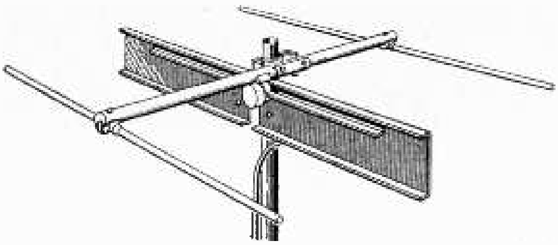
Chaume's printed circuit valveholder with screening-can retainer.



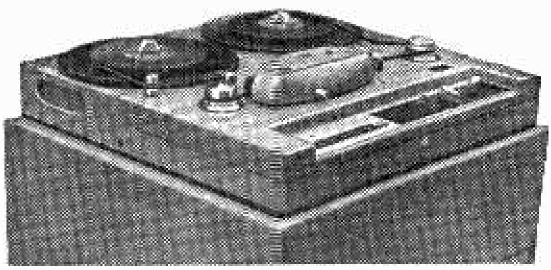
"Justohm" (Matera) variable resistor.



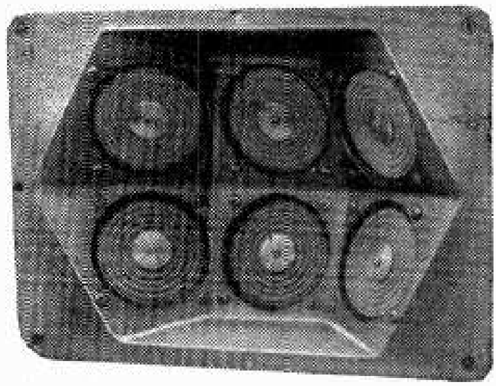
Strip-lashing for aerials (Balmet).



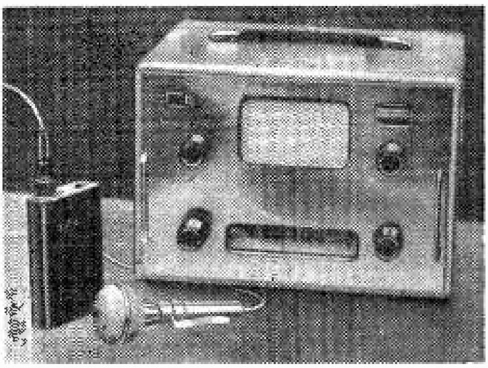
Portenseigne's pressed-aluminium Band-III dipole.



F12 tape recorder (Belin) with photo-electrically operated tape-breakage switch.



"Batterie Mondial" wide-range loudspeaker.



"Mikroport" wireless microphone with pocket transmitter and complementary receiver.

fairly well established and tuner design seems to have stabilized on the double-triode and triode-pentode arrangement, using rather-large coil assemblies and mounting the valves beside, instead of on top of, the turret. This makes it difficult to adjust coil cores on the "biscuit" in use and several manufacturers have mounted the coils at an angle to the biscuit to lessen the difficulty. Printed wiring does not seem to be popular, with one notable exception—a new tuner from Halftermayer. This uses a printed-wiring plate, which is dip soldered, and has printed-coil biscuits. Tuning of the individual coils is effected by means of eddy currents in small metal discs mounted on screws.

Several very interesting mechanical design features were noted in television aerials, the most original being possibly Portenseigne's new Band-III dipoles. These are stamped from aluminium sheet, so enabling a folded dipole to be made with unequal element widths without encountering the difficulties caused by having exposed tube joints at the outer ends of the elements.

A very neat chimney lashing system was shown by Balmet—this uses, instead of the more usual wire, a stainless or galvanized steel band about 2½-in wide. This is held and tightened round the chimney by a split pin and ratchet, the band being threaded through the "legs" of the split pin. The same fixing is used to hold the mast in a stirrup and, in view of its area of contact and strength (3,000lb in tension), enables a single band to be used in the majority of cases which require a double wire lashing.

Some interesting ideas were evident, too, in the small-parts field. Matera were showing a new small pre-set resistor—the Justohm—designed for printed circuit use. Instead of the conventional sliding contact selecting a portion of a deposited track, the track is graded and moves under two fixed contacts so that the area of track in circuit does not vary: thus there is no need to derate the component at low resistance values. Also because there is always some resistance in circuit the "Justohm" saves the cost of a limit resistor. Matera's potentiometer for printed circuits has highly-compliant metal-strip leads instead of tags—so avoiding any danger of damaging the circuit board by transmitting mechanical stresses to it from the control knob and easing replacement problems.

Two chassis fittings on F. Chaume's stand were noted —a dial-lamp holder moulded from "Rilsan" (a nylon-like substance) which offers good insulation resistance and a certain amount of flexibility whilst retaining securely the lamp, and B9A and B7G valveholders designed for printed circuit use. These carry a small spring clip, which is connected to the earth tag, for retaining and making contact with the valve screening can.

It was rather difficult amid the wealth of test equipment on view to pick out any specific items, but two multi-range meters which seem to depart from common practice are the Charvin Arnoux "Precitest" and the Metrix Model 462. The "Precitest" affords all the usual facilities of a medium-sized meter but each group of components—i.e. movement, shunts, cut-out, range-switch panel etc.—is replaceable without recalibration. Another unusual feature is that the meter is protected in three different ways; the movement and rectifiers are bypassed by semiconductor diodes in the event of overload, whilst these are backed by a cut-out and a fuse protecting the shunt and series resistors.

Semiconductor diodes are also used to protect the movement of the Metrix 462; but this is most notable for the facilities that are packed into a small space ($\approx$6in $\times$ 4in $\times$ 2in, weight $\approx$ 1½lb). Potential is measured with a sensitivity of 20,000Ω/V on both a.v. and d.v. ranges, the measurement of a.c. is provided for by indicating the potential developed across a resistor and the three "ohms" ranges permit the checking of resistances as high as 10MΩ and as low as 5Ω. Metrix were also showing a megohmmeter using a transistor-derived 500V supply, stabilized by Zener diodes.

WORLD OF WIRELESS

Component Production

A YEAR of "steady if quiet progress" is recorded in the twenty-sixth annual report of the Radio and Electronic Component Manufacturers' Federation presented at the annual general meeting on March 11th. The approximate value of last year's production of 1,940M components was £100M compared with the previous year's 1,750M components valued at £93M.

Nearly 42% of last year's production was used in domestic sound and television receivers; 31% in professional equipment; 15% was directly exported and the remainder used in audio equipment, defence equipment and in retail sales.

The total value of exported components and audio products was approximately £21M, an increase of £1M on 1957. Over half of this total was for audio equipment. Record players, changers, etc., increased by 17% to £8.6M; tape recorders and parts by 18% to £1.1M and loudspeakers and microphones by 7% to £960,000. Public-address and other sound-reproducing equipment accounted for £570,000—a decrease of 11% on 1957. By far the biggest overseas market for audio equipment is the U.S.A. which, up to the end of November, purchased £3.85M worth; Canada was the next highest with £960,000. The biggest individual market for components (including test gear) was Australia (£910,000), followed by India (£700,000).

It was announced at the A.G.M. that this year's Components Exhibition will be the last at Grosvenor House. In future it will be held at Olympia towards the end of May in alternate years—beginning in 1961. The Components Show will thus alternate with the Instruments, Electronics and Automation Exhibition, to be held next in May, 1960.

Technical Writing Awards

WITH the object of making more widely known abroad technical progress in this country, the Radio Industry Council awards each year up to six 25-gn premiums to writers of technical articles.

The awards for 1958, which will be presented by the new director of the R.I.C., Air Marshal Sir Raymund Hart, on April 15th, go to the following:—

V. J. Tyler ("A New High-Efficiency High-Power Amplifier," *Marconi Review*).
D. J. R. Martin ("New Types of D.C. Amplifiers," *Electronic & Radio Engineer*).
W. J. Bray ("A Survey of Microwave Radio Communication," *Electronic Engineering*).
S. Fedida ("All Travelling-Wave Tube Systems," *Electronic Engineering*).
E. Mendoza ("Electronic Developments at Very Low Temperatures," *British Communications and Electronics*).
E. Lloyd Thomas ("Analogue Computation," *British Communications and Electronics*).

The panel of judges, headed by Professor H. E. M. Barlow, of University College, London, last year included B. C. Brookes, lecturer in the presentation of technical information at University College, P. D. Canning (Plessey), F. Jeffery (Murphy), and E. H. Ullrich (S.T.C.).

Television Convention

DURING the Brit.I.R.E. Convention on Television Engineering to be held in Cambridge in July, Dr. Vladimir Zworykin will give the fourth Clerk Maxwell memorial lecture. Another overseas contributor to the convention will be Dr. S. K. Mitra, Emeritus Professor of Physics, Calcutta University.

The convention, which will be held in the University from July 1st to 5th, is being organized to cover not only the broadcasting aspects of television engineering but also its applications in science and industry. Sessions will be devoted to such topics as transmitters, aerials and propagation, cameras, receivers, video recording and colour techniques.

Particulars of the convention will be obtainable in April from the Institution.

Servicing

THE present scheme, operated jointly by the City and Guilds of London Institute and the Radio Trades Examination Board for the award of separate certificates for radio and television servicing, has been developed piecemeal over the past ten years and is now "obviously out of date," to quote the Institute. C. & G. and the R.T.E.B. have, therefore, decided that a complete revision of the existing scheme is urgently needed. It is hoped to publish a revised five-year scheme leading to a new combined Radio and Television Servicing Certificate shortly.

"Toute la Radio"—25 Years

WITH the March-April 1959 issue our esteemed contemporary *Toute la Radio* completes 25 years of publication. Since 1934, under the direction of Monsieur E. Aisberg, it has maintained a consistently high technical standard together with a characteristically lucid style of presentation. We extend our congratulations on past achievements and felicitations for the future.

Reconditioned Tubes.—Recent announcements that in the process of reconditioning c.r. tubes some manufacturers were rescreening and remetallizing them, has raised the question of purchase tax. H.M. Customs and Excise have ruled that whilst the possibility of these processes was not envisaged when last year's announcement on purchase tax on reconditioned tubes was made (see *Wireless World*, August, p. 353), they are prepared to accept rescreening and remetallizing as a minor repair and, therefore, not taxable. Incidentally, two tube manufacturers, Mullard and Siemens Edison Swan, have announced schemes for the reconditioning of tubes.

Navigation Award.—The captains and navigational crews from the Aircraft and Armaments Experimental Establishment who were concerned with the trans-ocean tests and evaluation flights of the Dectra navigational system have been awarded the Johnston Memorial Trophy by the Guild of Air Pilots and Air Navigators. The trophy is awarded annually for "the most outstanding feat or performance in aerial navigation, for the development of principles of air navigation, or for flights involving the development of the technology of navigation."

E.E.A. Council.—The following representatives of member firms of the Electronic Engineering Association will serve on the council for the ensuing year: A.T.E. (H. R. A. Wood), B.T.H. (V. M. Roberts), Cossor (F. J. Dellar), Decca Radar (C. H. T. Johnson), E.M.I. (W. C. Morgan), Ferranti (J. N. Toothill), Marconi's (F. S. Mockford), Metrovick (L. H. J. Phillips), Mullard (R. R. C. Rankin), Murphy (K. S. Davies), Plessey (P. D. Canning), Siemens Edison Swan (J. W. Ridgeway), S.T.C. (L. T. Hinton) and Ultra (E. E. Rosen). The new chairman is L. T. Hinton (see page 168), and the vice-chairman, R. R. C. Rankin.

Radio Industry Exhibitions, Ltd., has been formed by the British Radio Equipment Manufacturers' Association to organize the National and other British radio and television exhibitions. Under the reorganized Radio Industry Council (see last month's issue) B.R.E.M.A. undertook responsibility for "domestic" radio and television shows. The directors of the new company are F. W. Perks (British Radio Corporation), who is chairman, E. K. Balcombe (Alba) and Walter M. York (Ekco).

Relay Services Association has elected the following officers for the ensuing year: Sir Walter J. Womersley (president), F. J. Bellchambers (chairman), J. W. Kinsman (vice-chairman), and Lt. Cmdr. H. MacCallum, H. Noble, Cmdr. J. W. C. Robinson, W. T. C. Smeathers and A. D. Thomas (vice-presidents).

Stereophonic Broadcasting.—The Percival system of stereo transmission developed by E.M.I. is being demontrated in the U.S.A. The system, which, as described in our November, 1958, issue, radiates the two channels from a single transmitter, was demonstrated during the recent Chicago convention of the National Association of Broadcasters and also at the I.R.E. convention in New York.

Instrument Testing.—The British Scientific Instrument Research Association has established an electrical instrument test service at its laboratories in Chislehurst, Kent. Operated under the supervision of the National Physical Laboratory and using N.P.L. certified equipment, the department will test and issue certificates for instruments up to precision grade accuracy. Further information regarding this service, which is not restricted to members of the association, may be obtained from B.S.I.R.A., South Hill, Chislehurst, Kent.

Mullard "At Home."—Their second electronics exhibition in Mullard House, Torrington Place, London, W.C.1, is being arranged by Mullard for April 6th to 10th. The exhibition has been planned to give manufacturers, designers and professional users of electronic equipment an opportunity to see the company's latest developments in valves, tubes and semiconductor devices for industrial and communications purposes. Admission to the exhibition, which is open daily from 10 to 6, is by ticket obtainable from the company.

Fellowships in Metallurgy.—Applications are invited for the award of Mond Nickel Fellowships for 1959. The Committee awards up to five fellowships annually of an approximate value of £900 to £1,200 each. They usually take the form of a one-year travelling fellowship in metallurgy. Details and application form (returnable by June 1st) can be obtained from The Secretary, Mond Nickel Fellowships Committee, 4, Grosvenor Gardens, London, S.W.1.

Western Nigeria is planning to inaugurate a television service later this year. The two stations, which will operate in Band I using the 625-line standard, will be near Ibadan (the Western Region capital) and Ikeja, near Lagos. It is planned to devote not less than 50 per cent of transmission time to educational programmes. Equipment for the two stations is being ordered from Marconi's.

Soviet production of sound broadcasting receivers during 1958 totalled 3.9M—an increase of 10% on the previous year. The year's output of television receivers was 1M, which was 38% more than in 1957. These facts are given in the report of the Central Statistical Board of the U.S.S.R. Council of Ministers quoted in *Soviet News.*

Japanese Radiocommunications.—The number of radio stations in Japan now totals over 33,000; an eightfold increase during the past eight years. Of this total, 11,000 are used by the fishing industry, which heads the list of users, 4,500 by amateurs and 3,500 by the police.

Receiving Licences.—During January the number of combined television and sound licences in the U.K. increased by 145,311, bringing the total to 9,044,378. Sound only licences totalled 5,667,533, including 368,694 for sets fitted in cars.

South Wales V.H.F.—Wenvoe's fourth v.h.f. transmitter (for the Third Programme and Network Three) came into service on March 1st. It radiates with an e.r.p. of 120kW on 96.8Mc/s. Wenvoe's other frequencies are 89.95 (Light), 92.125 (West Home) and 94.3 (Welsh Home).

Sound insulation is being featured at the Factory Equipment Exhibition to be held at Earls Court, London, from April 7th to 17th. Among the 300 exhibitors are also a number of manufacturers of industrial communications equipment.

Demonstrations of their stereo and single-channel sound reproducing equipment will be given by Scientific & Technical Developments, Ltd., at their Wallington, Surrey, factory from March 30th to April 5th. Admission is by ticket available from S.T.D., Melbourne Works, Wallington.

Kaleidasound is the name given to the exhibition and demonstration of recording and reproducing equipment being held jointly by CQ Audio and Reps (Tape Recorders) at the Imperial Hotel, Russell Square, London, W.C.1, from April 2nd to 5th. Tickets are obtainable from CQ Audio, Ltd., 2, Sarnesfield Road, Enfield, Middx.

Heath Kits.—Daystrom, Ltd., the U.K. associates of the American Heath Kit organization, are giving demonstrations of their equipment at the Royal Hotel, Woburn Place, London, W.C.1, from April 2nd to 5th.

Receiver maintenance course, covering both sound and television, is being held at the Wesley Institute, Wesley Road, London, N.W.10, on Monday and Wednesday evenings from April 6th.

CLUB NEWS

Bexleyheath.—A repeat showing of the Mullard film "The Principles of the Transistor" will be given to members of the North Kent Radio Society on April 9th. A fortnight later they will have a demonstration of audio equipment by Whiteley Electrical. The club meets at 8.0 in the Congregational Hall, Chapel Road, on the second and fourth Thursday in each month.

Bradford.—A lecture on stereophony will be given by F. Thislethwaite at the April 7th meeting of the Bradford Amateur Radio Society. Meetings are held at 7.30 at Cambridge House, 66, Little Horton Lane, Bradford 5.

Cleckheaton.—The April programme of the Spen Valley Amateur Radio Society includes talks on the electron microscope by G. W. Reply at Leeds University (1st); the automatic telephone by a Post Office representative (15th); and on metal rectification by S.T.C. (29th). The last two meetings will be held at the George Hotel, Cleckheaton.

Wellingborough.—The April programme of the Wellingborough and District Radio and Television Society includes lectures on "The Romance of the Radio Star" by G. C. Wooldridge (2nd) and "Winding your own Radio Transformers" by J. Wagstaff (16th). The Society meets at 7.30 at Silver Street Club Room.

Personalities

Major L. H. Peter, M.C., A.F.C., M.I.E.E., has retired from the position of Chief Engineer with Westinghouse Brake and Signal Co., but will continue to act as a consultant. Born in 1891, he was educated at Blundell's School, and after studying under Professor Silvanus P. Thompson at City & Guilds, worked for 5 years in heavy electrical engineering before joining the Royal Engineers in 1914. The following year he transferred to the Royal Flying Corps and recalls that his first squadron was commanded by W. Sholto Douglas (now Lord Douglas of Kirtleside). He joined what is now the Westinghouse Brake and Signal Co. in 1919. In the early 1920s the discovery of the copper-oxide rectifier by Dr. L. O. Grondahl interested him and he devoted a great deal of time to its development and it was this and a general interest in "wireless" that brought him into contact with the radio industry. Major Peter was one of the six founder members of what is now the Radio and Electronic Component Manufacturers' Federation, of which he has been president for the past two years. He has just completed 50 years as a member of the I.E.E.

Major L. H. PETER

L. T. HINTON

L. T. Hinton, B.Sc.(Eng.), A.C.G.I., M.I.E.E., the new chairman of the council of the Electronic Engineering Association on which he represents Standard Telephones and Cables, has been with the company and its predecessors since 1920. He took an active part in the development and engineering of long-distance repeatered voice-frequency cable systems on the Continent and later worked in South America on trans-oceanic shortwave radio-telephone systems. Mr. Hinton's present position in S.T.C. is manager (trade associations).

J. R. Hughes, A.M.I.E.E., M.Brit.I.R.E., has been appointed a director and commercial manager of Hivac Ltd., a member of the Automatic Telephone & Electric Group. He has been with Hivac, latterly as chief commercial engineer, for some eleven years, having previously been for five years technical secretary of the British Radio Valve Manufacturers' Association.

J. D. Stephenson, M.Sc., Ph.D., M.I.E.E., a director of Mullard Limited, recently completed 25 years service with the company. Dr. Stephenson joined Mullard from Durham University where he took degrees in physics, applied science, and electrical engineering and did four years of research work.

Frank H. Spurling, who has been with E. K. Cole since 1951 and has been in charge of the technical sales writing section of the publicity department, is appointed press relations officer.

Sir John Dean, B.Sc., A.R.I.C., F.I.R.I., chairman and chief executive of Telegraph Construction and Maintenance Co., has been appointed a director of British Insulated Callender's Cables, which recently took over the Telcon organization. Sir John, who joined the original Gutta Percha Co. in 1922 and became chief chemist of T.C. & M. Co. in 1930, has been chairman of the company since 1954.

A. R. Boothroyd, B.Sc.(Eng.), Ph.D., for the past seven years lecturer in the Electrical Engineering Department of Imperial College, London, has been appointed by London University to the Readership in Electronics tenable at that college. Dr. Boothroyd, who is 33, graduated at Imperial College in 1946 and after a year as a research engineer with English Electric returned to the college as a research student. He received his Ph.D. degree for research in the field of network synthesis. As a lecturer he has specialized in communications and circuit theory and during the past few years his research has been mainly concerned with transistor circuit applications.

H. E. Drew, M.Brit.I.R.E., who has been appointed Director of Electronics Production (Air) in the Ministry of Supply in succession to **R. E. Sainsbury,** joined the Civil Service in 1938 after 14 years in the R.A.F. He joined the staff of the Bawdsey Research Station in 1938 and in 1946 went to the M.o.S. headquarters staff of the Directorate of Radio Production. Since 1951 he has been assistant director in the department of which he now becomes head.

Nyman Levin, B.Sc., Ph.D., A.R.C.S., D.I.C., F.Inst.P., since last July deputy director of the weapons group of the Atomic Energy Authority, has been appointed director. He is 53. Dr. Levin was with Marconi's from 1930 to 1940 when he went to the Admiralty. He was engaged on the development of microwave valves and equipment at what is now known as the Services Electronics Research Laboratory. Soon after the war he became head of the instrumentation group at the Admiralty Research Laboratory and in 1951 was appointed superintendent of the Admiralty Gunnery Establishment. From 1955 to 1958 he was Chief of Research and Development to Rank Precision Industries. He is succeeded as deputy director by **E. F. Newley,** M.Sc., A.M.I.Mech.E., A.M.I.E.E., who after 12 years in the Post Office Engineering Department joined the Admiralty at Teddington in 1949. He was appointed deputy chief engineer in the weapons group, A.E.A., in 1955 and since 1957 has been Chief of Warhead Development at Aldermaston.

Ian Campbell-Bruce has been appointed sales director of Muzicord (Sales), Ltd., which produces and supplies recorded programmes of music for use in factories, offices, etc. He is 44. On leaving Harrow in 1931 he was apprenticed to the Baird Television Co. In 1937 he joined the Air Ministry Directorate of Signals, was commissioned in the R.A.F. during the war and subsequently returned to the Air Ministry where he stayed until 1956. He was until recently sales director of Cossor Communications, Ltd.

J. B. Hassett has retired from the joint managing directorship of Hassett and Harper, Ltd., of Birmingham, which he founded 51 years ago.

J. D. Sinclair has been appointed manager of the Industrial Division of Amplivox, Limited. He will be concerned with marketing electro-acoustic equipment in the aeronautical and industrial communications field. He was formerly assistant chief of sales with Muirhead.

Peter Alsop has joined Technograph Electronic Products, Ltd., and is responsible for the Technical Sales Division in the computer, guided weapons, and airborne equipment fields. He was previously with E.M.I. Electronics where, during the past three years, he had been employed in an advisory capacity on the application of new techniques and processes, including printed circuitry and resin encapsulating.

John C. Duckworth, B.A., F.Inst.P., A.M.I.E.E., will become managing director of the National Research Development Corporation on April 1st in succession to the Earl of Halsbury who has retired. Mr. Duckworth, who is 42, was at T.R.E. (now R.R.E.) throughout the war. He was for three years at the Atomic Energy Research Establishment, Harwell, before joining Ferranti in 1950, where he was in charge of the development and design of the guidance and control system for the guided weapon "Bloodhound." For the past year he has been Chief Research and Development Officer of the Central Electricity Generating Board.

Peter E. Axon, O.B.E., Ph.D., M.Sc., A.M.I.E.E., has joined Ampex Electronics, Ltd., the recently formed U.K. subsidiary of the Ampex Corp. of California. Dr. Axon, who is an authority on both audio and video magnetic recording, will head this wholly-owned subsidiary of Ampex which will start the manufacture of instrumentation magnetic tape equipment at a factory in Reading in a few months. Dr. Axon, who is 41, was formerly in the Research Department of the B.B.C.

J. Moir, M.I.E.E., a frequent contributor to *Wireless World*, has joined Goodmans Industries as technical director and also technical consultant to Relay Exchanges, who recently acquired Goodmans. Mr. Moir was for nearly 30 years with the British Thomson-Houston Company, where for some time he had been responsible for the design and development of sound reproducing equipment at Rugby.

OUR AUTHORS

H. V. Griffiths, M.B.E., engineer-in-charge of the B.B.C.'s receiving and measuring station at Tatsfield since 1933, writes in this issue on long-distance propagation in Band I. He joined the original British Broadcasting Company at its Birmingham station (5IT) in 1924. He was engineer-in-charge of the experimental short-wave "Empire" transmitter (G5SW) at Chelmsford for a short time before transferring to the Research Department in 1928 for experiments in diversity reception conducted in conjunction with Marconi's. He was on the research staff of Marconi's from 1930 until 1933 when he rejoined the B.B.C.

John M. Peters, B.Sc. (Eng.), A.M.I.E.E., A.M.Brit.I.R.E., whose series of articles on elements of electronic circuits starts in this issue, is a senior production engineer at the Admiralty Surface Weapons Establishment at Portsdown. He served a student apprenticeship with S.T.C. after which he entered the electrical branch of the Navy. He was subsequently for a short time with Johnson and Phillips, of Charlton, before entering the Civil Service in 1950 in which he initially served at the Underwater Detection Establishment, Portland. He is 33.

F. R. W. Strafford, M.I.E.E., a frequent contributor to *Wireless World* during the past 26 years, starts in this issue a series of articles on aerial problems associated with the introduction of a second television service in Band III. He was for some years technical manager of Belling & Lee and is now a consulting radio and electronics engineer on his own account. He was a licensed amateur at 15½ and now operates station G2PD.

W. K. Hsu, Grad.Brit.I.R.E., writer of the article on reversible Dekatron counters, joined Elliott Brothers (London) last year, prior to which he was U.K. representative of the Radex Cosmo Co. He is 25 and since coming to this country has taken a post-graduate diploma course in control engineering at Battersea College of Technology.

