Wireless World

ELECTRONICS, RADIO, TELEVISION

JUNE 1962

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VOLUME 68 No. 6.
PRICE: 2s. 6d.

FIFTY-SECOND YEAR
OF PUBLICATION

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Iliffe Electrical Publications Ltd., Dorset House, Stamford Street, London, S.E.1

Please address to Editor, Advertisement Manager, or Publisher as appropriate

PUBLISHED MONTHLY (4th Monday of preceding month). *Telephone:* Waterloo 3333 (65 lines). *Telegrams:* " Ethaworld, London, Telex." *Cables:* " Ethaworld, London, S.E.1." *Annual Subscriptions: Home and Overseas,* £2 0s. 0d. *Canada and U.S.A.* $5.50. Second-class mail privileges authorized at New York, N.Y. BRANCH OFFICES: *BIRMINGHAM:* King Edward House, New Street, 2. *Telephone:* Midland 7191. *COVENTRY:* 8-10, Corporation Street. *Telephone:* Coventry 25210. *GLASGOW:* 62, Buchanan Street, C.1. *Telephone:* Central 1265-6. *MANCHESTER:* 260, Deansgate, 3. *Telephone:* Blackfriars 4412. NEW YORK OFFICE: *U.S.A.:* 111, Broadway, 6. *Telephone:* Digby 9-1197.

A LOW-NOISE ALLOY-JUNCTION TRANSISTOR AC107

for tape recorders

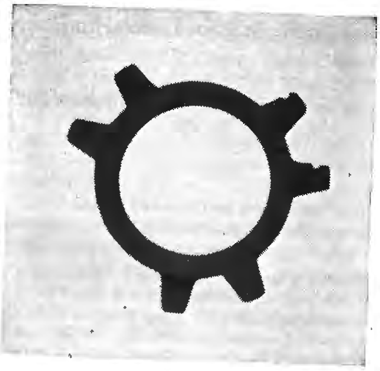
Manufacturers of inexpensive valve tape recorders have always been confronted with the problem of hum and microphony, and the need for a voltage amplifier which introduced a minimum of hum and microphony has always existed. Transistors, with their absence of heaters and inherently good microphony properties, offered a logical solution, and the Mullard low-noise transistor, type AC107, is now being used extensively as a voltage amplifier feeding subsequent valve stages in up-to-date hybrid tape recorders.

The development of battery-operated tape decks leads naturally to the use of all-transistor circuitry. Again the AC107 has been adopted for this application, and is being used in present-day battery operated recorders.

Finally, manufacturers of high quality audio equipment who wish to use transistor pre-amplifiers with high quality valve amplifiers are making increasing use of the AC107. This new Mullard low-noise transistor, designed specifically for a.f. amplification in low-signal-level stages, is thus contributing greatly to the high standards attainable with a wide range of modern audio equipment.

FD404 PICTURE SHIFT MAGNET

Picture shift magnets are fitted immediately behind the deflection coils on the neck of a television picture tube to position the picture on the screen. The Mullard picture shift magnet, type FD404, has been developed to overcome the disadvantages associated with the tungsten steel types used previously. Eddy currents are set up in the tungsten steel which reduce the sensitivity of the deflection coils, so that extra scanning power is required. The new shift magnet is made from Magnadur powder bonded with non-conducting P.V.C., so that eddy currents are negligible. The FD404 thus has electrical and magnetic characteristics which prevent it interfering with the performance of the deflection coils while permitting sensitive control of the position of the picture.

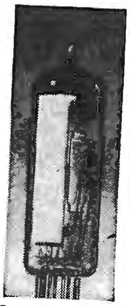


WHAT'S NEW IN THE NEW SETS

These articles describe the latest Mullard developments for entertainment equipment

EM87 SENSITIVE VOLTAGE-LEVEL INDICATOR

10V GRID BASE



In many present-day tape recorders, the recording output voltage available for driving the voltage-level indicator is about 10V, which is often insufficient to close the display of existing types of indicator. For this reason, Mullard have designed a new indicator—the EM87—which has a grid base of only 10V. An even shorter grid-base—and hence greater sensitivity—can be achieved if the target voltage is reduced by connecting a resistance in series with the target.

An additional feature of the EM87 is that a recording signal greater than 10V will cause the luminous areas of the display to overlap, thus giving a brighter section at the centre of the display. These large voltages can result in distorted recordings, and the brighter section of the display thus serves as a useful indication of when the recording signal modulation is excessive.

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Wireless World

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Components—

WE would like once again to congratulate the Radio and Electronic Component Manufacturers' Federation on the excellence of their Annual Report (this time for 1961) which gives a detailed and well-balanced picture of the industry against the background of world trade.

Total production of components is valued at £140M (+8% on the previous year). Components used in professional equipment amounted to £50M (+16%), in domestic receivers £32M (−9%) and in audio equipment £12M (+20%). Of this total £39.8M (+20%) was exported, principally to Europe, the Commonwealth and N. America, with the European market assuming a steadily increasing predominance.

Looking at the radio and electronic industry as a whole the estimate of the value of total production in 1961 is given as £420M (excluding other electronic products which are classified under associated industries). Professional equipment is valued at £200M (+18%), domestic receivers £100M (−10%) and audio equipment £40M (+14%). The fall in the number of television receivers produced, 1.3M (−13%), was to some extent offset by a record output of radio receivers including transistor portables, 3M (+20%). Total radio and electronic exports reached £68.5M (+18%) and included professional equipment, £25.3M (+15%), domestic receivers, £3.8M (+9%) and audio equipment £10.5M (+15%).

These figures are impressive, particularly when it is realized that the increase of productivity for the same period by the engineering and electrical group was 7% and by the whole country was only 1.2%.

The "body politic" of the Industry has many vigorous limbs, but often they seem to lack proper co-ordination. The right hand either does not know or is all too painfully aware of what the left hand is doing. Independently they exhibit remarkable skills, but there are times when full integration of all faculties is necessary to meet external hazards. A healthy circulation of good blood is as essential to general co-ordination as it is to special skills. It supplies and transports all the basic elements necessary for growth and has access to widely different tissues; its condition is indicative of the health of the body as a whole. By analogy the component manufacturers can claim with some justification to be the life blood of the industry, and in their Report they have expressed themselves as "prepared to support the formation of any central organization designed to represent all interests, provided that it is constituted on the right lines and at the right level and is truly representative of all sections of the Industry." We hope that the Council will go further and take the initiative of which it is undoubtedly capable to bring about a long overdue rapprochement.

—and Materials

Slightly modifying the analogy of the previous item on this page, we may say that if components are the cells and corpuscles of the electronics industry, metals, insulants and other materials are the amino acids from which the complex proteins of corpuscles and indeed of larger tissues and structures are built.

Fundamental advances in electronics, as in other technologies, are more often than not dependent on the discovery—in these days even the design—of new chemical compounds and materials, and a full and early appreciation of their properties.

It is gratifying to learn, therefore, of an extension of the experiment in university technological education at the University College of North Wales, which, in addition to providing a degree course in Electronic Engineering under Prof. M. R. Gavin (with a sub-department of Control Engineering), is now to establish a Chair of Materials Technology (to be occupied by Dr. R. W. Cahn). Quoting from the official