OBITUARY

Thomas Lydwell Eckersley, B.A., B.Sc., F.R.S., one of the most brilliant research workers in the field of radiowave propagation, died on February 15th, at the age of 72 after a long illness. After taking a degree at University College, London, and doing some notable research work at the N.P.L. and the Cavendish Laboratory, Cambridge, he served during World War I in the Royal Engineers in Egypt and Salonika where his theoretical and experimental work on "night effect" and coastal refraction served to lay the foundations of his subsequent career. "T.L.," brother of "P.P.," joined Marconi's in 1919 and began research into the resistance of transmitting aerials and later propagation problems. He applied the phase integral method, familiar in quantum mechanics, both to the magneto-ionic theory of ionospheric propagation and to the problem of the effect of the earth's resistivity on the diffraction of radio waves round the earth. On much of this work the present-day systems of forward-scatter transmission are based. In 1940 Mr. Eckersley joined the Air Ministry, and two years later became Chief Scientific Adviser to the Inter-Services Ionosphere Bureau established at Great Baddow. Ill health compelled him to retire in 1946, but he continued as a consultant to the Marconi Company. In that year he was awarded a Fellowship of the American Institute of Radio Engineers. The citation stated, *inter alia:* "Both his approach to the problem from the standpoint of practical communications and his invention of mathematical tools useful in the computation of radiated fields are achievements of lasting value, acclaimed by the whole radio world and form a monument of which he may be justly proud." He received the I.E.E. Faraday Medal in 1951.

Sir Owen Richardson, F.R.S., discoverer of the fundamental physical law governing the emission of electrons from hot bodies—known as the Richardson Law—died on February 15th at the age of 79. Sir Owen, who was knighted in 1939, spent the greater part of his academic career at King's College, London, where for 10 years he occupied the Wheatstone Chair and was for 20 years director of research in physics. Prior to going to King's he was appointed, at the age of 27, professor of physics at Princeton University, where he stayed for 8 years. In 1928 he was awarded the Nobel Prize for Physics.

W. J. Picken, O.B.E., M.I.E.E., engineer-in-chief of Marconi's W/T Co. when he retired in 1946, died on February 24th at the age of 72. He joined the company in 1913 and was engaged with Captain H. J. Round on the direction finding and interception network which played a vital role in the anti-U-boat operations around our coasts. In 1919 he transferred to the company's research staff and was engaged on valve development work until 1928 when he was appointed valve controller. For part of the last war he was seconded to the Admiralty where he worked in the department responsible for the development of all valves for defence purposes. He became secretary of this department (known as C.V.D.) in 1946 on his retirement from Marconi's. Mr. Picken relinquished this post in 1953 since when he had been consultant to the English Electric Valve Co.

Frederick J. Camm, well-known editor of *Practical Wireless*, *Practical Television*, and a number of other "practical" journals published by George Newnes, died on February 18th. "F. J." who was 63 and had been with Newnes since 1930, was a brother of Sir Sydney Camm, director and chief designer of Hawker Aircraft, Ltd.

News from the Industry

English Electric Group.—Preliminary trading figures for last year have been issued by the English Electric Co. showing a group profit for the year after taxation of £3.017M compared with £2.951M in 1957. The Marconi group of companies, which is in the English Electric group, made a profit after taxation of £431,783 (about £34,000 less than in 1957).

Metal Industries, Ltd., have made an offer to acquire Avo, Ltd., who it will be recalled recently took over Taylor Electrical Instruments. In the electrical division of the M.I. Group is Igranic Electric (Bedford), and Brookhirst Switchgear (Chester), which are operated by Brookhirst Igranic, Ltd.

Sealectro Corporation, and its associated company Deltime Incorporated, both of Mamaroneck, New York, announce the opening of a British branch: Sealectro Corp., at Hersham Trading Estate, Lyon Road, Walton-on-Thames, Surrey (Tel.: Walton-on-Thames 6285). The U.K. branch, which is headed by F. R. Shacklady, S. T. Deakin and C. T. Nuttall, will handle the European sales of the companies' products.

Computation Laboratories.—I.B.M. World Trade Laboratories Corporation, of New York, announces the formation of a British subsidiary, I.B.M. World Trade Laboratories (Great Britain), Ltd. W. S. Elliott has been appointed managing director of the laboratories, at present at Hursley House, nr. Winchester, Hants, which are undertaking research primarily in the field of electronic data processing and computing.

Newton Victor, Ltd., the X-ray department of Metropolitan-Vickers, has introduced a specialized brazing service to industry. This service is being provided at the department's Finchley Works, where the plant is used in the manufacture of X-ray tubes and valves. The joints catered for include stainless steel to stainless steel; stainless steel to steel; copper to steel; steel to steel; copper to copper; steel to Nilo K; and Monel to other metals. A method of brazing beryllium has also been developed and applications for tungsten brazing can be investigated.

I.C.I. has brought into operation a large-scale development plant for the manufacture of high-quality silicon of semiconductor grade. The plant, operated by the I.C.I. General Chemicals Division on Merseyside, can produce silicon in either lump form for crystal pulling or in rod form for zone refining.

Marconi's have received a contract from the Ministry of Supply on behalf of the Air Ministry for the planning, supply and installation of a high-power station at the R.A.F Staging Post at Hitaddu in the Maldive Islands. In all, fourteen communications transmitters (ranging from 3.5-30kW) and nine receivers are to be provided, together with ancillary equipment.

Siemens Edison Swan are providing the radio-communications equipment for 12 new vessels for the Shell Tanker Fleet. Another A.E.I. Company—B.T.H.—is providing the vessels' radar equipment.

Felgate Radio, Ltd., of 6, Studland Street, London, W.6, is being voluntarily wound up. The Liquidator is J. H. Banfield, of Staple House, 51-52, Chancery Lane, London, W.C.2.

Lane Magnetic Recorder Co., of 23, Dyke Road, Brighton, is being wound up. The Liquidator is R. B. M. Knight, of 52, Old Steine, Brighton, 1.

Brush Crystal Company, Ltd., have started the commercial production of new piezoelectric materials—polycrystalline ceramics based on a lead zirconate-titanate solid solution—with a usable temperature range of up to 250°C.

Industrial Ceramics.—Royal Worcester Industrial Ceramics, Ltd., has been formed by Royal Worcester, Ltd., to market its industrial ceramic materials. The works are at Tonyrefail, Glam., and the London office at 30, Curzon Street, W.1. (Tel.: Grosvenor 1712.)

Racal's Instrument Division has been formed into a new company, Racal Instruments, Ltd. J. H. Head, late of Advance Components, Ltd., has joined the board of this new company as director and general manager.

Servomex Controls, Ltd., have concluded an agreement with Feedback, Ltd., whereby Servomex will manufacture and market Feedback designs. The range of equipment includes servo components and assemblies as well as apparatus for servo-system analysis.

EXPORTS

Scandinavian TV Link.—A combined multi-channel radiotelephone and television link between the Norwegian capital and Karlstad, Sweden, is being supplied by Marconi's, who will also extend the radiotelephone circuit to Arvika, Sweden. There will be three intermediate stations in the 190-km Oslo-Karlstad link.

Forward-scatter radiotelephone transmitting equipment for Nassau, which will form part of a link connecting the Bahamas with the U.S.A., is being supplied by Standard Telephones & Cables. Two 10-kW transmitters operating in the 2,000-Mc/s band will be used. They will also be installing a line-of-sight v.h.f. telephone network linking Nassau with the Eluethera Islands.

Radar.—A long-range early warning radar station, with associated communications networks and automatic direction-finding equipment, is to be supplied by Marconi's to the government of Jordan.

EMIAC II, the E.M.I. general-purpose analogue computer, is being demonstrated at a number of centres on the Continent during the next two months. Having visited Dusseldorf and Munich early in March, it is in Milan from March 20th to 25th and will then go on to Stockholm (April 3-9); Paris (April 16-23); and Hanover (April 26-May 5).

Calibration Centre in Delhi.—Marconi Instruments, Ltd., have seconded J. E. Taylor to Associated Instrument Manufacturers (India) Private, Ltd., to assist in the setting up and operation of a Calibration Centre in Delhi.

A "**Mercury**" electronic digital computer, valued at about £150,000, has been sold to the University of Buenos Aires, Argentina, by Ferranti.

Multi-channel carrier equipment for radiotelephone links has been ordered from Siemens Edison Swan by the Ghana Posts and Telegraphs Department.

India.—Thakral & Preece (Electronics), of 199, Tehsilpura, Amritsar, are anxious to contact manufacturers of electronic equipment with the view to representing them in India. The company, which is setting up a service organization in Delhi, has an office at 103, Hambrough Road, Southall (Tel.: Southall 4131).

A Second Band-III Programme? —The Aerial Problem

By

F. R. W. STRAFFORD,* M.I.E.E.

How Gain, Directivity and General Performance of Existing Aerials Could Be Affected at Other Frequencies

THE radiation of a second programme—should it come—in Band III will raise important problems of aerial design and installation. Of the eight channels internationally reserved for Band-III television only four are, to the best of the author's knowledge, available at present. These are Channels 8, 9, 10 and 11.

One must assume, *a priori*, that co-siting of the radiators of the transmitters will be arranged, and that the effective radiated power of the two programmes will be substantially equal. In these circumstances the field strengths of the two transmissions would, under the ideal conditions of a flat and perfectly conducting earth, fall off equally in amplitude with increasing distance. Unfortunately, the propagation conditions are so modified by the practical introduction of uneven terrain, buildings and other structures, that the mere small difference in the frequencies of the two transmissions will result in a difference of field strength, at any randomly chosen site in a densely built-up area, of anything from zero to 20dB.

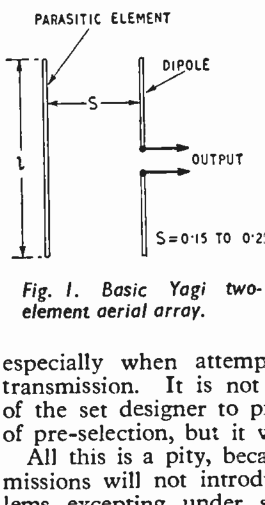


Fig. 1. Basic Yagi two-element aerial array.

This fact, alone, rules out the possibility of using an adjacent channel for the second programme. The present TV receiver would have inadequate input selectivity to prevent mutual interference, especially when attempting to view the weaker transmission. It is not beyond the technical skill of the set designer to provide the requisite degree of pre-selection, but it would be very expensive.

All this is a pity, because adjacent-channel transmissions will not introduce any major aerial problems excepting under severe ghosting conditions. This may sound a little puzzling and needs some explanation.

The amplitude of multi-path reflections (ghosts), coming in from various directions, is very sensitive to frequency. It has already been stated that the main field can change by 20dB in amplitude if the frequency is shifted, and the same applies to the ghosts. Thus, when installing a directional aerial to provide optimum de-ghosting on a particular channel, the aerial is rotated until the worst ghost is made to "sit" in one of the *sharp* minima of the directivity pattern of the aerial. If, now, reception were desired on a neighbouring channel the chances are that the major ghost would arrive from another angle, thereby necessitating a new position for the aerial. The present forest of aerials on the landscape is a sufficient eyesore without having to contend with rows of permanently erected ladders (supplied free with each aerial?).

Nevertheless, if the two programmes were radiated on adjacent channels the great majority of aerial installations would be suitable, without modification, on the previous assumptions of co-siting and equal radiated power.

For the purpose of this article it must be concluded that adjacent channels would not be used for any one service area and it may well be that a separation of two or even three channels may be chosen after due consideration of the technical problems associated with co-sited transmitters, especially if the radiators were all assembled on the same mast—which sounds like reasonable economy.

Hence, it is necessary to examine the aerial problem on the basis of a separation of two or more channels between the two transmissions. The problem is very much bound up with the field strengths of the two signals at a given site.

Local Reception.—At distances up to a few miles from the transmitters the field strength, in spite of the possible difference of 20dB between the two, will be adequate to provide sufficient receiver input from existing aerials. There may be local problems of mutual interference, but this is not an aerial problem.

Primary Area Reception.—Excluding the local portion of the primary area, most Band-III aerials are of the multi-element type based on the Yagi principle. This, basically, consists of the fed dipole plus a number of parasitic elements, one being used as a reflector and the others as directors. In order to obtain optimum performance the lengths of the parasitic elements are quite critical, which is the same thing as saying that the response of the aerial with respect to frequency is equally critical. This means that an *increase* of, say, five per cent in the lengths of the parasitic elements will worsen the performance to the same extent as a *decrease* of five per cent in the frequency. The reason why the Yagi array has these selective characteristics resides in the use of unbroken elements for the parasites. When an unbroken element—that is, an element without a centre feed to an impedance load—is acted upon by an electromagnetic wave the phase of the resultant induced currents varies quite rapidly with frequency. The gain and directional properties of the Yagi array are based on the effect, on the fed dipole, of the re-induced fields from the parasitic elements, and the optimizing of performance depends upon getting these fields in the appropriate phase.

The most simple example is that of the two-element Yagi, commonly referred to as the "H"

* Radio and Electronics Consultant.

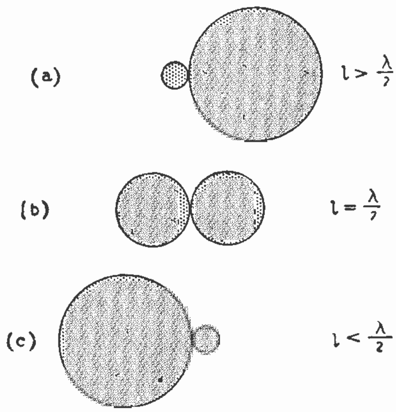


Fig. 2. Effect on gain and directivity of two-element Yagi by varying the length of the parasitic element.

aerial, Fig. 1. The effect of the phase of the induced current in the parasitic element on the gain and directivity of the array is shown in Fig. 2 (a), (b) and (c). The length of the dipole is not very critical and is usually cut to about 0.95 of half a wavelength, according to the diameter of the element, in order to obtain resonance. If the length, *l*, of the parasitic element is made about five per cent longer than a half-wavelength it acts as a reflector and the gain and directional characteristics of Fig. 2 (a) are obtained. If the parasitic element length is made equal to one half wavelength (Fig. 2 (b)) the array becomes bi-directional with equal gain in each direction. Decreasing *l* by a further five per cent completely reverses the directivity (Fig. 2 (c)). Hence, a total change of ten per cent in length can reverse the directivity and make such an aerial useless unless rotated through 180°. This means that a change of ten per cent in frequency will have the same effect, so that a two element array adjusted for optimum gain on the vision frequency of Channel 10 (199.75Mc/s) will exhibit reverse directivity on Channel 6 (179.75Mc/s). The array will become bi-directional, and the gain will fall by 6dB on Channel 8, although practical measurements indicate that the separation required is somewhat greater than the theory suggests. Even so, it is obvious that the Yagi array does not like working over a wide frequency band. In the U.S.A., where multi-channel television transmissions are commonplace, all sorts of technical subterfuges are used to provide some degree of wide-band operation over Band III, but the result is always a compromise. The Americans have the advantage of using a 300-ohm feeder which does increase the bandwith. It is rather pointless to go into the reason because there is very little chance of our industry departing from coaxial feeders, mainly because of the installation problems, such as the need for stand-off insulators every few feet, and so on.

Since gain and directivity of the most simple type of Yagi array is known to deteriorate, quite rapidly, with change of frequency, it is to be expected that the useful bandwidth becomes less in proportion to the number of elements employed. This means that the greater the channel spacing of two programmes the greater will be the aerial problem in the fringe area where arrays from five to ten elements are commonly employed. Concentrating,

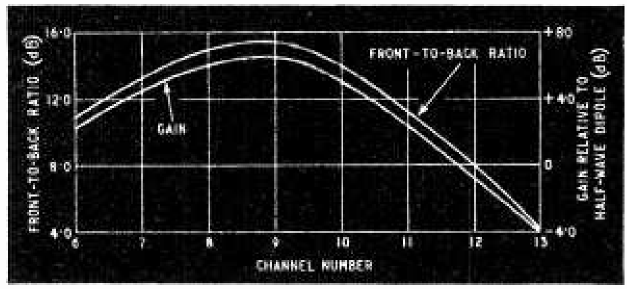


Fig. 3. Performance of a three-element Yagi over Band III.

however, on the primary service area where, in general, the three-element array has proved satisfactory, it is instructive to examine the properties of a typical three-element Yagi comprising folded dipole, reflector, and director over the frequency range of Band III—that is, from 174 to 216Mc/s. The selected aerial was designed, basically, for Channel 9 vision, at which frequency (194.75Mc/s) the maximum forward gain and front-to-back ratio was obtained.

Fig 3 is a plot of the gain and front-to-back ratio from Channels 6 to 13 inclusive. During the measurements the aerial was fixed such that the line of the array pointed to the radiating source.

It will be seen that at a spacing of three channels upwards from Channel 9, that is, at Channel 12, the gain has fallen by 6dB—just halved—and while this loss might pass relatively unnoticed in that part of the primary service area nearest to the trans-

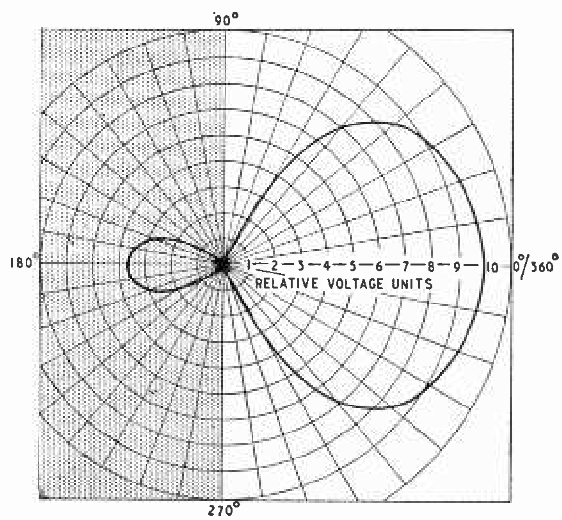
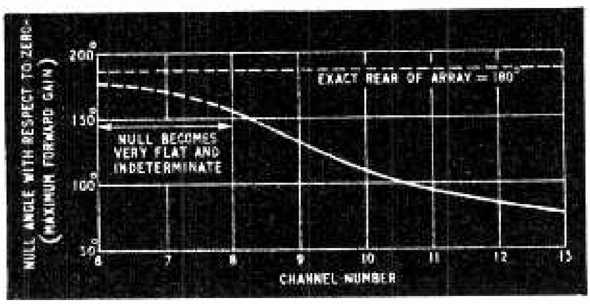


Fig. 4. Horizontal directivity of a typical three-element Yagi aerial. The shaded portion includes angles of useful ghost rejection.

mitter, say up to 25 miles, there might be quite a large sprinkling of noticeable degradation of reception at farther distances, particularly when nearing the boundary of the area. Even a spacing of two channels gives a loss of about 4dB. Statistically analysed—and that would mean hundreds of practical tests—there would be very little to choose between a spacing of two or three channels It is clear from the curves, however, that, if single-channel spacing were technically possible there would be no aerial problem so far as the local and primary service areas were concerned. This is wishful thinking in view of the earlier remarks in the article.

Turning to the front-to-back response; this falls off quite sharply with frequency so that operation two or more channels from the optimum will considerably affect the ghost-reducing characteristics of the array, and this could be serious in certain built-up areas where adequate signal strength is available to take care of any deviation from expected gain in the aerial, but a high front-to-back ratio must be maintained to eliminate ghosts.

The directional characteristic of a three-element Yagi does not exhibit a single null at the rear, nor can it be made to do so however much one attempts it by cut-and-try adjustment to the length of the reflector and director elements. In fact, it does not appear to be possible to obtain a 180° null in a two-element Yagi array (see Appendix). Fig. 4 is a typical directional response taken, in this instance, on the three-element array previously measured and, of course, on Channel 9. Very often, when eliminating *one* ghost, it is desirable to rotate the array so that the direction of the ghost coincides with one of the two nulls rather than the normal 180° position, for it is clear from Fig. 4 that greater rejection of the ghost will result by so doing. In fact, in most cases of de-ghosting this is the technique usually employed. It is very instructive to examine whether the angle of the null changes as one attempts to use the aerial away from its design channel. This is shown in Fig. 5, where it can be seen that a very considerable change in the null-



Above: Fig. 5. Null angle of Channel 9 three-element Yagi array at other channels.

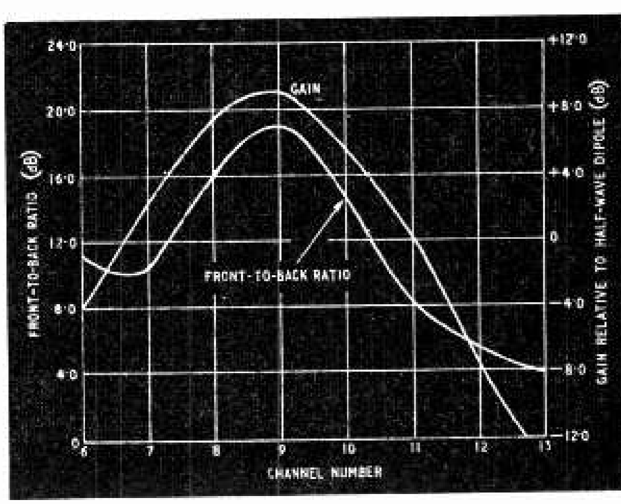
angle occurs even for operation one channel removed. In moving from Channel 9 to 10 the null moves forward by as much as 20° which would cause the re-appearance of any strong ghost eliminated on Channel 9. Three channels off optimum the null moves forward so much that it is only 75° from the position of maximum forward gain. Since the only troublesome ghosts come in from directions over the rear 180° of the aerial (shown shaded in Fig. 4), one may discount, completely, the ghost-removing qualities of such an aerial when operated two channels from the design frequency. If this sort of thing happens on three-element-Yagis it can be expected on similar arrays with more elements. Measurements confirm this, but matters are rather complicated because there are more than two nulls and a rather confusing family of curves results.

Fringe Area Reception.—It is in the fringe area that the really serious problems will be presented and Fig. 6 is a plot of the gain and front-to-back ratio of a six-element Yagi array optimized for maximum gain on Channel 9.

It will be seen that, at two-channel spacing, the gain has fallen by some 9dB on the higher-frequency side, and by 7dB on the lower-frequency side of Channel 9. This is an intolerable loss under genuine fringe conditions where the average aerial installation consists of a single or stacked pair of multi-element Yagis supported well above the house, usually on a guyed mast. One example of an area in which real fringe conditions exist is Cambridge. It should be stated that, where the array is mounted well above the highest point of the building the comparative field strength of two transmissions of equal radiated power will not vary to the extent predicted for the type of installation generally seen in the primary service area where the array is generally a few feet above chimney level, and, verv often, at gutter level. It is in these circumstances that differences of up to 20dB may be expected due to standing-wave effects. At a height of twenty feet or more above chimneys the variations are not likely to exceed 3dB except where there are large nearby structures such as multi-storeyed flats, churches, pylons, and so on. Even on the supposition of gaining 3dB of field strength on the removed channel the nett loss of 6dB would suffice to lose synchronization on a picture previously acceptable, and to produce a marked deterioration of a good picture. At a spacing of three channels the six element array is so inefficient as to be some 8dB *down on a simple dipole* on Channel 12, and 4dB down on Channel 6. Any installation engineer will know that the removal of a multi-element array, and its replacement by a simple dipole, in a genuine fringe area will result in either complete loss of synchonization or of picture. Fig. 6 also shows the rapid loss of front-to-back ratio as a function of de-tuning, and this adds to the problem of noise reduction and ghost removal.

There are two possible solutions to the problem. One is to have a second multi-element array opti-

Below: Fig. 6. Gain and front-to-back ratio of six-element Yagi array.



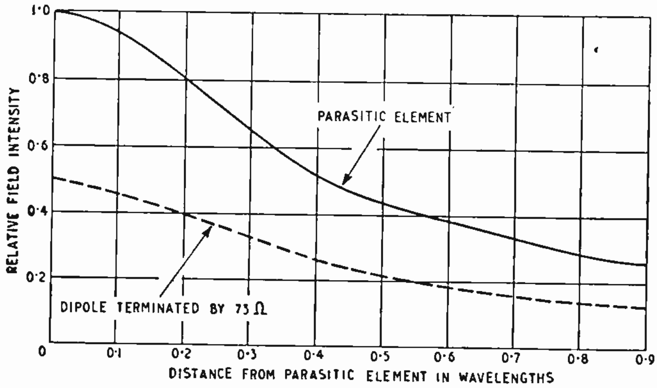


Fig. 7. Re-radiated field from resonant half-wavelength parasitic element in the absence of the main dipole element.

mized for the alternative channel and to connect it to the output of the other array. But aerials cannot be connected in parallel in the same manner as door-bells! Unless special precautions are taken the connecting circuits will interact to the detriment of both aerials, and some form of diplexer or cross-over selective filter will have to be developed to cater for the mutual isolation of two circuits whose frequency separation will be as low as 10Mc/s for two-channel spacing, and 15Mc/s for three-channel spacing. Unlike the simple diplexer used for isolating Bands I and III transmissions, some 150Mc/s apart, the new filter would appear to present some severe technical and economic problems. Nevertheless, it is a problem which must be faced because, if the second programme materializes, there will be the usual "add-on-something" period until wide-band aerials have been accepted. It is a well-known fact in the "Trade" that dealers are slow to anticipate new developments until the need becomes so pressing as to be almost chaotic, and there is nothing to suggest that this reluctant attitude would vanish overnight if some firm statement were made regarding the date of an alternative programme. There would be the last-minute rush.

The second, and technically sound, solution is to design an efficient wide-band aerial capable of providing a gain of not less than 6dB over the whole of Band III. The aerial should possess good directional characteristics and it would be desirable to combine useful Bands I and II properties. Even if this were not possible the aerial could replace the Band III section of a twin-aerial installation and be connected through the usual diplexer to the receiver. The concluding part of this article will consider the wide-band aerial together with a review of what has already been achieved.

REFERENCES

[1] "Radio Aerials" Chap. 5, Sec. 5.8; E. B. Moullin.

[2] "TV and Other Receiving Antenas." Chap. 9, p. 431: Arnold B. Bailey. (John F. Rider, Publisher, Inc.)

Commercial Literature

Electrical Resistance Materials; a booklet describing the properties and uses of various grades of nickel-chromium and nickel-chromium alloys, including some for use up to 1250°C. Available from Publications Department, Henry Wiggin & Company, 20 Albert Embankment, London, S.E.11.

Construction Kits by Heathkit. Illustrated leaflets describing briefly various equipments which can be constructed, including an oscilloscope, v.v.m., stereo amplifier, a 40-watt transmitter and a transistor portable receiver. From Daystrom, Gloucester.

Microphones, a pamphlet guide to the selection of Lustraphone types for particular uses, amplifying the details in the firm's catalogues. From Lustraphone, St. George's Works, Regent's Park Road, London, N.W.1.

C-Core Transformers and chokes, hermetically sealed and filled with dry air and oil, complying with Inter-Services specifications RCS214 and RCL215. Dimensions are tabulated or types with ratings from 5VA to 1600VA. From Standard Telephones and Cables, Edinburgh Way, Harlow, Essex.

Valves for Amateurs: a broadsheet of abridged data on transmitting and receiving valves and semiconductor devices. Frequency bands covered by transmitting valves are shown graphically and there is a table of equivalents. From Mullard, Mullard House, Torrington Place, London, W.C.1.

Air Surveillance Radar operating in the 10cm band with range in excess of 100 nautical miles and above 40,000 ft. Horizontal beam width of the double-reflector back-to-back aerial system is less than 1°. Descriptive brochure from Decca Radar, 9 Albert Embankment, London, S.E.11.

Quartz Crystals for frequencies between 1kc/s and 45Mc/s with tolerances of $\pm$ 0.01%. Some types in two-pin holders and others in glass valve envelopes. Also crystals for ultrasonic transducers, 100kc/s to 20Mc/s. Illustrated leaflet and price list from The Quartz Crystal Company, Wellington Crescent, New Malden, Surrey.

V.H.F. Tuners, switched and continuous tuning types; also a.m. and a.m./f.m. feeder units; and main amplifiers and control units for single-channel and stereo sound reproduction. Technical specifications and circuit descriptions in an illustrated booklet from C. T. Chapman (Reproducers), High Wycombe, Bucks.

Tape Dictating Machine weighing only 7½lb, with accessories available including foot control unit, stethoscope-type headset, desk finger-tip control unit and converter for operating from 12V d.c. power. Leaflet from Lee Products (Great Britain), Elpico House, Longford Street, London, N.W.1.

International Instruments Show

INSTRUMENTS from 55 manufacturers in 10 countries (see list) will be included in the 5th International Instrument Show being organized by B & K Laboratories. The exhibition is to be held at the Instrumentation Centre, 4 Tilney Street, Park Lane, London, W.1, from April 6th-10th. It will open on the first day at 11.45 and on subsequent days at 10.0 and closes at 7.0 except on Wednesday (April 8th) when it will close at 9.0. Application for free admission tickets should be made to the organizers at 4 Tilney Street, W.1.

Austria: Ludwig Siebold.
Denmark: Bruel & Kiaer, Danbridge, Disa Electronic, Struers Chem. Lab.
France: Jobin et Yvon.
W. Germany: Belzer-Werk, Deutsche Elektronik, Dynacord, Hackethal, W.T.W.
Holland: Peekel Laboratories.
Italy: Lares, Veam.
Sweden: Elema Schonander, Gustaffson, Sivers Lab.
Switzerland: Metrohm, Muller-Barbieri, Vibrometer.
U.K.: Advance Components, Avo, G. & E. Bradley.
U.S.A.: Ad-Yu Electronics; All American Tool Co.; Allen-Bradley; ASCOP; Audio Devices; Bourns; Branson Instruments; Burroughs Corp.; DeMornay Bonardi; Electrical Industries; Electronic Speciality; El-Tronics; Epsco; Hoffman Electronics; Huggins Laboratories; Hughes Aircraft; Kay Electric; Krohn-Hite; Micro-Power, Nuclear-Chicago; Pacific Semiconductors; Polarad Electronics; Polytechnic R. & D.; Precision Instruments; Raytheon Manufacturing; Sage Electronics; Sprague; Tape Cable Corp.; United Electrodynamics; Valor Instruments; Waterman; Weinschel Engineering.

Time Future — TELEVISION AND TRANSISTOR

By P. P. ECKERSLEY, M.I.E.E., F.I.R.E.

In two previous articles the first Chief Engineer of the B.B.C. has given an account of the early days of wireless communication and the development of sound broadcasting, with which he was intimately concerned. In this concluding article he gives his views on the growth of television and the technical and social impact of telecommunications in the years to come.

"THE Idiot's Lantern"—"A window opening upon the sentient world"—"Hamlet in a boot cupboard"—"A means to teach Democracy the art of being ruled"—"The ruin of the art of the film"—"Education's greatest boon"—"The ruin of Education"—"The refiner of man's mind, taste and manners".—"My dear! In the flats where Amanda has to live *everybody* has one. My dear! The *noise* and the *people*".—"We've given the old Duchess a television set and she loves it—except that Harding person".

Indeed, television provokes disparate opinion. It washes over the population night after night. Does it wash away the dross and so sharpen outlines, or does it ossify, thus cramping movement?

We remember the House of Lords in its finest hour; ancestral voices prophesying national disaster and ultimate degradation if we dared to let television come under the same kind of control as does "The Free Press of Democracy". We remember and wonder and sometimes we believe that the debate was about a truly vital issue, for television is power.

And all this because, some time in the early 'thirties, a Scotsman, the late John Logie Baird, said, in effect: "We now have the light-sensitive cell, we now have the thermionic valve, *ergo*, we now have television". But let it also be clear that Professor A. A. Campbell-Swinton, in a letter to *Nature* dated June 18th, 1908, described how a television service might be consummated. He proposed using a cathode ray tube with electromagnetic scanning coils for both transmission and reception. The scheme was more fully described by him on November 7th, 1911, when he took up the subject again as a basis for his Presidential Address to the Röntgen Society. The camera tube was to consist of a mosaic of photoelectric cells, thus, in principle at least, anticipating the Zworykin iconoscope and the Emitron camera.

I saw a good deal of Campbell-Swinton when television was first mooted; he was singularly modest, reticent even about his original proposals; he praised Baird for his insight, meaning his realization that, while the basic idea of television might not be new, nevertheless the instrumentality was ready to make it practicable.

Baird stood above his contemporaries in imagination, but, as events proved, below them in knowledge. Baird's first crude demonstrations stimulated the whole technical world to tackle the problem of producing a worthwhile service; in a few years the brains and resources of the big companies transformed those flickering images of the first demonstration into acceptable moving pictures.

I was truly sorry for Baird. He was, in my opinion, "fooled to the top of his bent"—told by a sensation-boosting Press that he was the world's greatest technical genius, that he stood head and shoulders above his contemporaries, dazzled by the prospect of millions of money, he was induced to "go it alone". Earlier than he did Baird ought to have gathered about him physicists, technicians and such, who, using the money so freely available would, without doubt, have built up a Baird system at least in no way inferior to those developed later on by the big companies. At last, but not soon enough, the Baird company did engage the services of one of the pioneers of broadcasting, the late Captain A. G. D. West, who eventually produced the Baird system. Readers will doubtless recollect that, in the early months of the Television Service in 1936, the B.B.C. put this system into service in parallel with another devised by the Marconi Company and E.M.I. and this other was the only one to be retained.

A recollection of Baird is of him throwing his hands into the air, crying "Don't talk to me of sidebands!"—it was just what I was talking to him about. How fatal to hopes are the brute facts of physics.

There is a law which says that citizens may be fined £10 for leaving litter in public places; some equivalent punishment should be visited upon those who unload their guilt in public. Confession may be good for the soul but it seems to me a weakling's indulgence—so much as a prelude to a confession.

Put quite crudely the fact is that I did not want television to succeed. Why? Largely because it would interfere with plans for expanding sound broadcasting, partly because it was a suggestion from outside; it did not arise within the B.B.C. Nothing that I in fact did, or could do, retarded the development of television, my external actions were correct and logical. I was right not to encourage the Baird ballyhoo and I was right to say "show us a worthwhile picture and we will try to transmit it". In fact, a television service was started after I left the B.B.C., but even then, in my heart of hearts, I still opposed and, here is the point, in opposing I found what I conceived to be technical reasons why television could not succeed. Taking the well-known formulæ for ground wave attenuation, knowing the order of carrier frequency required for a 3-Mc/s sideband, I calculated the ground-wave attenuation and found a service area of—well, say, a mile or two in radius! I forgot, because I did not want to remember, that metric waves do not come under the same laws as those hundreds of metres in length.

I became in fact the engineer who does not want a new idea to succeed and uses what dangerous little learning he may possess to deny and to oppose. Only this once have I been on the side of the devil and I learned a humiliating lesson. I must, however, compensate this abasement by stating, very firmly, that some of my ideas have been good enough to have been turned down by official opinion. Let the reader take this not as a confession but as a cautionary tale. But in the case of television neither my opposition, more ideological than influential, nor any one else's could have stood in the way; television had to come and I was silly not to realize it.

I do not own a television receiver. This is not an extension of past prejudice, it is because of a preference for a form of life which, while it does not scorn the delights of the electronic theatre cannot find time to indulge them; there is a preference for social contacts, books, theatre, concerts and a furtive pleasure in writing unpublished verse. I have, of course, spent many evenings looking at television programmes but not so persistently as to form habits of interpretation. This may have resulted in a more objective view and therefore more authority to detached criticism.

From an overhearing of casual conversation among experts and from desultory reading I gather that many technicians and others view the future of television as brightened by colour and limned by stereoscopy. I part company with such because I believe that before these improvements can be of any real value the viewing angle has got to be larger; more simply, in my belief, today's screen is too small. I know! I know! there are all sorts of "scientific" postulates about distance and angle and eyes and so on—the sort of thing that reminds one that a law of aerodynamics proves that the humble-bee cannot fly but "the bee, not knowing this, goes on flying".

It is fascinating to see how television programme producers are automatically trying to make a virtue of necessity, adapting their technique to this limitation of the small screen. The camera seems to be forced to convey its message by a successive showing of the detailed mosaic of the pattern rather than, as on the theatre stage, the pattern itself and by itself. In television emotion is, as it were, conveyed by a series of shots, first the tensity of the heroine's right toe, next the twitch of the nose, next the crook of a finger. The camera fidgets and this fidgets me.

It is rewarding also to see my theories about presentation again confirmed, this time in terms of television. The producer does his best to make a virtue of the necessity of the small screen but, to my mind, there is too little virtue because too little screen!

But even supposing the screen were larger, would colour make such a revolution as some would have us believe? We must not forget the extra cost of a colour receiver. Imagine when colour was first introduced to the cinema that picture theatres showing coloured films had charged extra; how many would have counted the cost worth while? We have seen black and white films that lifted us out of our seat and, even at N. Kalmus' orchidaceous best, others that sent us somnolently back to it. And think again when you have seen a film and someone asks you, three days later, was it in colour? You may find it hard to answer. Was it good? Your answer comes pat.

Again, stereoscopy—is it needed? Again, the cinema; 3D died; possibly those spectacles discouraged it, but that showed that they did not greatly benefit the spectacle.

If, however, the screen were enlarged then I believe that what are now more in the nature of stunts, what might be no more than palliatives for poor programmes, could be of benefit. First things first, and to me the big screen is a paramount necessity. (No advertisement intended.)

So far I may have revealed a grudging attitude towards television, it might be thought that an original prejudice lingers on and produces these curmudgeonly phrases, these half admissions. Maybe the impression may be so, but to oppose it let me quote what I wrote some twenty years ago when television was in its initial stages and when its future was uncertain. This, or something very like it, is what I wrote:

"Even as I run my eye down the titles some have changed, showing that a new item has superseded the old. Apparently I have missed a Choral Symphony from Moscow, but I can still watch "How it Works" in which I have a particular interest. So I lower myself into a chair and press the appropriate button on a remote control panel placed conveniently beside me. The voices accompanying the picture displayed on the screen 10 square feet in area are suddenly in the room, startling in their naturalness. A bit loud, so I reduce them with the volume knob under my hand. I must get my dinner soon or I shall miss the première of a new English comic opera called "Reading from Left to Right", otherwise I would stay to see the end of the tennis. But I shall get the results in my house newspaper tomorrow. This will be printed, while I sleep, by a machine in the lobby. Not a hint of background noise or spots on the picture spoils the programme and the sound quality is so lovely that reproduction criticizes every detail of the playing and speaking."

How do I pay for all this? I don't know. This is a dream not a nightmare. It's a whale of a dream!

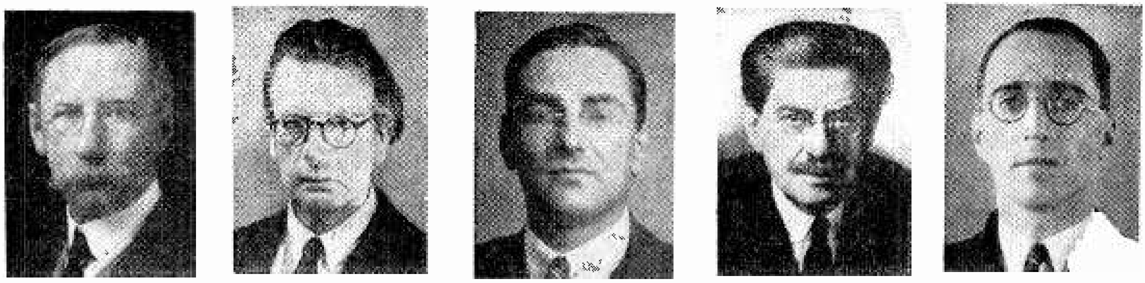
"I have a dream about the future. I see the interior of a living-room. The wide windows are formed from double panes of glass, fixed and immovable. The conditioned air is fresh and warm. Old-fashioned people would feel uncomfortable without the fire and fireplace, others might miss the raucous brown box we used to call 'the wireless.' But flush against the wall there is a translucent screen with numbered strips of lettering running across it. These are the titles describing the many different 'broadcasting' programmes which can be heard by just pressing the corresponding button.

"I glance down the list. Obviously programmes of the same sort are grouped together. The music group includes Scheherezada, Rimsky Korsakov (London), Beethoven's Ninth Symphony, Kosterkovitch conducting (Moscow). Then some lighter music: Waltz Time (Vienna), Sea Pieces, Macdowel (Manchester). Lighter still we come to Jazz Festival (Los Angeles) and the Harmony Hitch Hikers (New York). Talks break out more seriously: The New Farming (Norwich), The Severn Barrage—Special Reporters interview President Inst. Civil Engineers (London).

"Television programmes are set apart. I can, if I like, see the repeat of an old favourite, 'The Importance of Being Earnest' or 'Men's Semi-Finals, Centre Court, Wimbledon' or 'How it Works' (children).

Surely the future, as I adumbrate in the quotation, is possible, but it would be lazy not to discuss, in broad terms, what will be the means to what I believe to be a so desirable consummation.

Speculations about the future of anything, let alone technology, are bedevilled by political uncertainties. Will the nations continuously rave or will it dawn upon the Big Boys that "peace-loving" means more than a propaganda gimmick, that it is a state of being? Regardless of nationality, I mistrust the Big Boys; as a young man I was asked



An inevitably invidious selection of photographs of some of those to whom we owe the inception of the world's first television service. Reading from left to right: A. A. Campbell-Swinton, J. L. Baird, A. G. D. West, I. Shoenberg, A. D. Blumlein.

to join in a war to end all wars, twenty-five years later my children were told to join another which, so it would appear, was fought to end all peace. Perhaps the failure of the aims of the former will be compensated by an equal failure of the apparent aims of the latter; let us assume so and get on with predictions about a peaceful future.

We are familiar with international programme exchanges, my prediction for a peaceful world sees a notable increase in their quantity and quality.

The reproduction of programmes brought to us from overseas is usually comparatively poor when the international link is formed by long-hop radio (what would be likely to be called by today's word-spinners suprahorizonal transmission). This use of the ionized layer as a wave reflector has the disadvantage of introducing differential fading of the sideband components and even though the improvements due to single-sidebank working are remarkable, the result is just not good enough when compared with "local" reception. For this reason I predict that, as and when they become available, the broadcasting organizations will make use of ocean cables for inter-continental programme exchanges. For overland communication it will be either cable or line-of-sight radio; depending upon economics.

In other words, the future of international broadcasting will be modelled on present systems for national broadcasting. The post and telegraph administrations of the world are building and will continue to build their own national networks and will collaborate in setting up international links; the world's broadcasting organizations will use these facilities, as they do today; but the facilities will be expanded and perfected.

Before we leave this question of how the world's national communication systems may be internationally linked, it is interesting to observe that this could be done without the use of ocean cables; it could, in fact, be done by means of line-of-sight radio stations. I leave my readers the fun of studying the globe and finding paths, never longer than line of sight between islands, which would link the world. Anchored ships not allowed! I have not tried to solve the puzzle, but I am told it is solvable—remember, copying Chesterton, the way we linked up Spitzbergen by way of Cape Good Hope.

In dismissing the long-hop radio from my future it would seem that I could, *inter alia*, dismantle Daventry and still the Voice of America. The value of these "overseas services" is equated to two alleged benefits, namely (a) propaganda, (b) keeping in touch with the expatriate. Postulating that before long we shall be plunged into a world-shaking peace, "propaganda" in its nasty aspect is unnecessary; postulating an international network, the expatriate will enjoy his contacts with "home" from a "local" source not by a fading and often noise-drowned signal.

Go back to my dream of the future with its big screen and its multitude of programmes then propaganda in its acceptable aspects is clearly manifest; anyone anywhere can chose not only the offerings of his own nationals but those of the civilized world. Nation unto nation *shall* speak peace if my dream were to come true. Incidentally referring to today's propaganda in its nasty sense, I often pose myself these questions; if it is really potent then is it not jammed? If it has little value and is therefore not jammed what is the good of it?

Thus my dream of time-future must now be clear; a multi-frequency service devised from a network that spans the world and brings to the citizens of it, by wire or radio (depending upon which serves the needs of good quality the best), local, national and international sound and vision programmes immediately available by the pressing of a button.

I doubt it requires any miraculous invention to allow the evolution I envisage to take place. The bigger picture, colour, and a wide choice of programmes, all demand "frequency," meaning a transmission medium which will carry a wide gamut of frequencies and give substantially equal attenuation and low noise level to the components within it. Clearly the mean frequency within the favourable gamut must be higher than that used for either v.h.f. or television today. If radio transmission on these extreme high frequencies were to be used, then reflections, refraction and blind spots would make the service, to say the least, hazardous. No! I must return once more to my conviction that, in some way or another, the network that will serve the households of the future will be essentially conductive. Maybe the waveguide will be developed; it appears to hold fascinating potentials for a multi-channel system. Recent developments in pulse-code modulation indicate that the bugbear of noise may be squashed (that is if a bugbear is the kind of bug that can be squashed).

It is further certain that the transistor, when it and its associated components are made more reliable than they are today, will be of enormous assistance in building up these networks, whatever their ultimate form. The essential advantage of the transistor is its power efficiency and, in time, will be its durability. Clearly the power economy offered by the transistor will benefit the ocean cable in the sense that it will reduce repeater spacing and so permit a greater message capacity—meaning more telephone channels, a better transmission of pictures and so forth.

I used to hymn the valve with

"Hither bring in one content
Anode, grid and filament."

No rhyme occurs to me when the reason for the transistor is so clear.

There are, however, times when I could wish the facilities that the invention offers could be more discreetly used. Lying upon a Mediterranean beach last year the beneficence of sun and the soothe of sea were, to say the least, undermined by the squawk of portables made more portable by the use of semiconductors. The very fact that the transistor allows so much to be contained in so little forces the designer of the portable to use those very minor loudspeakers which in their outpouring commit a major nuisance. This by the way, the rough with the smooth, one expects in time to get a reasonably priced receiver giving good quality without the intromission of mains hum, believing that a battery would supply sufficient, because silent, power.

Some rule limiting the power output of all sets installed in flats or attached or semi-detached houses would receive my unqualified support. About an eighth of a watt would be a fair maximum. There is another solution and that is to build proper sound insulation into houses and flats—why dream?

Why dream? Because dreaming is the way to reality. But once one starts speculation about time-future dreams may become so vague as to be hardly worth recording. Maybe this already applies to what I have written; for fear of piling Pelion upon Ossa it is time to leave off.

May I nevertheless be forgiven if, in a few concluding paragraphs, I pull out the Vox Humana stop and tread rather sentimentally upon the pedals? I hope for forgiveness because I suspect my sincerity will be obvious.

It is my belief that the pursuit of happiness is man's sanest occupation. But by happiness I do not mean the facile escapisms of lounging and leering, of passivity and conformity, I mean the term to be related to creation, making things, be they material or of the mind.

To be thus creative within the ambit of science and technology can be a pure delight, in one sense a lazy delight since it is certain that one's opponent, matter, will never make a mistake. In human affairs more subtle considerations apply, the manœuvres of politics, management, diplomacy and so forth face incalculable human factors; the administration of justice is guided by criteria which are mutable. In its behaviour matter is timeless, its resistances once overcome are for every subdued. But it is this very characteristic of predictability upon which the intellectual satisfactions of scientific discovery and technological invention is founded. There is an exquisite satisfaction in mastering a problem, of seeing the symbiosis between mathematical analysis and experimental verification.

I often wonder whether today's engineer is aware of what a fund of pleasure he can draw upon; when I see the rush, as bell or blast signals the end of the day's work my wonder turns to commiseration. Or do I mistake the impulse? Do many, as I do, live with their problems, take them to bed, bath and train, and there, or anywhere fight them to submission?

Such sentiments about the delights of labour must not be taken to imply a rejection of leisure; on the contrary "all work and no play makes Jack a dull boy." I count holidays, and the full enjoyment of them by a complete rejection of work, the most potent means to get work well done. Indeed I often wonder if the foundation of happiness is not to treat work as most treat their hobbies and hobbies as most treat their work. Leisure does not imply just slacking about, its true value is the opportunity for a change of occupation. That occupation, even on a sun-lit beach, may still consist of a survey of the wide champaign of thought.

Yes! It can all be such fun, so gay and, be it stressed, not so deadly serious a matter as some appear to consider it. Immersed some rainy afternoon in a warm interior confronted by a new circuit, a new device, pricking out a graph, watching the needles of the instruments, surely the Lab is "Paradise enow."

If the speculations about possible futures that I have sketched in the foregoing fail to materialize then they will ascend to the limbo of the departed spirits of idealists—good company I feel. If, in degree, they prove sound then it will be because of the work of engineers who find more to do than just solve problems, who see beyond technological barriers and —by breaking them down—desire to add something notable to, at least, human convenience, at most human happiness.

The more likely rewards lie in the field of broadcasting which, with the guidance of men of good will, can become, increasingly, a teacher of tolerance and an instructor of good living. If broadcasting can continue to fulfil such a destiny then some of us, who, many years ago, dreamed possible futures and made them in part come true, may feel a measure of thanks for the opportunity and a measure of satisfaction in making use of it. But there is much more to be done; we who began hope it will be well done and therefore done in the mood of gaiety and enthusiasm without which nothing can be well done.

Books Received

Theorie der Spulen und Ubertrager by Richard Feldtkeller. Third edition of a treatise on coils and transformers with high-permeability cores. Pp. 187; Figs. 142. Price DM 24. S. Herzel Verlag, Birkenwaldstrasse 185, Stuttgart, N.

Electronic Circuits, by E. J. Angelo, Jr. Presents a unified treatment of circuits incorporating valves and transistors. Part of a comprehensive revision of courses in electrical engineering at the Polytechnic Institute of Brooklyn. Pp. 450; Figs. 561. Price 70s. McGraw-Hill Publishing Co., Ltd., 95, Farringdon Street, London, E.C.4.

Basic Electronics, by Paul B. Zbar and Sid Schildkraut. Second edition of a laboratory manual for the training of radio and television technicians sponsored by the Electronic Industries Association (formerly R.E.T.M.A.). Pp. 148; Figs. 118. Price 17s. 6d. McGraw-Hill Publishing Co., Ltd., 95, Farringdon Street, London, E.C.4.

Propriétés et Applications des Transistors, by Jean Pierre Vasseur. Essentially a practical treatise for engineers and advanced students, with a basic knowledge of radio techniques. Equivalent circuits and design formulæ are derived in all cases. Pp. 479; Figs 308. Price, 5,540 fr. Société Française de Documentation Electronique, 12, rue Carducci, Paris, 19.

Long Distance V.H.F. Reception

By H. V. GRIFFITHS*, M.B.E.

Observations and an analysis of the Causes of Interference in Band I

THE B.B.C. technical receiving and measuring station at Tatsfield has been observing over a wide band of transmission frequencies for many years and it numbers among its duties those of reporting upon ionospheric and other propagation conditions, and of identifying all signals likely to cause interference with B.B.C. transmissions. Radiotelephony from U.S.A. on v.h.f. was first observed in 1936 and U.S.A. radiotelephones have been logged in increasing numbers in the periods of maximum solar activity since then. A different mode of propagation has produced reception over shorter but sizeable distances, from places such as Warsaw and Western U.S.S.R., from which recognizable television has been displayed and the sound signals identified. A third mode of propagation, when it is evident, brings in West European broadcasts at fair strength, although they may normally be very weak or inaudible at other times.

It is hoped that the summarized results from post-war Tatsfield logs and reports may be of interest in showing the temporal variations in propagation by the three modes, but it should be understood that reception as indicated here does not differentiate between signals of widely different strengths, some very weak. Thus, a number of days of reception obtained at Tatsfield from distant stations does not necessarily indicate that interference with B.B.C. transmissions affected television viewers; the strength of the distant signal or the time of day it was heard may not have been "favourable" for actual interference to have been experienced, even in parts of the B.B.C. Service Areas receiving the lowest B.B.C. field strengths.

Another point of some importance is that the "intensity" of the sunspot maximum phases, characterized by the numbers of active sunspots, varies considerably in different cycles: the two maxima centred on the years 1947 and 1958 have been very intense but others recorded by observations (e.g. 1927) were much less so, in which conditions the probability of long distance reception in Television Band I would be small.

Modes of Propagation.—Three distinct modes of propagation are involved. These are:—

Ionospheric F-layer propagation over distances of several thousand miles in the sunspot maximum phase during the autumn-winter seasons. The highest frequency received has been 60 Mc/s.

Sporadic-E propagation over distances up to 2,100 km (1,300 miles approximately) occurring mainly in the summer season. There is some evidence that it may tend to occur more frequently towards sunspot minimum. Sporadic-E ionization occurs often in the form of large "clouds" in motion and there may be several reasons for its formation (see below). The highest received frequency has just exceded 70 Mc/s.

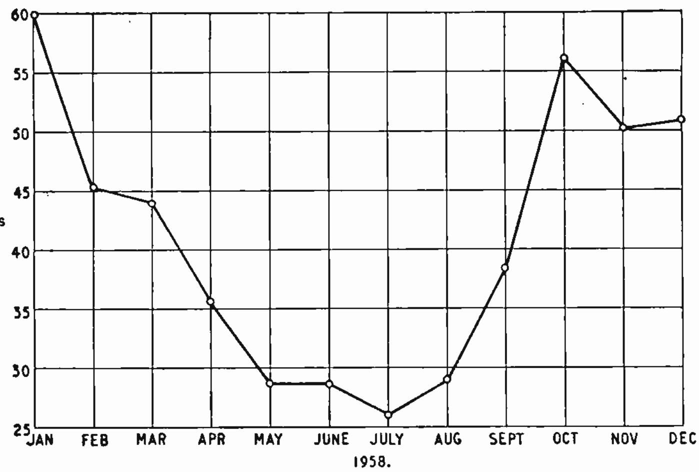
Tropospheric propagation over distances not usually greater than 900 km, 550 miles approximately (generally less). It occurs in weather conditions of high barometric pressure and still air (anticyclone). The terrain of the path must usually be fairly flat land or sea water, and the limits of propagation are often defined by high ground or mountainous country.

Occurrence of the Ionospheric-F Mode.—Ionization controlled by solar activity and varying in intensity with the sunspot cycle reaches a recurrent maximum at 11-year intervals; in the 19 sunspot cycles recorded by observatories since records began in 1749, the average duration of the cycle has been 11.1 years, with the longest period of 13.6 years and the shortest 9.1 years. The intensity of the maximum activity has also varied in different cycles over a quite wide range of sunspot "counts." Previous and present maximum phases occurred in May-June 1947 and February-March 1958 and these were very active, "high" maxima. In years about these high maxima, the practical maximum usable frequency (m.u.f.) for low wave-angles reaches the 40-Mc/s band during the *seasonal*, daytime peak period between the autumnal and vernal equinoxes, and on the days of highest activity in which the m.u.f. may be 10% or more above the average value for the month, frequencies up to 60 Mc/s may be receivable in the U.K. from North America. It is in these coincident conditions of high sunspot activity and high seasonal m.u.f. that reception may extend in the v.h.f. band below 60 Mc/s over the North Atlantic from U.S.A., and interference from this source with B.B.C. Television may result.

As yet, interference by this mode of propagation has been from North America and Canada only but this is probably because the number of v.h.f. transmissions originating from there is very large. U.S.A. signals in this band were first heard at Tatsfield in 1936, then more commonly in 1946-1948 and even more so in 1956-1958. Other signals, from West-Central U.S.S.R., have also been noted and, with possible increased use of Band I for high-power transmitters in East Europe, Asia or Africa, these paths may also contribute to interference in the future.

Previous (1947) *sunspot maximum.* The solar maximum phase was one of the two highest recorded to that date but was nevertheless lower than the 1958 maximum. In comparing the 1947 phase with that of 1958, it should be remembered that the number of transmitters in U.S.A. operating in the 40-60 Mc/s band was smaller in 1947 and the observations made at Tatsfield were also more restricted in man-hours, since B.B.C. Television was

* B.B.C., Tatsfield Receiving Station.



Highest received frequency per month from north and central U.S.A., north of latitude 30° N.

at an earlier stage of its development Nevertheless, reception was then recorded as follows:

Year	*Months—Days*	*Total days*
1946	Feb. (1), Oct. (1), Nov. (1), Dec. (2)	5
1947	Feb. (1), Oct. (1), Nov. (6) ..	8
1948	Feb. (1), Oct. (2), Nov. (2) ..	5
1949	Feb. (2)	2

Present (1958) *maximum.* The v.h.f. part of this phase has obviously not yet passed, although there will be a *seasonal* decline in the m.u.f. during the spring-summer months of 1959. Certainly, the 1958 maximum is unique in having the highest sunspot numbers ever recorded. The shape of the sunspot activity curve is commonly asymmetrical about the peak value, and previous cycles with a high maximum have usually shown a steep, rapid rise with a somewhat slower decline. Thus, it may be expected that the seasonal decrease of the m.u.f. will continue through the next few months but there may be a recurrence of long-distance v.h.f. reception in the 1959-1960 winter period. The data below is factual for the years 1956-1958, with estimates for 1959/1960 which may, of course, prove to be incorrect, since they are computed from the expected future trend of the solar cycle.

Year	*Months—Days*	*Total days*
1956	Mar. (7), Sept. (1), Oct. (12), Nov. (16), Dec. (26)	62
1957	Jan. (16), Feb. (5), Mar. (5), Sept. (2), Oct. (12), Nov. (21), Dec. (23)	84
1958	Jan. (28), Feb. (14), Mar. (2), Oct. (10), Nov. (27), Dec. (18) ..	99
1959*	Jan. (16), Feb. (9), Mar. (2), Oct. (9), Nov. (15), Dec. (15)	66
1960*	Jan.-Mar. (12), Oct. (18), Nov. (10), Dec. (12)	42

* *Estimated figure*

Note: The days of long-distance reception enumerated above include a proportion in which the signals were possibly too weak to cause significant interference to most B.B.C. viewers, other than those at the limits of normal B.B.C. reception.

Interference from "Forward-Scatter" Signals in the I.F. Band.—This should not be confused with the direct r.f. signals mentioned above, although it reaches the receiving aerial by ionospheric propagation and its occurrence is approximately concurrent with a proportion of the U.S.A. reception periods noted. It arises in the necessarily economical design of some television receivers, from inadequate selectivity against "break-through" of undesired signals using frequencies standardized in U.K. for intermediate frequency amplification. The recently standardized i.f.s. of 34.65 Mc/s (vision) and 38.15 Mc/s (sound) have since become actively used by high-power transmitters with measured r.f. field strengths in U.K. that at times exceed 2 mV/metre in winter afternoons in 1958. In these conditions, break-through may occur in some types of television receivers tuned to the lower channels in Band I but it can be reduced or eliminated by fitting an inexpensive, additional i.f. rejection filter in the aerial input connection to the receiver.

Sporadic-E Layer Propagation.—Reception over medium distances, between about 900 km (550 miles) and 2,100 km (1,300 miles) approximately, is at times obtained by refraction at about E-layer height or somewhat above, by "clouds" of ionization formed sporadically. Several reasons for the formation of sporadic-E have been proposed, including meteoric and cosmic ray bombardment, and by interactions from charged, cumulo-nimbus, "thunder-head" clouds, themselves at lower atmospheric levels. Each of these initiatory processes may contribute to the observed effects in reception: the "thunder-head cloud theory" has some support here since a proportion of sporadic-E effects seems to occur in conditions of hot, thundery weather in Europe. This type of sporadic-E reception is sometimes preceded, followed or is concurrent with tropospheric effects at higher frequencies, e.g., in Band II over shorter distances.

The incidence of sporadic-E interference is less predictable than the long-distance ionospheric-F propagation. There seems to be a tendency for it to occur more frequently in the years of only low or moderate sunspot activity† but it is commonly observed in summer each year, and in the peak years it has been experienced in the spring and autumn periods also.

Signals in the television Band I, propagated in this manner, have been identified from Central Europe (e.g. Poland, Western U.S.S.R.), the Central Mediterranean (e.g. Italy) and Black Sea U.S.S.R. regions. Besides the fundamental-frequency inter-

† The inverse relationship between atmospheric ionization and sunspot activity has recently been discussed in greater detail by E. P. Ney in a letter to *Nature*, February 14th, 1959, p. 451.—ED.

ference, there have also been numerous cases of strong harmonics from U.S.S.R. short-wave transmitters being audible in Band I. It should be noted that propagation from U.S.S.R. can occur at various times by refraction at F- or at E-layer heights, but that the supposed sporadic-E reception has mainly been logged in years of fairly low solar activity.

Observed Sporadic-E reception. Prior to 1953, the times allocated for v.h.f. reception and the listening facilities at Tatsfield were more restricted than they are now but signals were logged as follows:—

Year	*Months*	*Total days*
1949	June to Aug.	11
1950	May to Aug...	4
1951	May to July	4
1952	June and Aug.	3
1953	May to Aug...	19
1954	Jan., April to Aug. and Oct.-Dec. ..	45
1955	Jan. to Oct. Maximum in June to Aug.	86
1956	Mar. to Nov...	30
1957	Feb., Mar. and May to October ..	48
1958	June to December	34

Tropospheric Propagation.—The propagation of v.h.f. signals much beyond the radio horizon has been correlated with weather conditions, such as those producing "temperature inversion" or stratification, usually associated with high barometric pressure and still, windless air.

The most favourable periods for these conditions are usually in the months of January, June, July and August, but they can occur in other months. It should however be noted that the increase in strength, or abnormal reception, of v.h.f. by this mode of propagation is commonly selective in distance and to some extent in signal frequency: thus, a strong signal may be received at one place on one frequency but not necessarily at another not far-distant place, or (from the same station) in different v.h.f. band.

The number of Continental stations transmitting in Band I, at distances and over terrain likely to propagate to the U.K. tropospherically is not as great as in Band II. The principal signals in Band I originate in Holland Belgium, Northern France, Denmark, Norway, Sweden and (rarely) West Germany. Reception in this band over broken country from more distant countries such as Poland, Czechoslovakia, Italy, etc., is probably *not* tropospheric. When tropospheric reception occurs in Band II, in which stations are more numerous, there may be associated longer-distance reception in Band I that is seldom observed at Tatsfield, but may be more common in Northern U.K.

Observed tropospheric reception in Band I.—Cases of abnormal (tropospheric) reception noted in Band I are summarised as follows:—

Year	*Months—Days*	*Total days*
1955	Peak months May-Sept.	73
1956	Peak months May-Aug. and Sept.	45
1957	Including 14 days in July, 6 in June, 4 in Jan.	38
1958	5 days in May, 4 days each in June, Aug. and Oct. 2 days in Nov., 9 days in Dec.	28

Note: The poor summer weather of 1958 and, in a lesser degree, of 1957, is reflected above

Tropospheric reception in Band II. Days of abnormal reception, mainly in the summer months, have usually been more numerous:—

Year	*Total days*
1955	60
1956	76
1957	106
1958	74

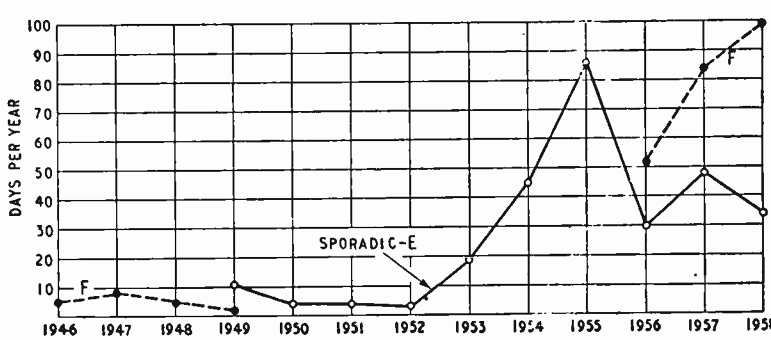
Interference with B.B.C. f.m. broadcasts is unlikely.

Conclusions.—During solar cycles of high sunspot number, in the years 0 ± 1 or so referred to the maximum of the cycle, "interference" in v.h.f. Band I is likely to occur on from 10 to more than 50 days in the year during autumn and winter afternoon and early evening periods, from U.S.A. and Canadian radiotelephones allocated frequencies in this band. On some types of television receivers, there may also be "interference" on the worst days in this period from other transmissions in the 30-Mc/s band breaking through into the i.f. of these sets, but this latter trouble can be reduced or eliminated by fitting filters at the receiver input. Future interference from other sources may possibly arise as the band becomes more commonly used. This "interference" is unlikely to affect all viewers; those in outer reception areas of Channel 1 are the most likely to detect it.

Interference from Mediterranean and East European stations can also arise by sporadic-E layer propagation occurring mainly in the summer months and perhaps more frequently in years of lower sunspot activity, with an annual incidence of from 4 to more than 50 days in the year, in the daytime or early evening period.

Interference may occur at intervals from tropospheric propagation of transmissions located in the coastal plains areas of Continental Europe during anticyclone weather conditions in any year. It is likely to be restricted to small areas of reception, mainly those near the North Sea and Channel coasts, and to be detectable at times from 30 to 70 days per annum

Acknowledgment.—The author is grateful for the assistance of Tatsfield operational staff in making the necessary observations and of R. A. Atfield and W. Hossack in assembling data from daily logs.



Observed long-distance reception by F and sporadic-E layer in Band I at Tatsfield.

Pickup for Low Record Wear

Notes on a Design to Track Within the Elastic Limit of the Record

*By J. WALTON**

IT has been the object of pickup design over the last decade or so to produce pickups that will track with less distortion to both the signal and record groove. In fact these two items to some extent go together.

Although a gradual transition to lighter and lighter tracking weights normally only gives a gradual improvement, there comes a critical point at which there is a sudden improvement with a change from permanent deformation of the groove at the first playing and considerable wear (as at present), to tracking within the elastic limit and the possibility of ending wear as we know it. Tracking within the elastic limit should also have its effect on various losses and non-linear deformations of the groove wall[1]. It also makes the reduction of stylus tip radius easier and can thus assist in decreasing tracing distortion[2]. A reduction in surface noise should occur as the wear decreases on both disc and stylus (with clean new discs). The improvement in the reproduction of transients should be pronounced.

Whilst the achievement of a pickup tracking within the elastic limit can thus be expected to open up a new vista in the world of sound reproduction, its universal usefulness will, of course, finally depend upon its "cost-availability". This factor has been considered throughout.

Effective Mass Required

In January 1955, F. V. Hunt of the Acoustical Research Laboratory, Harvard University, published the results of experiments[3] which not only show that with present-day tracking weights of 3 to 5gm we permanently deform the groove at the first playing, but also that under certain conditions the apparent stresses in the disc material could be less with a smaller tip radius.

Hunt's results indicate that a "needle force" of 1½gm on a 1 mil radius stylus might give operation within the elastic range. This means a tracking weight of 1.0gm and corresponding effective mass and compliance if the total dynamic forces are not to exceed 1½gm normal to the groove wall.

D. A. Barlow[4] considers a slightly lower figure than this is probable because of the difficulty of detecting the fine marks that would be caused in such experiments. However, a "half-thou" radius tip drawn over a flat record surface leaves a clearly visible mark if the loading is 2gm, and an "invisible mark" if the loading is 1gm! It would therefore appear that a very considerable change in the deformation of the groove and its rate of wear can be expected if the pickup is designed so as to keep the forces within such limits. So the objective was set of producing a pickup to track at 1.0gm (force of 1.5 gm maximum on groove wall) and therefore also a maximum dynamic lateral force of 1.0 gm. This pickup should also, if possible, give a high output.

Now every development project has a practical starting point no matter how arbitrary. The starting points in this one were the smallest sapphire rondel and piezo-electric crystal that were available in production, and a range of p.v.cs., nylon and metals for their inter-connection.

First of all the crystal (a twister bimorph about 0.325 in square and 0.02 in thick) was considered as being suspended freely (this will approximate to the truth at high frequencies where its inertia is most important), and consideration was given to its effective mass in relation to a driving point. Then, if the crystal is driven from a point external to its area, it is convenient in a first design approximation to consider it as turning about an axis through its centre of mass and at right angles to the line joining that centre and the driving point (stylus). It can be shown that its moment of inertia is the same for an axis that is either diagonal or parallel to the side, but since operation depends on a diagonal bend (a twist parallel

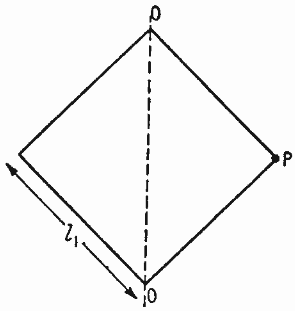


Fig. 1. Square lamina driven at one corner (P) in a direction at right angles to its plane so as to rotate about the diagonal O-O.

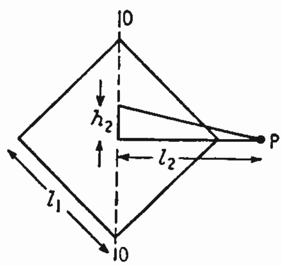


Fig. 2. Square lamina driven and moving as in Fig. 1, except that the driving point is outside the lamina and connected to it by a rigid triangular transmission arm.

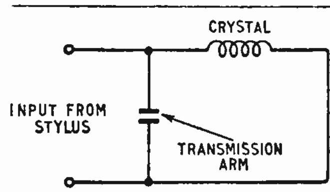


Fig. 3. Electrical circuit analogue of crystal and compliant transmission arm.

* Cosmocord Ltd.

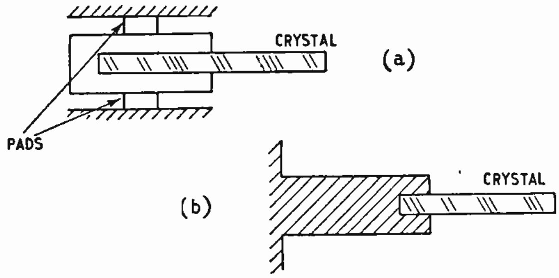


Fig. 4a Crystal supported by short " pads ".

Fig. 4b Crystal supported by long flexing arm.

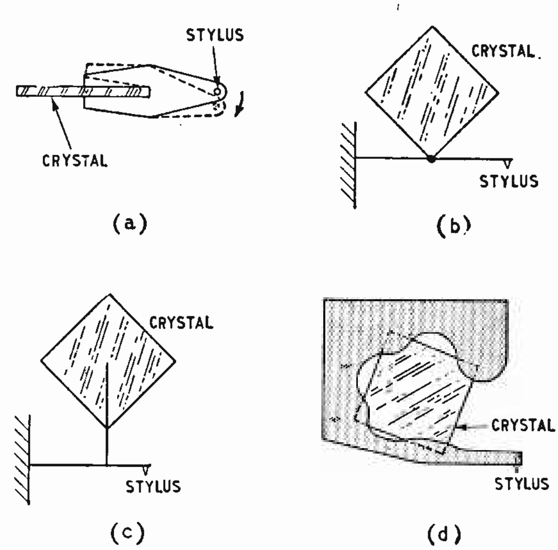


Fig. 5a A possible practical version of the crystal and transmission arm of Fig. 2. The dotted lines show how the stylus arm tends to lose contact with one side of the crystal when the stylus is deflected.

Fig. 5b A crystal and transmission arm arrangement which avoids the fault of Fig. 5a.

Fig. 5c A crystal and transmission arm arrangement similar to Fig. 5b, but in which the fault of Fig. 5a has been reintroduced.

Fig. 5d Practical version of Fig. 5b.

to one side), the most effective transmission will be along a diagonal.

Now the moment of inertia of a square lamina about a diagonal as shown in Fig. 1 is $m_1l_1^4/12$ where m_1 is its mass/unit area, and l_1 is the length of a side. With a density of 1.7 gm/c.c. for rochelle salt, this gives an effective mass at P of $m_1l_1^2/6$, i.e. 10 mgm.

Now for 1-gm tracking of a maximum modulation of 15 cm/sec at 10 kc/s, the required effective mass is equal to $1.0 \times 981/2\pi \times 10^4 \times 15$; i.e. 1.0 mgm, since the acceleration equals $2\pi \times$ frequency $\times$ groove velocity (neglecting the increase in acceleration due to tracing distortion). Ideally, this mass should be reduced to allow for the occasions when maximum displacement (which occurs at low frequencies and which effects the playing force through the compliance) occurs simultaneously with maximum acceleration.

It is thus necessary to try to reduce the effective mass of the crystal by finding the optimum length of a transmission arm. As a first approximation let us consider a crystal and transmission arm as in Fig. 2. The maximum width of the arm is determined experimentally according to its material. If both the crystal and arm are considered as rigid and turning together freely about O-O, then:—

Moment of inertia of crystal plus arm

$$= m_1l_1^4/12 + m_2h_2l_2^3/12$$

where m_2 is the mass per unit area of the arm.

Combined effective mass at P

$$= m_1l_1^4/12l_2^2 + m_2h_2l_2/12$$

For minimum effective mass

$$\delta/\delta l_2 \text{ (effective mass)} = 0$$

$$\text{i.e. } l_2^3 = 2m_1l_1^4/m_2h_2$$

which for the densities and thicknesses of usable materials gives an effective mass of 5 mgm. Since this is still insufficiently low, it is necessary to " decouple " the stylus from the crystal with a compliant transmission arm.

Compliant Transmission Arms

If we consider the system in terms of mechanical impedance at the stylus tip and convert into electrical analogues (see Fig. 3), we require a mechanical impedance at 10 kc/s of not greater than $2\pi \times 10^4 \times 10^{-3} = 60$ mechanical ohms, since mechanical impedance equals $2\pi \times$ frequency $\times$ mass. This corresponds to a compliance of not less than $(60 \times 2\pi \times 10^4)^{-1} = 2.4 \times 10^{-7}$ cm/dyne, since the mass of the crystal is relatively large. But, in any case, the compliance required to cope with amplitudes of 0.01 cm at 40 c/s at a tracking weight of 1 gm is approximately $0.01/981 = 10 \times 10^{-6}$ cm/dyne. Again, ideally this compliance should be increased to allow for the occasions when maximum displacement and acceleration occur simultaneously.

If the transmission is designed with distributed mass and compliance the required low mechanical impedance might be achieved. But before proceeding further with this thought let us consider the general configuration and what is involved in terms of production.

It is indicated that the construction must be some pliant material such as p.v.c. and experience shows that the minimization of the effects of variations in the dimensions of plastic mouldings or the fitting together of parts with production tolerances would be a useful trend in design. The following observations are made to this end.

Small variations in the lengths of short " pad " supports for the crystal can cause large variations in pressure upon them with resulting variation in performance (see Fig. 4a), but variations in the length of a flexing arm cause only proportional variations, i.e. comparatively much smaller variations (see Fig. 4b). Also, not only does the elimination of short pressure pads help consistency, but the use of long members in flexure tends to reduce non-linear movement and resulting distortion.

Also, the fit, for instance of a replaceable stylus in a transmission arm, can cause variations in the compliance of its connection. A rondel fixed permanently into the arm not only can have a connection which is considerably more rigid than the arm itself, but such a permanent fixture becomes almost obligatory if the mass of extra bushings, etc. is to be eliminated.

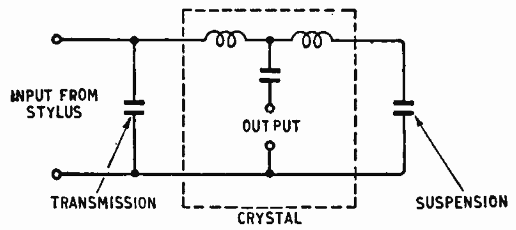


Fig. 6 Electrical circuit analogue of crystal with compliant suspension and transmission arm.

Another problem has been the resonances of individual members due to their own mass and compliance, but if mass and compliance are in fact to be distributed, as suggested above for the transmission arm, then by varying the cross section of the arm we can have a member that is aperiodic within limits and with the same compliance.

Furthermore, the transmission arm should move in the same arc as the crystal if unnecessary losses are to be avoided. The arm must also be such that its compliance is greater than can be expected at its join to the crystal, since some variation of fit is inevitable (particularly with metal transmissions). However, when Fig. 2 is translated into a practical system as in Fig. 5(a), the tendency of the stylus arm to lose contact with the crystal on one side (see dotted lines in Fig. 5(a) is found to be a less desirable feature than the uncorresponding arcs of motion of the arm and crystal in the alternative of Fig. 5(b), providing that the fault of Fig. 5(a) is not re-introduced as in Fig. 5(c). Thus, considering the above, it would appear that a possible system could be as in Fig. 5(d), a conception particularly suitable for the desirable one-piece construction.

Practical Results Achieved

At this point it may be as well to consider if there will be sufficient output from this basic arrangement. For a square crystal the output equals $10^{12}D/1700(W/T)^2$ volts, where W, T are the length of a side and thickness of the crystal respectively, and D the displacement in metres (from information supplied by Brush Electronics). If the system is without mechanical resistive loss, then considering the lowest frequencies for the first simple assessment, the displacement will be (amplitude on disc) × (crystal compliance) ÷ (mounting plus transmission compliance), since the crystal compliance is very much less than the transmission compliance. Now the crystal compliance is 113×10^{-10} W^2/T^3 metres/newton where W, T are in inches (Brush Electronics), which equals 0.15×10^{-6} cm/dyne; and the compliance of the transmission arm used is 15×10^{-6} cm/dyne. Thus for 1 cm/sec (r.m.s.) −20dB at 40 c/s, i.e. an r.m.s. amplitude of 4×10^{-6} metres, we get an output of 130mV, which for what it is worth, is a reasonable magnitude.

If the resonances of the crystal and its suspension can be arranged to be so distributed throughout the audio range that they modify the performance to correct for the recording characteristic, then a first approximation to the performance might be indicated by the circuit analogue of Fig. 6. The distribution of the main compliance between transmission and suspension assists in countering the tendency for the transmission compliance to give "drooping top." This procedure becomes akin to nodal clamping of the crystal.

At this stage experimental models were made to verify the above conceptions and lay a basis for further work.

In the beginning a rigid system was considered and an optimum length of arm deduced. Now it can be shown that this system has an optimum axis of rotation for minimum effective mass. For example, consider the excitation at P of a uniform bar as in Fig. 7.

Moment of inertia about O-O

$=M(l^2/12 + d^2)$

$=M(l^2/12 + [x - l/2]^2)$

where M is the mass of the bar.

Therefore effective mass at P

$=M(l/3x^2 - l/x + 1)$

For minimum effective mass

$\delta/\delta x$ (effective mass) $= 0$

i.e., $x = 2l/3$

when effective mass $=M/4$

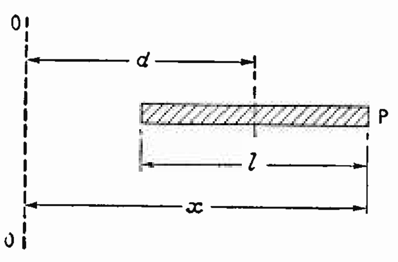
which is only 3/4 of its effective mass when pivoted about its centre of gravity.

Without prolonging the argument, this principle can be applied to our system considering centres of areas of components and the effective centre of rotation of the whole, to find the best line of action through which the transmission from stylus to crystal can operate.

The transmission arm design evolved from the minimum dimensions required for integral support of the rondel to the bulk of the material required at its rear for damping the lowest internal resonance, i.e. that due to the mass of part of the internal support, transmission assembly and the whole crystal, resonating with the combined compliance thereof at about 2 kc/s.

The minimum mass of material that can be considered integral with the stylus (see Fig. 8) amounts

(*Continued on page 185*)



Above: Fig. 7 Long bar driven at one end (P) in a direction at right angles to its length and rotating about O-O (away from its centre of gravity).

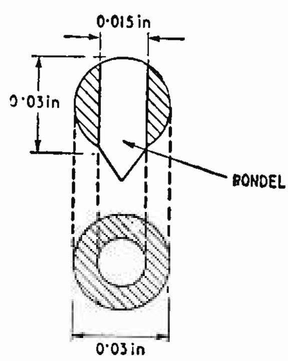


Fig. 8 Material (shaded) which can be considered integral with stylus.

to just over 0.4 mgm (including rondel). The total effective mass, since the crystal is now well decoupled, is this mass plus that effectively offered by the transmission arm. The high-frequency impedance of this arm approximates to the effective mass of its front half i.e., $m_2h_2l_2/48$, which for this arm = 0.2 mgm. Thus the total effective mass is 0.6 mgm.

However, the effective impedance arrived at by finding the minimum tracking weight for the pickup on a measured velocity at 10 kc/s indicates a total impedance equivalent to nearly 1½ times this mass. This is probably due to the mechanical resistance (as required for damping) in the p.v.c. and various schemes are afoot to improve on this.

In the meantime, however, a very useful development of a pickup tracking the largest modulation levels at 1½ gm has been achieved and which has a superior performance with a brilliant attack on transients.

As is to be expected from an effective mass of about 0.6 mgm, the upper resonance of this pickup reaches 40 kc/s, since this resonance is given by $1/2\pi\sqrt{mC}$ where C is the compliance of the disc material (i.e. 2.8×10^{-8}cm/dyne) and m the effective mass. The response remains flat within 4dB to just over 20 kc/s. The output is the normal 200mV for a crystal cartridge into 2 MΩ.

Attention has been given to good tracing geometry, and also, as is so easy with this system, to correct proportioning of vertical and lateral compliances by altering the cross-sectional shape of the transmission arm. The intermodulation distortion is exceptionally low (at 1½ gm), and experiments (rather lengthy in this case) are being conducted as to the effect on record wear.

The final form is sketched in Fig. 9. The one-piece construction not only has its effect on the possibility of making smaller moving parts and on uniformity of production performance, but also enables the cost to be reduced so that the whole pickup head can be replaced instead of merely the stylus, which is too tiny for home replacement. The stylus arm has sufficient vertical compliance to retract on the application of excessive pressure.

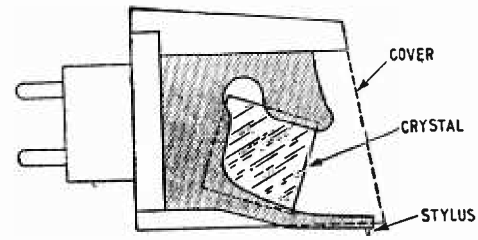


Fig. 9 Sketch of final form of pickup.

For use with this pickup it was found necessary to develop a special arm having very low side thrust and friction, and which was self-levelling and not very subject to interference from external vibrations. The arm produced has a measured side thrust of 0.02 gm and vertical friction of less than 0.05 gm, and was found to still track without effecting the reproduction when the turntable was raised and lowered in time with the music!

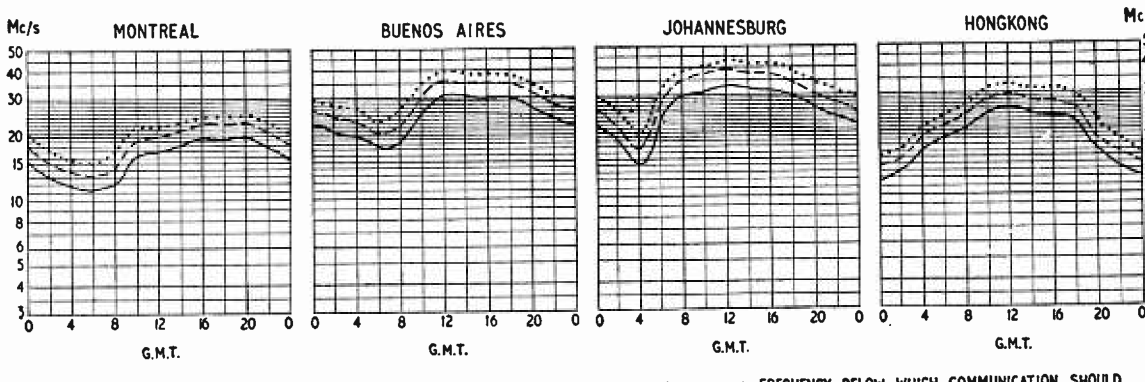
Development will proceed from the new level and any new cartridge (including a lightweight stereo) will be accommodated in the same arm.

REFERENCES

[1] O. Kornei, *Journal of the Society of Motion Picture Engineers*, Vol. 37, p. 569, (1941).
[2] F. S. Lewis and F. V. Hunt, *Journal of the Acoustical Society of America*, Vol. 12, p. 348, (1941).
[3] F. V. Hunt, *Journal of the Audio Engineering Society*, Vol. 3, p. 2, (1955).
[4] D. A. Barlow, *Wireless World*, Vol. 63, pp. 228, 290, (1957).

SHORT-WAVE CONDITIONS

Prediction for April



THE full-line curves indicate the highest frequencies likely to be usuable 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

LETTERS TO THE EDITOR

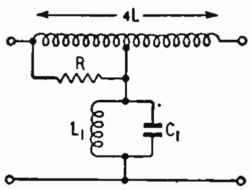
The Editor does not necessarily endorse the opinions expressed by his correspondents

"The Bifilar-T Circuit"

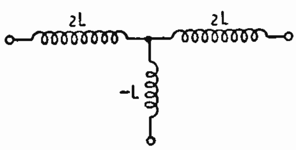
I READ the above article in the February issue with interest, though the many contortions to which the basic circuit was subjected in the course of the discussion prompted me to see if I could find a less cumbersome end-product than a lattice.

May I submit for the author's attention the following analysis of the given bifilar-T circuit?

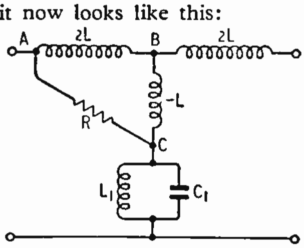
Here is the circuit:



The centre-tapped coil treated as a three-terminal net can be reduced to the following star arrangement (providing perfect coupling is assumed between the two halves of the coil):



The circuit now looks like this:



The points A, B and C now form the vertices of a delta, which can be converted to a star whose arms from A, B and C to the centre of the star have the following impedances respectively:

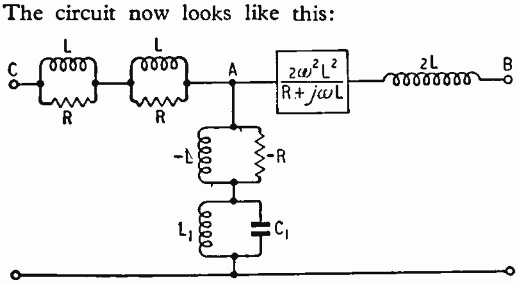
from A $(2j\omega LR)/(R+j\omega L)$

from B $(2\omega^2L^2)/(R+j\omega L)$

from C $(-j\omega LR)/(R+j\omega L)$.

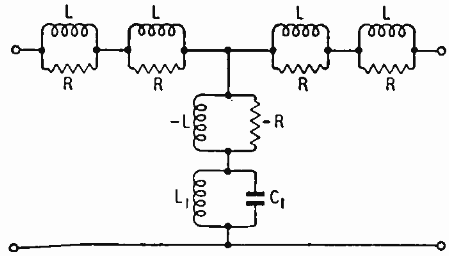
The first of these is the impedance of two coils each of inductance L, in series (uncoupled), and each shunted by resistance R, while the third is the impedance of one "coil" of inductance $-L$, shunted by a resistance $-R$.

The circuit now looks like this:

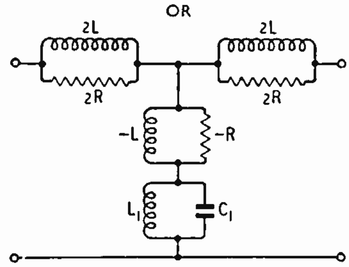


We now add the two impedances in the arm AB and get $(2j\omega LR)/(R+j\omega L)$, which is the same as the impedance of arm AC, and can therefore be similarly represented.

So we come to the final arrangement:



OR



An interesting phenomenon is that this simple T circuit is quite symmetrical whilst the original bifilar -T is apparently not so. This is readily accounted for if we recall that the centre-tapped coil 4L is a $1:-1$ transformer with perfect coupling, and so any impedances in its primary are reflected perfectly into its secondary circuit.

Having arrived at a symmetrical T, we can straightway apply standard simple formulae to derive the two primary constants, Z_0 and propagation constant, of the filter section.

The losses of the tuned circuit L_1C_1 can most easily be expressed, in this case, as a shunting resistance Z_D, the circuit's dynamic resistance. If this is possible, and R is made equal to Z_D, the impedance of the shunt arm becomes zero (causing infinite attenuation, therefore) at a frequency making the reactance of L_1 and C_1 in parallel equal to that of L, in sign and magnitude.

Saffron Walden. G. DE VISME.

The author replies:

Squadron Leader de Visme prefers to proceed by a star-delta transformation and would no doubt be equally happy to take the π-equivalent for the transformer to provide a bridged-T network which could then be reduced either by a star-delta or a delta-star operation. One of these processes was in fact used, I think, in the original *Wireless Engineer* editorial. As it turns out, the best sequence will finish up in a π-network so that end impedances can be incorporated. With the T equivalent, part of the top arms must be taken over to form filter half sections with these end impedances. This, sir, is where the shoe pinches: as I showed in my article the bifilar-T network by itself does not have the response we want in our television i.f. stage but depends very much on its interaction with the end elements. Of course, we should find this out when we applied the standard formulae for the two primary constants.

The multitudinous contortions to which the basic circuit was subjected involved very little algebra and no recourse to standard formulae. Apart from a fiveinch slide rule and a copy of "The Golden Bough" I had no aids to science in the Austrian farmhouse in which I was staying. The treatment was regarded as an exercise in the solution of networks by first principles. You do not need standard formulae and they may hinder thought.

Squadron Leader de Visme calls the lattice cumbersome. Frequently, I agree, the lattice is not a satisfactory *construction* although its economy may be attractive and it sometimes offers the only practical way. For analysis, however, it has many advantages. When the lattice arms have the appropriate canonical form the cut-off frequencies of a filter are immediately apparent: with ladder networks only the frequencies of infinite attenuation can be seen at a glance. The pole-zero plots reveal immediately what kind of a filter we have and what factors determine the confluence of two bands. The Norton transformations lead us very early to the conditions for infinite attenuation.

THOMAS RODDAM.

THE differential transformer filter (with resistance cancellation) dealt with by Mr. Thomas Roddam in his article "The Bifilar-T Circuit" has interesting antecedents.

The reader is referred to the following:

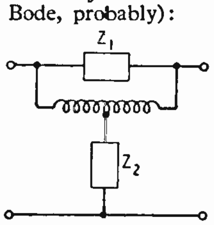
Fig. 16 of: Hendrik W. Bode: U.S. Patent 1,828,454 Oct. 20th, 1931, application dated 1st July, 1930.

A. Jaumann: "Uber die Eigenschaften und die Berechnung der mehrfachen Brückenfilter," *Elektrische Nachrichten-Technik*, Vol. 9, No. 7, 1932. Fig. 5b (actually 5a and 5b were switched around in this article, which is a bit confusing if you read it).

Jaumann says that the differential transformer filter using two transformers was disclosed in:

Riegger: German Patent 444.268, 1923.

But it seems to me that Jaumann worked out this one (independently of Bode, probably):



which is the circuit Mr. Roddam discusses in his article. E. A. Guillemin shows the same network (Fig. 48, p. 204) in his 1932 paper:

"A Recent Contribution to the Design of Electric Filter Networks" *Journal of Maths. & Phys.* (M.I.T.) Vol. XI, No. 2, 1932 pp. 151-211,

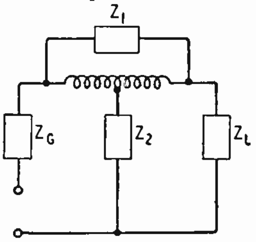
but gives no references.

O. Brune in "Note on Bartlett's Bisection Theorem for 4-Terminal Electrical Networks," *Phil. Mag.*, Ser 7, Vol. XIV Nov. 1932, pp. 806-811 attributes the network to Baerwald, and that reference is:

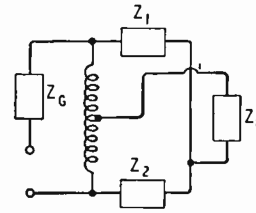
H. Baerwald: "Die Eigenschaften Symmetrischer 4n-Pole u.s.w.," *Sitzungberichte, Preuss Akad. Wiss.* Dec. 1931, pp. 781-829

Thus the use of this differential transformer circuit as a *filter* seems difficult to trace much earlier than H. W. Bode, 1930.

If one studies the complete circuit:



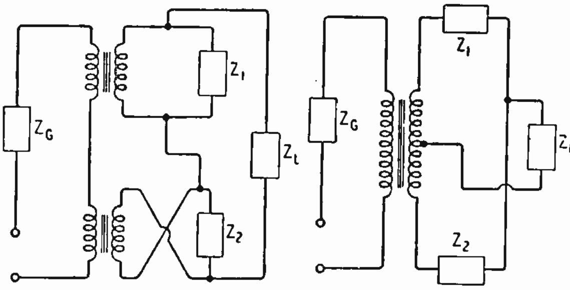
it is seen that the circuit can also be "turned inside-out":



In this shape the two impedances Z_1 and Z_2 of the first network have changed places with the generator and load impedances respectively. This circuit has also been used as a filter, especially by Jaumann.

If, in the first circuit above, a line input is placed at Z_G and a line output at Z_L the circuit becomes the familiar hybrid coil balancing circuit used in two-way telephone repeaters.

The two differential circuits shown here (both are equivalent to symmetrical bridge, or lattice, networks)



are closely related to the early differential galvanometers. Of two arrangements, closely related to these two circuits, Oliver Heaviside said in 1873:

"The great similarity between the systems of resistance measuring by means of the differential galvanometer and Wheatstone's Bridge, the latter having probably been suggested by the former, must have struck anyone who, etc."

See: O. Heaviside: "On an Advantageous Method of Using the Differential Galvanometer for Measuring Small Resistances." *Electrical Papers*, Vol. I, pp. 13-15 and *Phil. Mag.* Ser. 4, Vol. 45, April 1873.

Differential circuits are very old indeed in the shape of differential galvanometers.

They can be traced back to the older Becquerel

Ann. de Chim et Phys., Vol. 32, 1826, pp. 420-443, and Edmond Becquerel:

Ann. de Chim et Phys., 3 series, Vol. 17, 1846, pp. 242-290, and:

H. W. Dore: "Untersuchungen im Gebiete der Inductions-elektrizitat," Berlin, 1842.

Differential galvanometer circuits were referred to by S. Hunter Christie who in his Bakerian Lecture on Feb. 28th, 1833 (*Phil. Trans, Roy. Soc.* 1883, Pt. I, pp. 95-142) described the device which was most unreasonably named the Wheatstone Bridge just because Sir Charles described it, in his Bakerian Lecture, of June 15th, 1843.

Therefore, the circuit discussed in Mr. Roddam's article certainly opens up historical perspectives!

Ramstad, Norway. KAYE WEEDON.

The author comments:

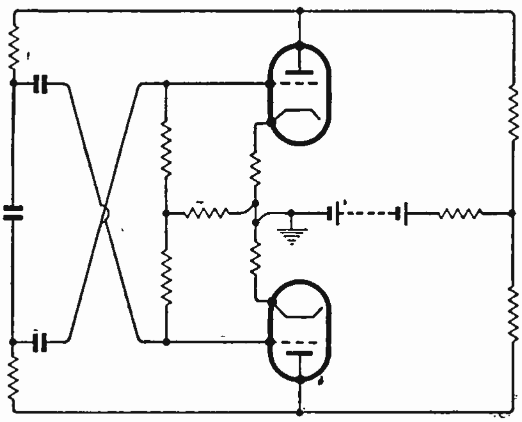
At first sight we might think that this circuit lay dormant for 80 years. In fact this was only one of the many devices which lay ready for the great work of Campbell and Zobel who considered the interaction of the network and its terminations. With the bridges we are concerned with the balance point and the load is relatively unimportant but with filters the source and the load are all important in defining the behaviour in the transition region. This fact is brought out in my article.

THOMAS RODDAM.

"Alternatives to the Wien Bridge"

IN the above article by J. F. Young in the February issue, the author states that he has found no reference in the literature to the use in oscillators of the circuits illustrated in Fig. 8 of the article.

Such circuits* were used by me in 1944 and are des-



[* One of which is reproduced herewith.—Ed.]

cribed in an article on "A push-pull resistance-capacitance coupled oscillator," published in *Phil. Mag.* in November, 1944 (Vol. 35, p. 715).

London, S.W.11. W. F. LOVERING,
Electrical Engineering Department,
Battersea College of Technology.

YOUR contributor, Mr. J. F. Young, describes several most useful alternatives to the well-known Wien bridge selective circuits in your February issue. His suggestion that the circuits Figs. 8(a) and 8(b) are more obvious than the usual arrangement appears to be borne out historically since they were, in fact, used as oscillators before the Wien bridge.

At first the C-R and R-C sections were isolated from one another by buffer valve amplifiers [1, 2] which also provided the necessary gain to maintain oscillation. Subsequently the two sections were cascaded [3] as shown in Figs. 8(a) and 8(b) of Mr. Young's article and the Wien half bridge (Mr. Young's Figure 1) was introduced at the same time.[3]

W. V. RICHINGS,
Dawe Instruments, Ltd.

[1] Lattmann & Salinger. "Über Rückkopplungsschaltungen ohne Resonanzkreise (On back coupling connections without resonance circuits)." *Elektrische Nachrichten-Technik* Part 4, 1936, p. 130.
[2] Yates-Fish, N. L., Willans, P. W. and Muirhead & Co. Ltd. British Patent No. 489,849 (Application 1937).
[3] Willans, P. W. and Muirhead & Co. Ltd. British Patent No. 497,148 (Application 1938).

The author comments:

I am grateful to the correspondents for adding to the knowledge of the history of these circuits. I understand that the Wien bridge was used in oscillators in the early 1930s, and that there is a reference in *General Radio Experimenter*, Vol. 6, Nov. 1931. The information added by the correspondents makes me even more astonished that the circuits appear to have been used so little compared with the Wien bridge.

Incidentally, I have noticed some errors in my original article. The calibration of the circle in Fig. 6 should be reversed, i.e., should increase clockwise, and in the first two lines on p. 95 the differential amplifier should be that of Fig. 4, not of Fig. 5. In the list of references, No. 11 should be *Electronic Engineering*, 23, p. 274 (1951). J. F. YOUNG.

Evaluating Aerial Performance

I WAS indeed pleased to see in the February and March issues Mr. L. A. Moxon's attempt at a "common sense" approach to aerial evaluation. Accurate evaluation of performance of a v.h.f. aerial is a difficult procedure, even for the specialists, and simple "rules of thumb"—such as remembering that the gain of an array of N half-wavelength elements will be approximately N times that of a single element—are of great assistance.

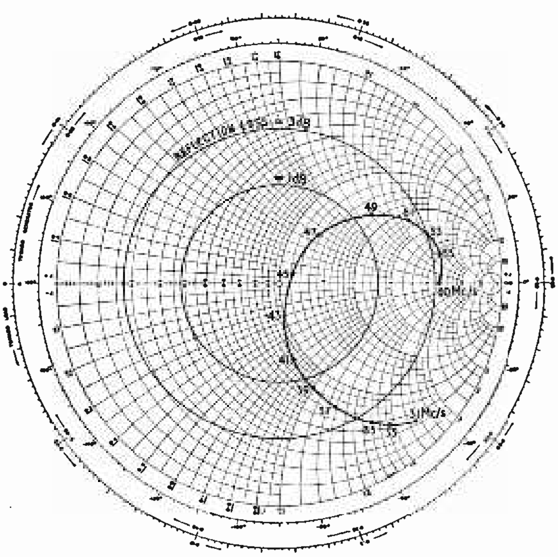
It is, however, most important that these rules be based on correct assumptions for, although they are themselves only approximate, the use of successive approximations in their derivation can easily render them incorrect to the point of being misleading.

An example of this is in the value given for the bandwidth of a Channel 1 dipole. The first assumption made in this calculation is that a thin linear dipole behaves in a similar manner to a transmission line having constant inductance and capacitance per unit length. This is obviously not true and must therefore be treated with strict reserve.[1] The approximation $X = jZ_0 \cot 2\pi b$ is sometimes used to investigate the behaviour of dipole reactance *near to the first resonance*,[2] but it certainly cannot be extended to the point where Mr. Moxon suggests that radiation resistance equals reactance. Even the radiation resistance itself will have taken up a very different value from that at resonance by merely a few per cent change in frequency.

The second assumption which is made is that if the resistive component of the aerial impedance can be made equal to the magnitude of the reactive component a "3dB down" point will be reached. This is, of course, by analogy to the universal Q curves for tuned circuits where a generator of constant voltage or constant current (for series or parallel circuits respectively) is assumed. In the case of the dipole it is feeding a load, or is being fed by a source, whose impedance is made equal to the radiation resistance at resonance and a constant power must be assumed. Thus if the aerial impedance can be made $R_r + jR_r$ a reflection coefficient of magnitude 0·45 will be obtained resulting in a loss in power transfer of only 1dB.

The accompanying Smith diagram shows the measured impedance plot of a typical commercial Channel 1 dipole, the impedance co-ordinates being normalized to 75Ω. It will be seen that the "3dB down" points are at

[1] E. B. Moullin, "Radio Aerials," p. 340 and Sergei A. Schelkunoff, "Antennas: Theory and Practice," p. 425.
[2] R. A. Smith, "Aerials for Metre and Decimetre Wavelengths," p. 40.



(*Continued on page* 189)

35.75 Mc/s and 53 Mc/s thus giving an impedance bandwidth of 17.5 Mc/s. Even the impedance bandwidth to ±0.5dB is 8.5 Mc/s and the variance with the approximate value is obvious.

Cheshunt. C. F. WHITBREAD.

Printed Circuits

I HAVE read with interest the contributions on the above subject. Having spent about 25 years on electronic faultfinding, in the factory and in the hard world outside, the toughest going met, so far, has been the few years spent as a mobile TV engineer. Bearing this in mind I cannot let the remarks about servicemen pass without comment. They show a complete lack of comprehension of the problems that are an everyday part of the job and are tinged with the usual hostility reserved for the unknown.

But to the subject. Ignoring all mechanical snags which, viewed dispassionately, just mean time, gained by the manufacturer, lost by service department, there is a major factor which seems to have been overlooked. It is that the print does not make visual sense; it is provided to connect components. Anyone attempting to reconstruct the circuit from its meanderings in the restricted time available in service work will end up in a mental home.

The manufacturing side knows the circuit and the location of each component intimately, therefore the method adopted to connect components has little or no effect upon fault-finding efficiency. The service engineer tends to look upon the manufacturer as the so-and-so who uses devilish ingenuity to make life more and more uncomfortable as the years go by, the latest thorn being the printed circuit. Why should he take this unreasonable attitude when the manufacturer finds no difficulty whatever. The answer lies in lack of knowledge, not of printed circuits as such but of the identity of every component on every panel of every one of the hundreds of different sets he is called upon to service, without this knowledge the printed panel makes as much sense as a junk box. Given an average wired layout, it is possible to follow, fairly rapidly, at least a major part of the circuit through and identity components by their location in the wiring.

"Haven't the fools ever heard of service data?" I seem to hear them say. The lamentable fact is that data for every set tackled is not always to hand, readily available or even available in the case of recent models. There would be much less cause for friction if every set had a circuit stuck on its back and the printed panels were also printed with component identities, colour coded for frame, line, sync, etc. Whether the serviceman is right or wrong, his word with a prospective customer for a new set counts for more than any amount of advertising. As this is so, surely some effort should be made by the makers to look at their products from the perspective of one who has to rectify their mistakes and then at least attempt to do something constructive rather than just adopt the attitude which W. I. Flack reflects in his letter in the March issue. Incidentally, may I dedicate to him the one that goes:—

"I told him it was the first turning after Bill Jones' Farm but he didn't even know where Bill's farm was. How can you help an idiot like that?"

Havant. R. J. WILSON

IN publishing a letter of mine in the March issue of the "Wireless World" in which I referred to an earlier letter from Mr. A. G. Tucker on the subject of printed circuits, I appear to have raised a minor storm, but I am indeed glad to note the interest which this has aroused. I feel however, that in the defence of printed circuits, I must continue this correspondence further.

I appreciate Mr. Tucker's comments on the speed with which his company repairs receivers and it is refreshing to know that such speedy service is available. I cannot, however, agree with him that printed circuit receivers have not been in existence long enough for their reliability to be confirmed, receivers being frequently life tested under adverse atmospheric conditions. I have also received reports some months ago from the U.S.A. referring to receivers at least six years old which did not show any appreciable deterioration. Furthermore, I myself possess a printed circuit receiver which is approximately five years old and as far as performance and appearance is concerned it is not appreciably different from the time that it was made.

The letter from Mr. E. Kisch leads me to believe that he has not had an extensive experience in the servicing of printed circuit receivers. I do agree with him that I could not readily spell out Czechoslovakia backwards, but if it happened to be printed on the reverse side of a piece of phenolic board as used in printed circuits and it was necessary to check the spelling then I would illuminate that side so that an outline of the image could be seen through the material and I am confident that I could see the letters sufficiently clearly for me to spell the word out backwards, forwards or inside-out. In the same way when I require to follow the wiring of a printed panel, I illuminate the reverse side of the panel and I can then see all the conductors clearly outlined A convenient method of doing this is to place a 25-watt lamp close to the reverse side of the board, alternatively, a pencil-type torch which gives only a small area of light may be used, and enables any conductor to be traced between any components.

I cannot accept his simile, of alternate words being printed on the front and reverse sides of a page. As he so very rightly says, "to print and read in the fashion that we do is an acquired habit" and "the experienced and skilled technician is used to looking at valve holders and coils from below", he has therefore acquired the habit of working back to front. Since we have all acquired the habit of reading theoretical circuit diagrams, in one plane only and since the printed circuit is after all only a physical conception of the circuit diagram, then I am quite certain that it would not take long to acquire the habit of following, understanding and repairing printed circuit receivers.

Finally, I was interested that Mr. Wesley-Collins made the point that "with a thorough knowledge of the basic theory combined with a logical approach, servicing of both types of circuits should not present undue hazards", that after all is what I stated in my previous letter. Regarding any cost saving due to the application of modern techniques, It goes without saying that these advantages are invariably passed on to the user. Any manufacturer who does not do that and thereby raises the cost of his equipment would soon fall behind in the very competitive industry in which we are engaged. W. I. FLACK.

Slough. Radio and Allied Industries, Ltd.

Relativity

THE following solution to the custard pie problem incorporated in my article in the March issue would, I think, be hard to beat. It comes from Mr. and Mrs. Peter Donaldson of Cambridge.

In mounting your custard attack
Your car gets a little push back.
If it keeps up its speed,
The engine will need
To supply the mv^2 you lack.

Another way of looking at the same thing is to reckon the work done on the pie by the motorist as the product of the force he exerts and the distance through which it acts. When the car is moving forward, that distance is greater than when it is standing.

"CATHODE RAY."

Reversible Dekatron Counter

Circuit to Allow Subtraction of Input Pulses from the Existing Count

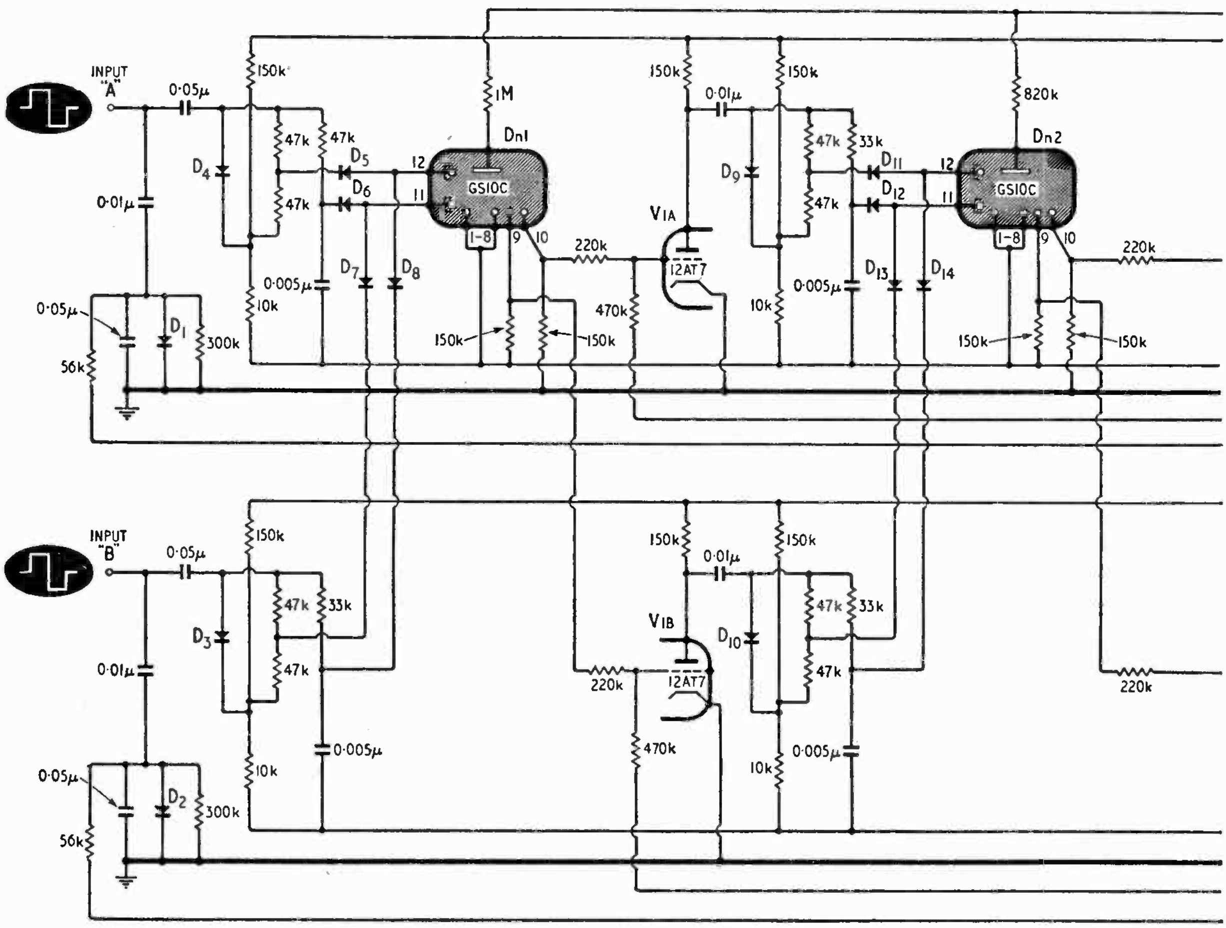
By ***W. K. HSU***

A DOUBLE-PULSE Dekatron tube consists basically of 30 cold-cathode diodes arranged in a circle around a common anode. The whole is enclosed in a gas-filled envelope. The common anode is connected through a high resistance to a potential of about 450 volts. The anode potential drop is just sufficient to maintain a glow and the maintaining voltage is insufficient to strike a second discharge. Therefore only one cathode glows. The glow is clearly visible through the glass top of the tube.

In a double-pulse Dekatron selector tube the first, fourth, seventh, etc. cathodes are connected together internally. So are the second, fifth, eighth, etc. The former may be called " first-guides " and the latter " second-guides." These guides and each of the remaining ten cathodes are connected separately to pins on the tube base. The base connections of a typical Dekatron are shown in Fig. 1.

Normally the cathodes are at earth potential, the first and second guides being biased positively. If the first-guides are pulsed negatively the guide adjacent to the glowing cathode becomes ionized and, because the anode discharge tends to follow the potential of the most negative electrode, the glowing cathode is extinguished and the discharge is transferred to the adjacent first-guide. Thus, if now the second-guides receive another negative pulse the glow follows on to them, but as these second-guides are positively biased the glow moves on to the next cathode. In Fig. 2 diode D serves to clamp the guides to a fixed potential. R_2 and C_2

Complete circuit diagram of the reversible counter.



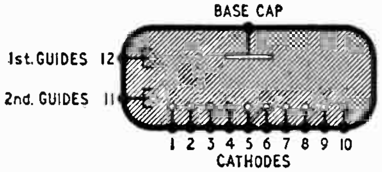


Fig. 1. Symbolic diagram of a typical Dekatron.

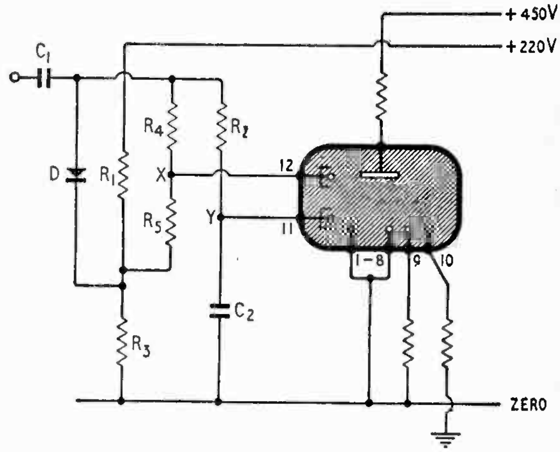


Fig. 2. Circuit for pulsing the first and second guides, X and Y being the guide feed points.

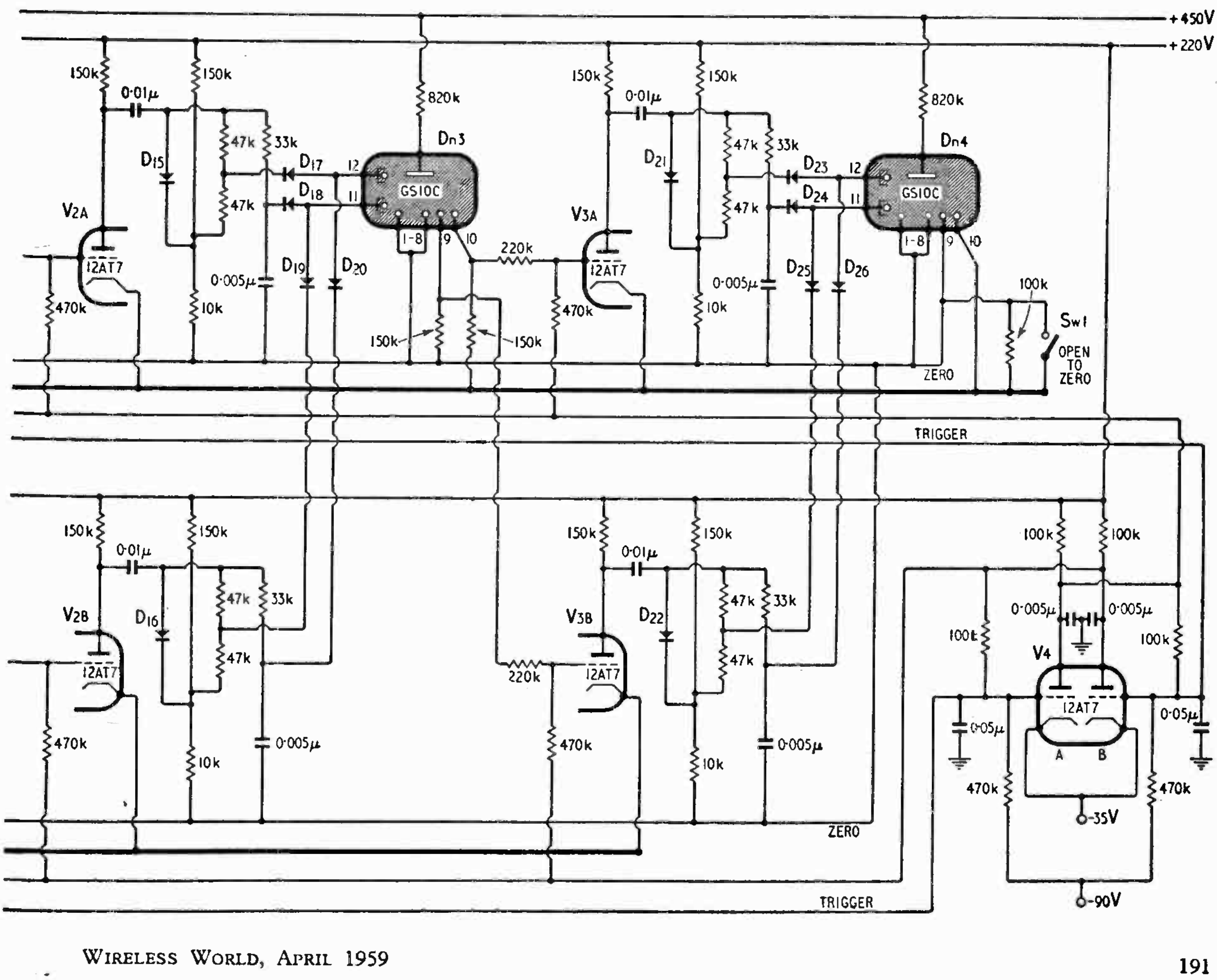
produce a delay so that guides first and second may be fed from a single-pulse input via C_1.

It is possible to transfer the glow in the opposite direction as mentioned above. This can be done simply by applying the guide pulses in the reverse order. If the former direction adds, then the latter subtracts.

The required cathodes can be connected to earth through resistors, say 150 kΩ, and across these positive pulses of about 30 volts may be derived to drive a following stage every time the glow arrives at the cathodes.

A normal adding Dekatron counter consists of a series of these tubes with interstage coupling pulse amplifiers. An output pulse is derived from the "10" digit of the "units" decade. After amplification it carries one digit forward in the "tens" decade, and so on. When the counter is to be reversible, difficulty arises in the interstage coupling valves because the "10" pulses still carry digits forward—to add, even when the units decade reverses. These have to be suppressed and a "carry" signal from the 9's must be made to carry backwards one digit at the subsequent decade. One can easily make this comprehensible by considering numbers, say 28, 29, 30, 31, and going backwards, 31, 30, 29, 28 and so on.

Thus the two carry pulses, one from 10's, which must be effective only during addition, and the other



from the 9's, which must be effective only during subtraction. This difficulty can easily be overcome by the use of a flip-flop bi-stable circuit. Considering Fig. 3, the voltages shown are all with respect to earth. V_4 cathodes are dropped to a negative supply of $-$ 35 volts so that on conduction the anode is about 15 volts positive with respect to its cathode, due to the drop in the internal resistance of the valve. This is equivalent to $-$ 20 volts with respect to earth. During the cut-off condition the

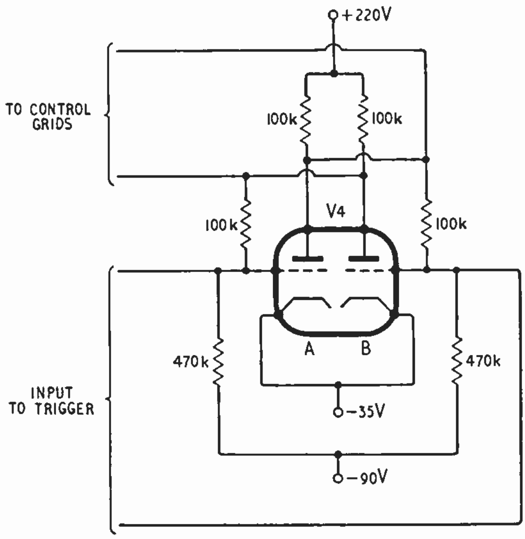


Fig. 3. Bi-stable circuit used in the reversible counter.

anode is at about 170 volts positive with respect to earth. These voltage changes are made to open and shut the gating amplifiers. Grids of V_{1A}, V_{2A}, V_{3A} are controlled by V_{4A}, and those of V_{1B}, V_{2B}, V_{3B} are controlled by V_{4B}. Suppose V_{4A} is in the conducting state; its anode is at $-$ 20 volts. Owing to the potential divider connection of the resistors on the grids, namely 470 kΩ, 220 kΩ and 150 kΩ in series, the grids of V_{1A}, V_{2A} and V_{3A} are now biased at $-$ 9 volts with respect to earth. Thus when a positive 30-volt pulse is coming from the 10's cathodes of the Dekatrons it will raise the grids of V_{1A}, V_{2A} and V_{3A} all positive, and these pulses are amplified and function to " carry " at the following decade.

On the other hand, V_{1B}, V_{2B} and V_{3B} are held at a positive potential via the potentiometer resistances 470 kΩ, 220 kΩ and 150 kΩ since V_{4B} is at cut-off. V_{1B}, V_{2B} and V_{3B} are now in a conducting state with slight grid current. A positive pulse coming from the 9's cathodes will not give a pulse output on their anodes. Thus in forward counting, pulses from the 9's are blocked and those from the 10's effect the carry. Similarly, in reverse counting, pulses from the 10's are blocked, but those on the 9's are carried forward to subtract.

The method of bi-directional coupling is by two standard coupling circuits connected in parallel. The first-guide output point on one is cross-connected to the second-guide output point of the other through two rectifiers wired back-to-back (i.e. D_5, D_8 and D_{11}, D_{14}, etc.), the Dekatron guide being taken to the junction of the rectifiers. The other Dekatron guide is connected to two more rectifiers similarly arranged to the remaining feeding points (namely D_7, D_6 and D_{13}, D_{12}, etc.).

In order to change the bi-stable circuit to the required state, parts of the incoming pulses are rectified by D_1 and D_2. The rectified voltage is fed to the grids of V_4 to accomplish the trigger action. Capacitors at the grids of V_4 serve to stabilize the state so as to produce locking action. Capacitors at the anodes of the bi-stable circuit bypass any stray pulses coming from the non-active parts of the coupling circuit which may be carried to the Dekatrons and introduce inaccuracies.

The counter may be zeroed to recount by opening the switch, SW_1 so that all digits, 1's to 9's, are now more positive than the zero digits, and so all the glows rest only on the zero digits for re-starting.

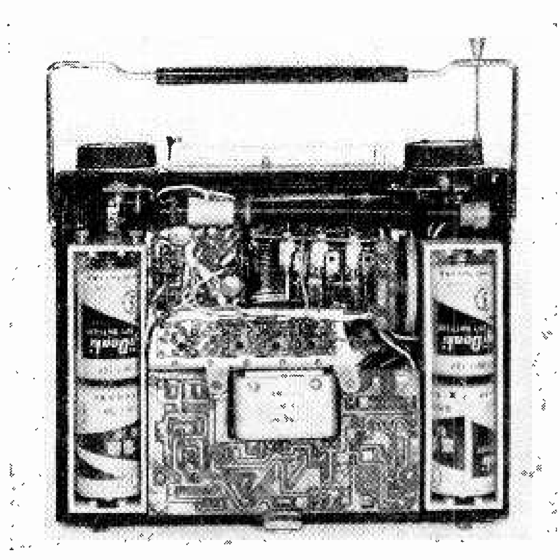
All components and valves are conventional and only a simple flip-flop circuit is additional. Input pulses may be from mechanical contacts, photo-electric cells, particle counting tubes, etc. In the complete circuit (p.72) two inputs are required, one of which advances the counting of digits while the other reverses the counting. Thus if the two inputs are energized together the number displayed on the counter remains unchanged.

Transistor F.M. Portable

IT was announced recently that the Sony Corporation of Tokyo, Japan, has introduced an all-transistor f.m./a.m. portable known as the Model TFM151. It employs 15 transistors and 4 germanium diodes in a two-band superheterodyne circuit covering 88 to 108Mc/s and 535 to 1605kc/s respectively. A ferrite-rod aerial is included for a.m. reception and a retractable rod aerial for f.m., but provision is also made for connecting external aerials if required. Likewise, either the internal 4 × 6-in elliptical loudspeaker or an external earphone may be used. The set operates from four 1.5-volt dry cells.

The circuit includes an r.f. amplifier using v.h.f. diffused grown transistors made by the Sony Corporation, and a 10.7-Mc/s i.f. is used for f.m. reception and a 455-kc/s i.f. for a.m. reception. The push-pull output stage gives 180mW maximum. Overall size of set is 3in × 8¼in × 9in and the weight 5½lb. It utilizes printed circuits.

Internal view of the Sony f.m./a.m. all-transistor portable.



Transistorized Absorption Wavemeter

Low-cost Sensitive Instrument Incorporating a Modulating Oscillator

By G. W. SHORT

SIMPLE absorption wavemeters of the type shown in Fig. 1 are widely used for testing and adjusting small radio transmitters. The tuned circuit is loosely coupled to the source of r.f. energy the frequency of which is to be measured, and the capacitor adjusted for maximum meter reading. Such instruments are very satisfactory, because they are free from spurious responses, simple to construct, and require no power supply. Their one disadvantage is lack of sensitivity. The power required to deflect the meter pointer must all be supplied by the signal source, and in practice the overall efficiency of the system is poor, for the following reasons. The crystal diode may be regarded as a d.c. generator. It is

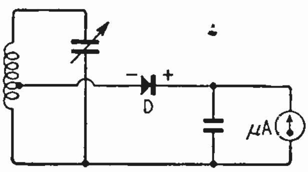


Fig. 1. Simple absorption wavemeter with diode detector.

likely to have an internal resistance of some hundreds of ohms when passing a current of 1mA. The resistance of a 1-mA meter will probably be around 100Ω. A considerable proportion of the input power is therefore dissipated in the diode. At low-signal levels, the rectification efficiency will be very poor, partly because the current/voltage curve of the diode is not very bent at zero bias, and partly because the diode resistance is of the order of 10kΩ at zero current.

These limitations are unimportant when the signal source is a transmitter, or a stage in a transmitter producing an appreciable amount of power, so that the necessary few milliwatts are readily obtained without imposing too much of a load. However, the writer required a means of making rough measurements of frequency on oscillators such as are used in battery receivers. Apart from the low power available, it was desired to make the measuring instrument sufficiently sensitive that a very loose coupling between source and indicator would suffice, because it is usually inconvenient to put coupling windings on oscillator coils, which may be in relatively inaccessible positions.

Since the only meter available was a 1-mA instrument some form of amplification was obviously necessary. The use of an r.f. amplifier was ruled out because the necessary valve and extra tuned circuit were too complicated, and a mains power supply would have been needed. Amplification of the d.c. output of the crystal rectifier is more attractive, since it can be done with a junction transistor worked from a single 1.5-V cell.

The first circuit tried was that of Fig. 2. The transistor is operated without external base bias current, so that, with no signal input, it is almost cut-off, and only the common-emitter collector leakage current (I'_{co}) flows. This was only about 100μA with the particular Mullard OC71 transistor used, and it was not considered that the battery drain justified the inclusion of an on-off switch. On tuning-in a signal, the transistor is switched on by the diode output current, and the meter deflection increases. The purpose of R_2 is to limit the meter current in the event of an overload. If R_2 and the meter resistance together amount to 1.5kΩ, then only 1mA can flow even if the transistor becomes a short circuit. In practice, one must allow for a reduction of battery voltage owing to deterioration, and use something less than 1.5kΩ, otherwise there will not be enough voltage left to operate the transistor properly at currents near 1mA. A total value of 560Ω was in fact used, so that the current was limited to rather less than 3mA with a new battery. R_2 also protects the transistor, and R_1 protects the diode from all but the grossest overload.

The base resistor R_1 was included for two other reasons. First, to increase the detector load resistance and so reduce damping of the tuned circuit and secondly, to enable the diode to be connected across the whole of the tuned circuit, in which position it receives the maximum possible signal voltage, a condition necessary for achieving good rectification efficiency. A 250-kΩ variable resistor was used, so that the optimum value could be found by trial and error. The optimum varies with frequency: at high frequencies the dynamic resistance of the tuned circuit is low and a low value of R_1 is best, while at low frequencies the reverse applies.

Although the circuit of Fig. 2 gave a marked improvement on that of Fig. 1, it was soon discovered that it is a poor performer at low-signal levels, the sensitivity increasing quite disproportionately to the signal strength. Some such effect was expected, because crystal rectifiers are inefficient at low levels, but the actual results were much worse than anticipated.

Upon reflection, it became obvious that one of the original assumptions was false, namely that the provision of R_1 results in reducing damping. It does, at high-signal levels, when the effective damping approximates to $R_1/2$. At low levels, however, the

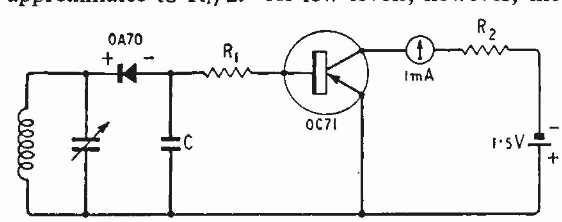


Fig. 2. Adding a transistor d.c. amplifier increases the sensitivity.

rectifier has a finite, and relatively low, resistance during both half cycles of the input wave, and, since C is a short circuit at the signal frequency, this low resistance is effectively across the tuned circuit, and causes heavy damping if the latter's dynamic resistance is large by comparison. If one is interested only in low-level signals, therefore, the circuit of Fig. 2 is useless. (Removing C removes the diode resistance damping, but reduces rectification efficiency still further, and is therefore not a cure.)

A second cause of poor sensitivity at low levels is the operation of the transistor near cut off. At low currents, the current gain is considerably reduced. To get the best out of the available components, therefore, it is necessary to "tap down" the tuned circuit so that coupling is optimum at low levels, and to operate the transistor with sufficient standing current to ensure that its gain is high. This leads to the circuit of Fig. 3. R_1 is used to adjust the base current to produce a convenient standing current (say 0.5mA). An on-off switch is now required, and this and R_1 can conveniently be combined in the form of a "volume control" with mains switch. A small forward current now flows through the diode. This is an advantage because it moves the operating point nearer the region of maximum curvature of the current/voltage characteristic. (In the circuit of Fig. 2 a slight reverse bias is applied by the emitter-base voltage drop. This increases the diode resistance but reduces rectification efficiency.)

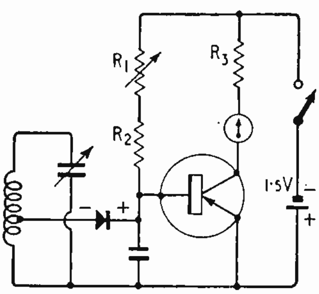


Fig. 3. Improved circuit with higher sensitivity.

If the input signal is modulated, an audio output can be obtained from the transistor, and by the use of a matching transformer the full power gain can be realized. The actual increase in sensitivity is greater than that computed, since ears are far more sensitive than meters.

Unfortunately, most of the input signals encountered in practice are unmodulated carriers. It is, however, possible to modulate them. In principle this can be accomplished by means of a switch placed in one of the positions shown in Fig. 4, or in others, which will be obvious. If the switch is opened and closed at an audio frequency, then an audio note will be heard if there is a signal coming from the source. The arrangements shown in Fig. 4, where (a) and (c) amount to "chopping" the incoming carrier, and that of (b) to chopping the d.c. output of the dectector. Now, a diode is an excellent substitute for an on-off switch, and can readily be operated at a high frequency. The easiest modulation method to achieve is that of Fig. 4(c) and Fig. 5 shows how it is done. The diode is driven by an audio-frequency generator, and short-circuits the tuned circuit every time it conducts; i.e., once every cycle. The r.f. signal reaching the detector is thus amplitude modulated. A transistor audio-frequency oscillator drives the modulator diode, the complete circuit being shown in Fig. 6. The oscillator shown is a Hartley, but any of the normal types can be made to function. A point to be watched is the d.c.-resistance of the coil or transformer used, which must not be so high that most of the battery voltage is wasted in it, leaving insufficient to operate the transistor. Some thought should be given to the state of the modulator diode D_1 when the oscillator is switched off. If it is left in circuit a reverse bias should be applied, otherwise unwanted damping of the tuned circuit will occur. In Fig. 6, with S_1 open, the battery votage is applied to the diode in the appropriate sense via the oscillator transistor. An alternative would be to place S_1 near to D_1 physically, and simply disconnect the latter, letting the oscillator run all the time.

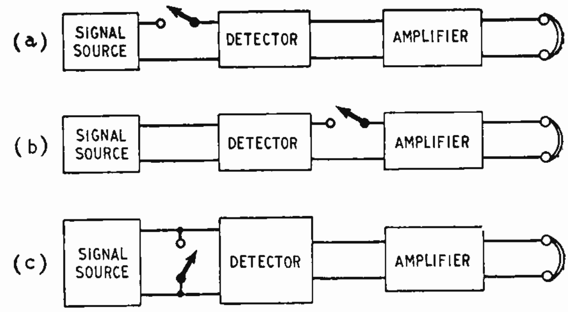


Fig. 4. Some possible ways of modulating the signal. The switch is assumed to be opened and closed at an audio frequency.

Resistor R_3 controls the amount of modulation. A suitable method of selecting it is to apply a fairly large signal and try various values of R_3, with the oscillator working, until one is found that reduces the meter reading to rather more than half that obtained with the oscillator off. This gives a reasonable compromise between amount of modulation and additional damping. The presence of C_3 ensures that D_1 conducts in pulses. When it does so, its resistance falls to a value which is low compared with the dynamic resistance of the signal circuit, even at high frequencies when the L/C ratio is small, so a reasonable depth of modulation is always obtained.

The purpose of R_4 is to control the amplitude of oscillation. In practice it affects the frequency as well. It will not always be necessary. The writer used a centre-tapped a.f. choke for T_2. If a double-wound transformer is used, a tuned-collector circuit is recommended, with a turns ratio of about 4:1 (not at all critical). A frequency of 1 to 5kc/s is suitable.

The wavemeter was constructed in a box made of wood and hardboard. The coil (L_1) plugs into the top of the box. No permanent arrangement for coupling to the signal source is incorporated since one suited to the task in hand is easily improvised. In many cases it is possible to put the wavemeter coil near enough to the source to produce a meter reading, and unless the source is well screened it is nearly always possible to use the modulator and headphones. The latter system has the shortcoming that, while it is very easy to detect a signal, it is impossible to tune it in with precision, because the ear is not very sensitive to small changes in

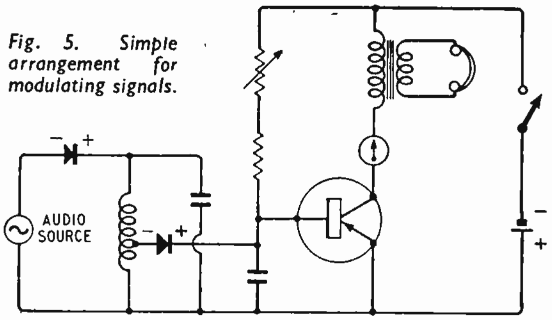


Fig. 5. Simple arrangement for modulating signals.

volume. The modulator has been found to be invaluable, however, for quick searching for signals of moderate strength. These are very easily heard, but produce only a small meter deflection, which can easily pass unnoticed if the tuning knob is turned quickly. The presence of an audio note at the appropriate part of the band enables the correct area to be searched slowly, so that the deflection is observed.

If a very wide frequency coverage is aimed at, the tuning capacitor must not have too small a capacitance, otherwise the self-capacitance of the coils used at the low-frequency end will restrict the band coverage. If the medium-wave band is to be covered, 100pF is about the minimum practicable value for C_1, and the upper frequency limit can then be extended to about 100Mc/s by using a fractional turn for the highest-frequency coil. The writer managed to cover 1 to 100Mc/s with five coils, but the calibration scales are crowded at the high-frequency end because the tuning capacitor has a straight-line capacitance law. A capacitor with a straight-line frequency law would be more suitable. If the total coverage required is small it is a good plan to restrict each band to a 2 to 1 range by using a trimmer. This will produce an open scale even with an s.l.c. tuning capacitor.

Tapped tuning coils may be used, as shown in the diagrams, but a separate coupling winding is equally suitable. In actual fact, it is more convenient to use a separate winding, wound over the earthy end of the main coil, since the optimum amount of coupling can then be found by trial and error without interfering with the main coil. At the highest frequencies, the detector diode can be connected across the whole coil without introducing too much damping. With reasonably good coils and adjustment of detector coupling it should be possible, using a 1-mA meter and strong signals, to divide each band scale into 100 useful divisions. This means that, at 1Mc/s, a frequency change of 10kc/s should be readily detectable.

The meter "reads backwards," as in the case of a grid-dip frequency meter. It is not necessary that the base-bias current control R_1 be variable. If a fixed value is used, the no-signal meter reading will vary somewhat with temperature. It has, however, been found useful to make R_1 variable, with a rather high maximum value. It can then be used as a backing-off control when strong signals are applied. A strong signal is liable to cut off the transistor and make measurement impossible, but if the bias current is then reduced it is often possible to bring the meter needle back to a convenient position. This procedure is sometimes more convenient than altering the coupling to the signal source.

The modulator is to be regarded as an optional extra. Even if it is not used, however, it may be worth while retaining T_1 so that headphones can be employed to identify modulated signals.

It would be possible, when the modulator is incorporated, to amplify the audio output, detect it and produce a meter reading or operate a "magic eye"-type tuning indicator. The sensitivity could by this means be increased enormously. The theoretical limit is that due to noise, but a practical one will be fixed at a higher level by stray coupling of the audio signal from the oscillator. It will be seen from Fig. 6 that if the portion of L_1 between the tapping point and the earthy end presents a finite impedance to the modulation frequency then some of the audio will be passed through D_2 to the transistor. If L_1 consists of many turns of fine wire, the leakage may be heard in the phones even without subsequent amplification. Another source of stray coupling is the internal resistance of the battery, hence the presence of decoupling capacitor C_6. Yet another is magnetic coupling between T_1 and T_2, which should be kept well apart and oriented so that the effect is minimized.

It is also possible to increase the sensitivity by using a more sensitive meter. However, the gain of the transistor will be reduced if the current through it is less that about 0.5mA. In fact, with many small transistors, the maximum gain is not

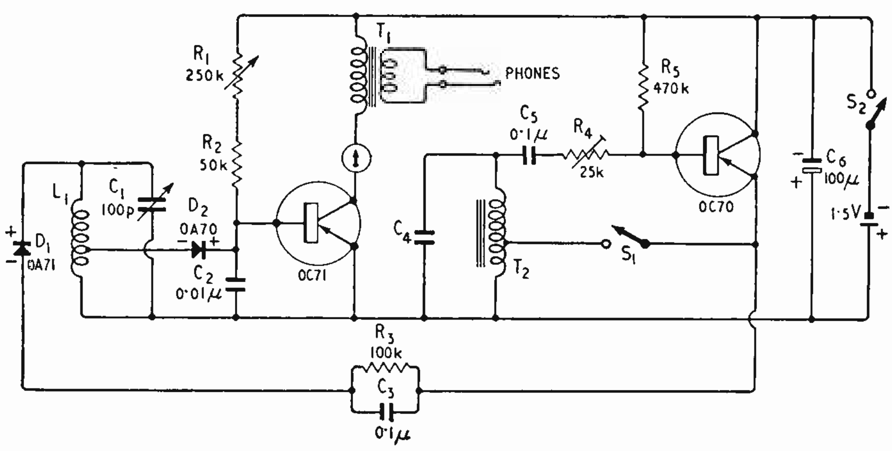


Fig. 6. Complete circuit diagram of wavemeter incorporating an audio oscillator and a diode modulator. If the primary resistance of T_1 is low it may be necessary to connect a current-limiting resistor in the collector circuit. C_4 is selected to tune T_2 to a suitable audio frequency.

achieved until the collector current is raised to about 3mA, but the reduction is not serious down to 0.5mA, or even 0.25mA. Unless one is prepared to incorporate a backing-off arrangement for standing current, there is therefore little point in using a meter with a f.s.d. much below 0.5mA. If a really sensitive meter is available (say, 100μA) then the circuit of Fig. 2 will probably be adequate. If the standing current in the transistor is then too great it can be reduced, at some cost to sensitivity, by connecting a resistor of a few thousands of ohms between base and emitter. If the standing current is rather less than the full-scale deflection value, the detector diode can be reversed and the meter will then "dip" on application of a signal, as with the circuit of Fig. 6.

COMPONENTS SHOW

THE 16th Annual Components Show organized by the Radio and Electronic Component Manufacturers' Federation is being held in London from April 6th to 9th. The 180 exhibitors listed below, a record number, are again being accommodated in two buildings—Grosvenor House and Park Lane House, W.1. It will be open daily from 10 to 6. 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
Air Control Installations
Allan, Richard, Radio
Amphenol
Anderton Springs
Anglo-American Vulcanized Fibre
Antiference
Ardente
Ariel Pressings
Armand Taylor
Avo

B.I. Callender's Cables
B.S.R.
Bakelite
Belling & Lee
Bird, Sydney S.
Bray, Geo.
Brayhead (Ascot)
Brayhead Products
Brimar Valves
British Communications Electronics
British Electric Resistance
British Physical Labs.
Brush Crystal Co.
Bulgin
Burndept

C.C.L.
C.I.B.A. (A.R.L.)
Carr Fastener
Cathodeon Crystals
Clarke & Co. (Manchester)
Collaro
Colvern
Connollys (Blackley)
Cosmocord
Creators

D.S.I.R.
Daly (Condensers)
Darwins
Dawe Instruments
"Diamond H" Switches
Dubilier
Duratube & Wire

E.M.I. Sales & Service
Egen Electric
Ekco Plastics
Electro Acoustic Industries
Electro Methods
Electronic & Radio Engineer
Electronic Components
Electronic Reproducers
Electrothermal Engineering

Enalon Plastics
English Electric
Enthoven
Erie Resistor
Ever Ready

Ferranti
Fine Wires
Formica
Fortiphone

Garrard
Goldring
Goodmans
Gresham Transformers
Guest, Keen & Nettlefolds

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

I.C.I.
Imhof
Instrument Review
Insulating Components

J. Beam Arials
Jackson Brothers
Jobling

K.L.G. Sparking Plugs
Kimber Allen

Labgear
Langley London
Lewis Spring Co.
Linton & Hirst
Lion Electronic Dev.
London Electrical Mfg. Co.
London Electric Wire Co.
Long & Hambly
Lustraphone

M.O. Valve Co.
Magnetic and Elec. Alloys
Magnetic Devices
Mallory Batteries
Mansol (G.B.)
Marrison & Catherall
McMurdo Instrument Co.
Measuring Insts. (Pullin)
Mica & Micanite Supplies
Micanite & Insulators
Ministry of Supply
Minnesota Mining & Mfg.

Morganite Resistors
Mullard
Mullard Overseas
Multicore
Murex
Mycalex & T.I.M.

N.S.F.
Neill, James & Co.
Newmarket Transistors

Painton
Parmeko
Partridge Transformers
Permanoid
Plannair
Plessey Company
Plessey International

Radio Instruments
Reliance Cords & Cables
Reliance Manufacturing Co.
Reproducers & Amplifiers
Rola Celestion
Ross, Courtney & Co.

S.T.C. (Component Group)
Salford Electrical
Salter, Geo., & Co.
Scott, Geo. L., & Co.
Semiconductors
Siemens Edison Swan
Simmonds Aerocessories
Sims, F. D.
Smith & Nephew
Spear Engineering Co.
Staar Electronics
Stability Capacitors
Standard Insulator Co.
Steatite & Porcelain Prods.

Stocko (Metal Works)
Stratton & Co.
Suflex
Swift Levick & Sons
Symons, H. D., & Co.

T.C.C.
T.C.M. Co.
Taylor Electrical
Technical Ceramics
Technograph
Telcon-Magnetic Cores
Teledictor
Telephone Manufacturing
Texas Instruments
Thermo-Plastics
Thorn Electrical Industries
Truvox
Tucker, Geo., Eyelet Co.
Tufnol

Vactite Wire Co.

Walter Instruments
Wandleside Cable Works
Wayne Kerr Laboratories
Wego Condenser Co.
Welwyn Electrical Labs.
Westinghouse
Weymouth Radio
Whiteley Electrical
Wiggin, Henry, & Co.
Wimbledon Engineering
Wingrove & Rogers
Wireless Telephone Co.
Wireless World
Woden Transformer Co.
Wolsey Electronics
Wright & Weaire

Zenith Electric Co.

U.K. Receiver Sales

THE record figure of 2.02M television receivers were despatched to the home market by U.K. manufacturers last year. This was an increase of 11% on the previous year and of 24% on the average for the years 1956/57. As will be seen from the table, despatches of sound receivers (which includes car radio) and radiogramophones dropped last year. The percentage decreases on 1957 were 7 and 18 respectively. The figures in the table (in thousands) are based on returns from members of B.R.E.M.A.

	SOUND		RADIOGRAMS		TELEVISION	
	1957	1958	1957	1958	1957	1958
Jan. ...	98	87	26	18	127	113
Feb. ...	100	81	23	14	119	103
Mar. ...	112	89	19	11	102	99
Apr. ...	91	83	15	12	77	73
May	120	102	16	9	110	96
June ...	112	108	10	6	99	89
July ...	123	107	14	11	112	107
Aug. ...	118	92	20	13	140	133
Sept. ...	132	137	32	25	235	269
Oct. ...	134	148	32	32	273	353
Nov. ...	116	130	31	39	246	345
Dec. ...	102	100	29	27	176	238
Total* ...	1,357	1,265	266	218	1,816	2,020

*Any differences in totals from the sum of the items are due to rounding.

MASERS

By "CATHODE RAY"

Small-Scale Atomic Energy for Radio

RATHER to my surprise I found it in the dictionary, which I had possessed since long before the maser was invented. But the reference was to a large wooden drinking bowl—"Their brimming masers to the feasting bring." Well, all I can say about that is that if one did it nowadays the only outcome would be a mouthful of liquid helium, which would be cold cheer, to put it mildly. For in the contemporary sense "maser" stands for "Microwave Amplification by Stimulated Emission of Radiation."* Even if the word's origin is hardly respectable in the sight of classical scholars, it saves quite a useful amount of tongue-power.

The reason for my drawing your attention to masers is not that before you know where you are they will be challenging stereo as mandatory equipment in every well-appointed home. The most enthusiastic would scarcely predict that their sphere of application will be large. And the less enthusiastic might claim that they are already on the way out (see next month's discourse). But they do crop up fairly often in current scientific literature, as we see sometimes in "Technical Notebook." My main reason, however, is that masers are rather beautiful illustrations of the atomic behaviour I was talking about last year.

For those who have joined since, the relevant facts are that atoms consist of a small central nucleus surrounded by a number of electrons swirling about in orbits. These orbits are hazy as regards the precise position of the electron at any given moment, but very definite as regards its energy. The farther out from the nucleus, the greater the energy. But the two most significant features are, firstly, that these orbital energy levels are not, as it were, variable continuously like a tuning control, but only in fixed steps like a band switch. And the second is that only two electrons are allowed in any one orbit at a time, and even they have to be distinguished by spinning like tops in opposite rotations. So the set-up is that if there are $2n$ or $2n$-1 electrons per atom they normally fill the n closest-in and lowest-energy orbits.

It follows that the only amounts of energy that any electron can accept are those just equal to the difference between its present energy and what it would have in one of the vacant higher orbits.

As for the energy, it comes in packets of all sizes, but directly you specify a size you fix the frequency of the waves by which it is radiated from place to place, according to the quantum rule:

$$E = hf$$

where f is in c/s, E is in electron-volts, and h is 4.15×10^{-15}. Therefore (and this is the crux of the matter) to raise an electron from one orbit to another necessitates energy at the precise frequency E/h, where E is the energy difference between the two orbits. And when the electron drops back from one orbit to another—as it usually does very quickly if there is a vacancy—the frequency of the energy it radiates is determined in the same way.

The energy steps near the bottom end of the scale (i.e., between orbits nearest the nucleus) are of the order of several electron-volts, so the corresponding frequencies are the order of 10^{15} c/s. That is away up in the visible light band, or even beyond, in the ultra-violet. So one usually quotes examples thereabouts, such as the strong absorption of ultra-violet radiation from the sun by the atoms of the upper atmosphere. And gas-discharge streets lamps are familiar examples of light production at fixed spot frequencies by "excited" electrons dropping back into lower orbits.

The number of possible frequencies is much larger than a simple account of the matter might suggest, and often what looks on a spectroscope like a single frequency response turns out to be two or more very close together. So there are some very small energy differences and correspondingly low frequencies. Some of them even come as low as our radio bands. Hence the "microwave" in "maser." And we have just been reminding ourselves of some examples of

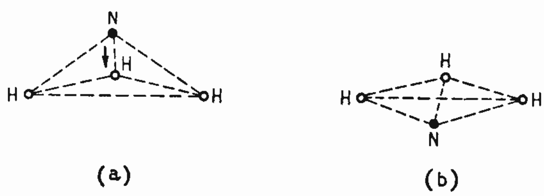


Fig. 1 Alternative shapes of an ammonia molecule (a) before and (b) after its nitrogen atom has jumped through its hydrogen triangle.

"emission of radiation" from atoms. But how about the "a" for "amplification"?

That, as Hamlet remarked, is the question. From what we have just recalled it seems that in these electronic energy exchanges one gets out exactly the amount one puts in. So the maximum prospective amplification is ×1, or 0 dB. That applies to atoms spaced so widely that they don't influence one another appreciably. In solid materials, where they are packed so closely that all the energy levels are split up like resonance peaks of coupled circuits, very complicated interactions cause the radiated frequencies (and therefore energies) to be in general lower than those needed to excite them (Stokes' Law). For example, what you see glowing in a fluorescent light is solid matter excited by electrical discharge through the tube generating radiation mainly at ultra-violet frequencies. If we are to get any amplification, then, it is clear that the excitation—raising the electrons to higher energy levels—must be done by some other source of energy than the signal to be amplified.

The next thing to note is that if the electrons dropped back (or *relaxed*) automatically to their lower levels in about 10^{-8} sec., as they do at visible

* Judging from a recent TV broadcast, most of the boffins pronounce it "mazer." Whether this is because (a) it traps them in a mental maze, or (b) they come up from Somerset where of course emission is ztimulated, or (c) they have been stimulated by the large wooden drinking bowls, I wouldn't know.

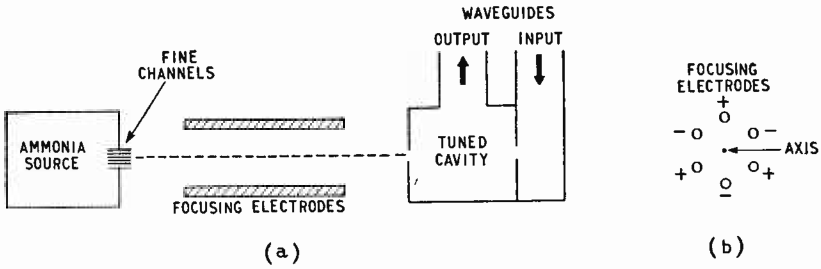


Fig. 2 Diagram showing the principle of an ammonia maser. (b) is an end view of the focusing electrodes shown in (a) in elevation.

frequencies, the uncontrolled and random delivery of energy would not amplify an existing signal properly. At the very much lower frequencies of radio, however, they normally stay quite a long time—more like 10^{-3} sec—in the upper levels. But if during that period they are exposed to a relatively small signal at their energy frequency, it is able to persuade or *stimulate* them to deliver up. Hence the " s " in " maser." This delivery of energy comes in phase with the stimulating signal, amplifying it.

At this point I'm in something of a dilemma. Truly electronic masers are a comparatively recent development, while an earlier type, which is not electronic at all in the sense we have just been considering, is too interesting to leave out. Although its basic principle is the same, its mechanism—and the form of apparatus used—is somewhat different. So let us digress a little.

When atoms come together to form molecules, they " click " into certain structural positions as a result of interaction between all their parts. Ammonia gas is peculiar in having two alternative molecular formations, with a sufficiently small energy change on going from one to the other to yield a useful microwave frequency. As you may remember, the chemical formula for ammonia is NH_3 which means that each of its molecules is a quartette made up of three hydrogen atoms and one nitrogen. The hydrogen atoms form the base of a shallow triangular pyramid, and the nitrogen the apex, as in Fig. 1.

If you have even been to an old-style lantern lecture, you may remember that the lecturer signalled to the operator by means of a slightly dished strip of steel, which when pressed sprang into a semi-stable alternative shape, radiating a sharp pulse of sound, heard by the operator (and the audience) as a click. Another click was emitted when the strip sprang back to its original form.

In somewhat similar manner, when the ammonia molecule is subjected to slight stress its nitrogen atom springs smartly through the hydrogen hoop, turning the whole thing inside out. At the same time it releases a very definite amount of energy (nearly 100 electron-microvolts) which, in accordance with $E=hf$, yields its radiation at the definite and unchangeable frequency of 23,870.13 Mc/s.

This frequency is specified to seven figures because it really can be relied upon to 1 in 10^7, which is a very useful constancy even in these days when considerably better has been done. But of course the disadvantage of constancy, for amplification, is that unless the signals you want to amplify are or can be at a frequency of 23,870.13 Mc/s it is just too bad. For some purposes it is quite possible to use this particular frequency. And where there is amplification there can usually be oscillation, and oscillation at a precisely known frequency can be used for checking other frequencies over a wide range.

Actually there are some precautions that have to be taken in order to obtain the frequency so precisely. It wouldn't do, for instance, to allow the ammonia molecules concerned to come close enough to " pull " one another. So in practice we must make them stream thinly into a high vacuum.

At normal temperatures the molecules in the higher-energy state are in a minority. So a given quantity of the gas contains more potential receivers of energy than givers. Far from amplifying a signal at the critical frequency, it would weaken it. So the potential givers of energy must be sorted out from the takers. This is done by what is known as a Stark-effect focuser, consisting of an array of electrodes in cylindrical formation around the ammonia stream, as in Fig. 2. Alternate electrodes are kept at high positive and negative potentials respectively. Along the axis, equal positive and negative are at equal distances and cancel out, so the electric field there is zero; but away from the axis it increases rapidly. The principle behind this is that excited molecules tend to move into weaker fields and unexcited into stronger. Consequently the excited ones are driven into the axial path, along which they eventually reach a cavity tuned to their radiation frequency. The others are deflected away.

A cavity is, of course, the microwave form of tuned circuit, and the input and output leads are waveguides. When a very weak signal is fed in, it stimulates the excited molecules to give up their energy, which adds to the signal, amplifying it.

Note that I said a *very* weak signal. In a part of the spectrum where energy is measured in electron-microvolts rather than electron-volts, the availability of energy would be small even if the ammonia were at atmospheric pressure. But since for the reason given it must be thinned out almost to a vacuum, the energy is very dilute indeed. In fact, the device overloads at not much more than 10^{-10} watts! That is not an insuperable objection, because the amplification can always be continued by more conventional amplifiers such as klystrons.

You may be asking who would go to the trouble and expense of a maser, with its vacuum pump and ammonia supply and other complications, if it is so drastically limited in output, and other kinds of amplifier have to be used anyway. The present-day answer might be no one, because other masers have been devised for amplification, as we shall see. But they, too, are neither cheap nor convenient. The real answer is that anyone who is more concerned with amplifying very weak signals than with cost and convenience should be interested in masers, because they differ basically from conventional amplifiers in using uncharged molecules instead of electrons. Below a certain level of signal strength, any kind of electron valve is useless as an amplifier, because the signal is drowned in valve noise—due to random electron charges, shot effect, flicker, etc. In radio

(*Continued on page* 199)

telescopes and radar systems, for example, the cost is already so vast that nobody is likely to jib at any reasonable device that greatly extends its range. Alternatively, for the same performance a first-stage amplifier with a better signal-to-noise ratio may actually save money, because every 3dB improvement enables the power of the transmitter to be halved. Masers have noise factors better than 1dB, contrasted with figures of the order of 15dB or worse for electronic amplifiers on the same frequency.

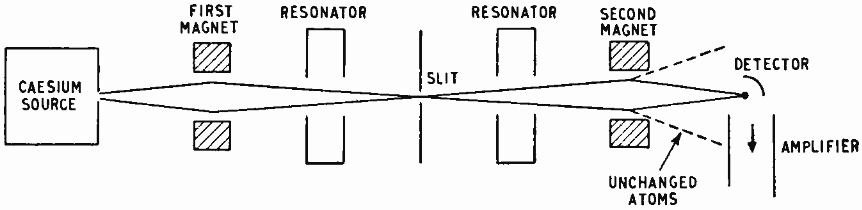


Fig. 3 Arrangement of a caesium "clock", showing the paths of atoms in the two alternative energy states.

Its amplification (within its strictly limited output power) can be increased in the usual way by positive feedback. As with the old broadcast receivers of the 1920s, which relied heavily on this principle, it is not too easy to control so as to obtain regularity of performance. It is much easier to bring the feedback well up and let it oscillate. This it does, as in more familiar equipment, without any input signal to start it. Because the frequency depends on molecular forces which are not affected by the usual disturbing influences such as temperature, it is very reliable and constant and makes a good frequency standard. It has recently been developed to such an extent that an accuracy of ± 1 part in 10^9 has been claimed, the frequency being specified as 23,870,129,235 c/s!

Although not strictly a maser (because it doesn't amplify) a very similar device of even higher precision is the caesium frequency standard. Caesium is one of the "alkali metals", which have a single valency electron per atom. This electron can spin either in the same direction as the nucleus or in the opposite direction. The energy of the atom as a whole depends to a small extent on which, so if it changes from one state to the other there is an energy change, which happens to correspond to the frequency 9,192,631,830 c/s.

Transitions (changes from one state to the other) can, as usual, be stimulated by a signal of the right frequency. For frequency-standard purposes one must be able to tell when the frequency is right. This necessitates detecting when the transitions are being caused at the maximum rate. The frequency of a local signal generator, variable around 9,192 Mc/s, is adjusted until the rate is a maximum.

The problem, then, is to detect transitions. The amount of radiation caused is too small to be measured, so transitions are detected by making use of the fact that a spinning electron, being a spinning electric charge, is equivalent to a small current around a small turn, and therefore to a tiny magnet. So it reacts on an applied magnetic field. If the atoms are shot between the poles of a powerful magnet they are deflected, in opposite directions according to the direction of spin. If this is done twice, atoms having the same spin throughout are deflected twice in the same direction. But if they change state en route between the magnets, the second deflection cancels out the first.

Fig. 3 gives some idea of the arrangement. Caesium atoms, released by heating the metal, are made to stream into a vacuum, rather like the ammonia. The paths shown represent the two opposite types of atoms, deflected in opposite directions by the first magnet. Two cavity resonators, energized by an oscillator, are next encountered, and if the atoms are changed thereby the second magnet deflects them on to the detector; if not, they are deflected away, as shown dotted.

The target for the changed atoms is a heated tungsten wire, from which the atoms boil off minus an electron. Being now positively charged, they can be collected by a negative electrode and amplified to work an indicator.

Since a frequency standard is also a time standard. the two devices just described are sometimes referred to as the ammonia clock and cæsium clock. The latest news of the cæsium clock is that it should very soon be obtainable correct to one second in 1,000 years!

But let us get back to our masers. The comparatively recent three-level solid-state types look much less like the ammonia maser than the cæsium non-maser does. But the basic principle is the same.

You may be wondering how, if ammonia gas molecules had to be thinned out to the consistency of a fairly high vacuum to prevent their getting near enough to one another to affect their energy levels, one could possibly think of using solid material, where the molecules are packed so close that their energy levels are broadened out into wide bands. The answer is that the molecules whose energy levels are used *are* widely spaced by diluting them with a vastly greater number of idle molecules. This scheme reminds one of the transistor, in which a germanium or silicon crystal acts as a sort of solid vacuum, all the action being due to an incredibly small number of "impurity" atoms—perhaps only in the proportion of one to many millions of inactive atoms.

Again, the energy levels employed are not in the main series of electron orbit levels (which are spaced much too far apart for microwave frequencies), but are products of electron spin. The whole spin story is extremely complicated, and the particular part of it exploited in this maser is different from the one we looked at in connection with the cæsium clock.

There, the utilized energy difference was between atoms with electrons spinning in opposite directions

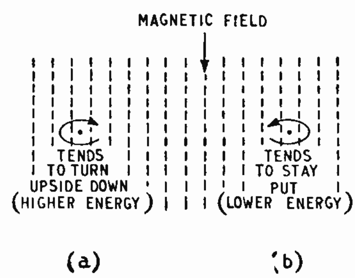


Fig. 4 The spin of an electron makes it a tiny magnet. Here two are shown with their magnetic axes parallel to an external magnetic field, (a) is in opposition to the field and (b) in the same polarity.

relative to their nuclei. In the maser, the difference is between different directions of electron spin relative to a magnetic field.

Fig. 4 may help to make this clear. The two electrons shown are equivalent to tiny magnets pointing in opposite directions. You can imagine them as microscopic compass needles. If there is no magnetic field, they have no tendency to point in any particular direction. But where there is a field they tend to line themselves up with it. Example (a), being oppositely aligned, finds itself possessed of energy to a maximum amount, for it is capable of turning through 180° against a certain amount of opposition, depending on the magnetic strength of the needle and the field. The other (b) has no such energy; it needs force to make it turn into any other direction. Between these extremes, a needle could have any intermediate amount of energy. But an electron, because it is subject to quantum restrictions similar to those that govern its orbits, can only have certain isolated energy values. These vary in almost exact proportion with the field, as shown in Fig. 5.

There are two interesting things about this. One is that a whole range of energy levels is available,

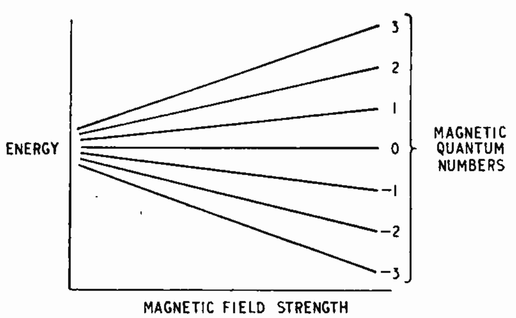


Fig. 5 The changes in energy, imparted by the external magnetic field in Fig. 4, develop along a number of separate lines (Zeeman effect). Three of these are utilized in "solid" masers.

not just two as in the ammonia and cæsium devices. They are not, in general, equally spaced. The other thing is that the energy differences—and hence the frequencies available—are continuously variable by means of the applied magnetic field.

The first thing enables one to do the exciting with power at a frequency different from the signal to be amplified. Obviously it would be no use trying to receive a very weak signal if a local oscillator was working on exactly the same frequency. So the oscillator is used to lift electrons from what might be called the basement of energy to the upper floor, and the signal works at the lower frequency corresponding to the shorter drop from upper to ground floor. The signal stimulates the excited upper-floor electrons to fall downstairs, yielding up that part of their excess energy.

Fig. 6 (a) shows how, in the absence of any exciting source, three consecutive energy levels might be populated with electrons. Between any two levels, there is a majority on the lower one, so any signal of the corresponding frequency would have a net loss of energy in raising electrons rather than a gain by their dropping back. The local oscillator,

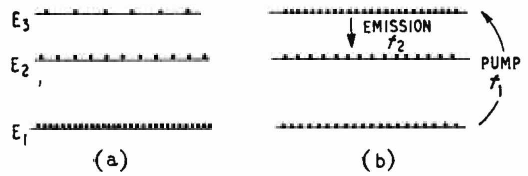


Fig. 6 Three Zeeman levels are shown here, with relative numbers of electrons in them indicated, (a) without excitation, (b) with excitation.

adjusted to frequency f_1 corresponding to $E_3 - E_1$, pumps electrons from E_1 to E_3 (Fig. 6 (b)), and a signal at frequency f_2, corresponding to $E_3 - E_2$, is thus enabled to benefit from the stimulated drop-back from E_3 to E_2. In a typical maser, f_1 is 9,400 Mc/s and f_2 is 2,800 Mc/s.

The apparatus of this maser is simple; it consists of a resonant cavity with suitable waveguide connections for f_1 and f_2, and a suitable crystal "doped" with a small proportion of atoms giving convenient magnetic energy levels. Lest that sound too easy, I must mention the inevitable snag—the need to work the whole thing at about −270°C. Hence the liquid helium mentioned in the opening paragraph. (In later models the requirement has been sufficiently relaxed for liquid oxygen, which is cheaper, to be used.) The reason for this, briefly, is that more normal temperatures keep the electrons in such agitation that they drop back and dissipate their energy before it can be usefully directed to signal amplification. In other words, the relaxation time is too short.

What may be an even more burning question in view of Fig. 5 is how the strong magnetic fields in the cæsium clock don't play Old Harry with the frequency stability. Again briefly, it is because the contrivers of that device cunningly select quantum number 0 for both upper and lower energy levels.

Before you run round to your dealer to buy yourself a maser and be told that it is temporarily out of stock, try waiting till next month to read all about another class of molecular amplifier—the mavar.

Interlocking Relay

AMONG some new relays introduced by Magnetic Devices, Ltd., Exning Road, Newmarket, Suffolk, is an interlocking model designed for alternate switching of circuits at regular or irregular intervals, as sometimes is required in electronic control equipments.

The Type 593 consists of a pair of small relays on a single mount with mutual interlock so that one or the other is always locked in. Either or both operating coils can be for a.c. or for d.c. operation and multiple contacts can be assembled on both relays. Type 593 is available as an open-type unit or hermetically sealed, the sealed version being mounted on 8-, 9- or 11-pin plug-in base according to the number of contacts fitted.

The maximum operating voltage is 140 d.c. or 250 a.c. and the current rating of the contacts is 5A at 30V d.c. or 250V a.c.

Magnetic Devices interlocking relay Type 593.

APRIL MEETINGS

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

LONDON

1st. I.E.E. Graduate and Student Section.—"Discriminators (F.M. Detectors) with particular reference to the Bond Disc" by S. J. Read at 6.30 at Savoy Place, W.C.2.

2nd. I.E.E.—Discussion opened by Sir Willis Jackson on "Women in engineering" at 5.30 at Savoy Place, W.C.2.

6th. Brit.I.R.E. Computer Group.—Symposium on "Large capacity storage devices" at 3.0 and 6.0 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

6th. Radar & Electronics Association.—"Thermonuclear research" by Dr. T. E. Allibone (A.E.I. Research Laboratory) at 7.0 at the Royal Society of Arts, John Adam Street, W.C.2.

7th. I.E.E.—"An electron trajectory tracer for use with the resistance network analogue" by M. E. Haine and J. Vine at 5.30 at Savoy Place, W.C.2.

10th. I.E.E. Medical Electronics Discussion Group.—"Problems of sight, hearing and touch" opened by Professor E. C. Cherry and "Human engineering recording problems" opened by H. C. W. Stockbridge at 6.0 at Savoy Place, W.C.2.

10th. Radar & Electronics Association Student Section.—"A modern British marine radar" by D. C. Thomas (B.T.H.) at 7.0 at the Norwood Technical College, Knight's Hill, S.E.27.

14th. British Computer Society.—"The sorting of data—an attempt to measure the severity of the task" by Dr. D. A. Bell (Birmingham University) at 2.30 at the Northampton College of Advanced Technology, St. John's Street, E.C.1.

16th. British Computer Society.—"The mechanical translation of languages" by Professor L. Hogben at 6.15 at the Northampton College of Advanced Technology, St. John's Street, E.C.1.

17th. I.E.E.—"Engineering aspects of commercial television programme presentation" by T. C. Macnamara and B. Marsden at 5.30 at Savoy Place, W.C.2.

17th. B.S.R.A.—"The quest for quality" by P. Ford at 7.15 at the Royal Society of Arts, John Adam Street, W.C.2.

17th. Institute of Navigation.—"The Dectra trials" by Colonel C. Powell (Decca Navigator) at 5.15 at the Royal Geographical Society, 1 Kensington Gore, S.W.7.

21st. I.E.E.—Discussion on "The problem of maintenance of electronic equipment in the process industries" at 5.30 at Savoy Place, W.C.2.

22nd. Brit.I.R.E.—"The application of magnetic resonance to solid state electronics" by Dr. D. J. E. Ingram at 6.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

23rd. I.E.E.—The Fiftieth Kelvin Lecture on "The Geophysical Year" by Sir David Brunt at 5.30 at Savoy Place, W.C.2.

23rd. Television Society.—"Design of experimental tuners for Bands IV and V television receivers" by K. H. Smith (Siemens Edison Swan) at 7.0 at the Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, W.C.2.

27th. I.E.E.—"The field strengths required for the reception of television in Bands I, III, IV, and V" by G. F. Swann at 5.30 at Savoy Place, W.C.2.

28th. Brit.I.R.E. Medical Electronics Group.—"Electron Microscopy" by Professor G. Causey and R. S. Page at 6.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

BELFAST

14th. I.E.E.—"The use of analogue computing elements in the design of automatic control systems" by Professor J. C. West and Dr. J. L. Douce at 6.30 at the David Keir Building, Queen's University, Stranmillis Road.

BIRMINGHAM

27th. I.E.E.—"Stereophonic sound" by K. N. Hawke at 6.0 at the James Watt Memorial Institute.

BRISTOL

14th. Television Society.—"Wave guides and applications" by J. C. Parr at 7.30 in the Colston Room, Hawthornes Hotel, Clifton.

CAMBRIDGE

14th. I.E.E.—Six short papers on "Application of electronics" at 7.0 at the Cavendish Laboratory, Free School Lane.

CHELTENHAM

13th. I.E.E.—"Transistors in communication and control equipment—a general survey" by E. Wolfendale at 6.0 at St. Mary's College.

EDINBURGH

17th. Brit.I.R.E.—"Stereophonic sound and electrostatic loudspeakers" a demonstration and lecture by D. T. N. Williamson at 7.30 at the Department of Natural Philosophy, The University, Drummond Street.

MALVERN

2nd. Brit.I.R.E.—"A simple high-quality f.m. broadcast receiver employing a pulse-rate discriminator" by P. J. Baxandall at 7.0 at the Winter Gardens.

MANCHESTER

2nd. Brit.I.R.E.—"Principles of transistor circuitry" by B. R. A. Bettridge at 6.30 at the Reynolds Hall, College of Technology, Sackville Street.

NEWCASTLE UPON TYNE

8th. Brit.I.R.E.—"Radio exploration of the galaxy" by Dr. J. Baldwin at 6.0 at the Institution of Mining and Mechanical Engineers, Neville Hall, Westgate Road.

NORWICH

20th. I.E.E.—"High-quality sound reproduction" by J. Moir at 7.30 at Assembly House.

PORTSMOUTH

8th. I.E.E.—"Rockets and satellites" by Dr. R. L. F. Boyd at 6.30 at S.E.B. Canteen, Drayton.

SWANSEA

9th. I.E.E.—"Domestic high-fidelity reproduction" by J. Moir at 6.0 at the Conference Room, S.W.E.B. Showrooms, The Kingsway.

YORK

7th. I.E.E.—"The relation between picture size, viewing distance and picture quality" by L. C. Jesty at 7.0 at the Royal Station Hotel.

RANDOM RADIATIONS

By "DIALLIST"

Radiation Belts

DID you read the article in *Nature* (February 14th) by Professor J. A. Van Allen and L. A. Frank, of the State University of Iowa, describing the observations made by the American "Pioneer III" of radiation belts surrounding the earth? These belts are regions in which vast numbers of charged particles on their way to the earth are captured and held by its magnetic field. Their existence had been suggested, but the latest observations show that the number of such particles is about a thousand times as large as had been expected. Both the shape and the density of the belts are likely to be affected by variations in sunspot activity. At present each of the two belts discovered is shaped in section like a pair of capital C's arranged so: C Ɔ, both ends curving in towards the magnetic poles, where auroral displays and the consequent interruption of wireless communications are most common. The first belt is about 2,000 miles above the earth's surface: the second about 10,000. The authors calculate that any space traveller unlucky enough to spend an hour in either belt might receive 100 times the maximum dose of radiation permitted in a week for atomic energy workers.

Anglo-American Research

The discoveries made about these radiation belts may prove of considerable value to the joint Anglo-American research station, which is to be set up at Hillhead, near Fraserburgh in Scotland. The main object of those who work there will be to investigate possible means of counteracting interference with the working of radar when the aurora occurs. It is hoped that if some way of doing this can be found, distant early warning stations will be built in northern Scotland. One would have thought that the same problem of interruption during intense auroral displays would have cropped up in connection with the D.E.W. line, which stretches right across Alaska and the north of Canada; but I don't remember ever seeing a mention of it.

C.R.T. Repairs by Makers

IT'S good news that some manufacturers are now running a re-processing service for their c.r.ts. There can't be much doubt that there's good business to be done and the benefits to customers are indeed great. An important aspect of the scheme is that each tube will retain its identity in the course of re-processing and that there will thus be no liability to purchase tax. The cost of rebuilding a tube will work out at less than half that of a new one plus the P.T. that goes with it; and re-processed tubes will carry the makers' full guarantee. It has always seemed absurd that when the most expensive part of a TV receiver developed a fault the makers should have taken the attitude "Sorry, there's nothing we can do about it." After all, motor car manufacturers have for years undertaken the reconditioning of engines and that's very much on the same footing.

The R.I.C.

IT'S a sensible move, I feel, for the radio industry to reorganize itself into what one may call its domestic and capital goods branches. This means that the Electronic Engineering Association, though it will continue to co-operate with the Radio Industry Council, will no longer be a member of it. The annual radio show has, in general, been meant to appeal specially to the home user of sound and television receivers and sound reproducing and recording apparatus and has not catered very successfully for the people who place million-pound orders for telecommunications or broadcasting systems. It's the domestic side of the industry that interests the ordinary man and woman most. The show is in future to be run by a new company, Radio Industry Exhibitions, Ltd., formed by B.R.E.M.A., and I'm sure they'll see to it that the annual display at Earls Court, or wherever it's held, becomes better and better as it goes on.

Electronic Sex-Detection !

AN interesting device was exhibited recently at Los Angeles by the Farnsworth Electronics Co. of Fort Wayne, Indiana. This company has done a lot of work on infra-red techniques and the device was intended to demonstrate the extraordinary sensitiveness obtainable in a detector of such radiation. Looking rather like a penny-in-the-slot machine, it claims to be able to indicate the sex of a person who stands on its platform and presses a button by causing a window labelled "man," or another labelled "woman" to light up. Some ten inches or so above the level of the platform there's a detector which responds to minute amounts of heat. Should the subject be a man, the idea is that his trousers stop most of the heat radiation from his legs. On the other hand, a woman's nylon stockings don't. It's said to be a hundred per cent accurate—provided that those who consult it are wearing the traditional garments of their sexes. But it can't cope with a woman clad in trousers (and I don't blame it!) or a man wearing shorts, with bare legs.

Telephones Awheel

IT is now possible for some West German motorists whose cars carry the necessary v.h.f. wireless equipment to telephone as they drive to any number in the country. At present the service is confined to the *autobahnen* and to the neighbourhood of certain large towns. It is not a particularly cheap service, for the equipment costs well over £300 for each car and in addition there's a licence fee of over £50 a year. Still, many business firms have found it worth while to install it in order to keep in touch with their vehicles engaged in journeys about the country. It also enables business executives to keep in contact with their offices as they travel. Each licensed car has its own telephone number and can be called up as required. So long as you know roughly where the car is, it's quite easy. You just ring your exchange, give them the 'phone number of the car and its whereabouts. Exchange then puts you through to the appropriate v.h.f. station, from which the wanted car is called. There are 18 of these stations at present and work is going ahead with the other twelve needed for a country-wide service.

A New Missile?

NEVER let it be said that the Americans take themselves too seriously. Turning up some recent issues of *Electronic News* I came across an account of a new device, the MOLE (Molecular Orbiting Low-Level Explorer), in which a phase-inverted inertial "blind" guidance system will be employed to permit of downward launching. This is being developed by the designers of the well-known CAT (Consecutive Analysing Target-seeker), the night-missile with its special electronic fail-safe device guaranteeing nine lives. Security clearance for visiting these projects is obtained by feeding the subject's history into a modified Fliegenfinger computer and matching against the curve of an Accuracy Inc. non-linear potentiometer. Some modifications to this system will presumably be necessary as it has so far failed to clear President Eisenhower since he has corresponded with Mr. Kruschev, a known communist.

UNBIASED

By FREE GRID

"Nuts"

TO save you the trouble of rescuing the February issue from the waste-paper-basket, I would remind you that in it I told you all about my adventures with the English Electric Co.'s Deuce machine at the Electronic Computer Exhibition at Olympia. Deuce was, among other things, giving the day of the week on which any date A.D. fell, and I said I regretted that I did not ask it on which day September 5th, 1752, fell.

I received replies from the company's engineers in London, Stoke-on-Trent and Preston. They all wrote to tell me that Deuce would have replied "Nuts," which is the stock answer for any unanswerable question as, of course, mine certainly was*. It was just a catch question similar to many others such as "What was the name of the monarch who reigned in England and Scotland in 1690?" to which Deuce would certainly reply "Nuts" were it possible to put such a question to it.

I should like to thank all those who took the trouble to write to me. I should also like to congratulate the company for putting such efficient young ladies on the stand. They seemed to know all the answers, and so Deuce was, in a way, redundant.

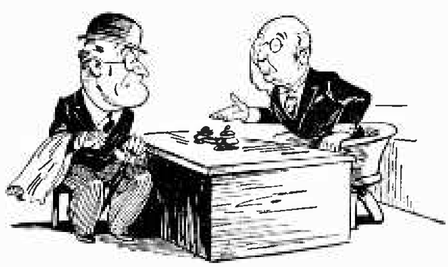
There is one thing which the Deuce engineers have not told me and that is the day of the week on which Julius Caesar invaded this country. The date was, of course, August 25th, 55 B.C., as every British schoolboy knows. Maybe some other computer manufacturer can tell me the day. After all, competition is a healthy thing.

Sub Rosa Recording

SOME time ago we heard a lot about telephone tapping, but there seems to me to be an even greater menace to the liberty of the subject. I refer to the growing practice of the *sub rosa* recording of interviews of a personal nature such as the painful one you have with your bank manager when you are seeking an overdraft.

A striking instance of this practice came to my notice recently when I had occasion to consult a psychiatrist. He was nothing if not efficient, and I soon found myself answering his pertinent—and sometimes impertinent—questions in a manner which I had no intention of doing when I first entered what I can only call his grill room. Although the consultation was very prolonged and I must have spoken several thousand words, I was astounded to notice that he did not take a single note.

The significance of this did not dawn on me until some days later when I had to return for a further consultation with this descendant of the world-famous pioneer whom the late Dean Inge referred to as "the unpleasant Dr. Freud." The psychiatrist had several pages of typescript on his desk to which he constantly referred when he was grilling me. I soon realized that at the previous interview my words must have been taken down on a concealed tape recorder.



In the grill room.

Now I am sure you will think the psychiatrist did the proper thing when he used a man-made recorder to take down my words accurately instead of depending on the far less reliable Nature-made recorder which we call by the name of memory. It was obviously the logical thing to do.

But who expects to find logic on the patient's side of the desk in a psychiatrist's consulting room? Isn't illogicality one of the things the psychiatrist is trying to cure? Therefore as an illogical patient, I make no bones about saying that I profoundly disagree with you mentally normal people; to me this *sub rosa* recording smacks of the Gestapo.

My opinion is, of course, obviously illogical, but to my sad psychiatric way of thinking a patient should at least be accorded the same privilege as an arrested person is entitled to, namely a caution that anything he says will be taken down, etc. In other words, I don't mind the recording but I strongly object to the *sub rosa* business.

I wonder if any of you agree with me? If so it is obvious that you need treatment too.

Stereo Acoustics

I WAS delighted to see so much space in the February issue devoted to stereophony, or what should more properly be called stereo acoustics. Not only did the Editor let himself go with some very refreshing ex-Cathedra pronouncements, but the correspondence columns—always among the most interesting parts of any journal—were greatly expanded to accommodate the large number of letters on the subject.

With regard to the Editor's remarks I heartily endorse his plea for means to be provided for enabling listeners to make a proper comparison between stereo and non-stereo. I am glad to see that at this year's National Radio Show, the Audio Hall feature of last year is to be extended. But I do hope that some attempt will be made to provide a section where comparisons, such as the Editor suggests, can be made.

In his letter to the Editor, Mr. A. O. Milne points out that Nature has provided very few people with matched ears. I found out, over 50 years ago, that my own were far from being a pair, and so when I attended the Opera I always used a separate ear trumpet for each ear, a mechanical volume control being fitted to each. Nowadays, of course, I use two entirely separate transistorized hearing aids at all concerts.

Lately I have been trying the same thing for stereo listening as I do not want to be chained to the leads of a pair of headphones. Apart from being able to match up my two ears I find that the stereo effect is enhanced by turning the input end of each hearing aid to the opposite sidewalls of the room.

I also agree with Mr. Milne about the benefit of listening in complete darkness but I must give a word of warning. I found this so popular among my adolescent offspring of both sexes and their young friends that I had an ever-growing audience of young people eager to listen to stereo records in the dark.

It was not until the manager of a local cinema, an old friend of mine, who, because of his occupation is well versed in one of the things which baffled even the wisdom of Solomon, dropped me a timely hint, that I realised that the young folks were turning my drawing room into a petting parlour. *verb. sap.*

Thanking You

I SHOULD like to thank Mr. H. C. Spencer for his kind remarks in the January issue in which he says he has received much constructive amusement from me for over thirty years.

I wonder if he has been confusing my writings with those of the past and present Editors as these are the only ones that have been going strong for over thirty years. I have been writing only since the issue of September 19th, 1930, so I still have 18 months to go before completing 30 years. Thank you, all the same, Mr. Spencer.

*There was no such date as September 5th, 1752. With the adoption of the Gregorian calendar that year the eleven days between September 2nd and 14th were omitted.—Ed.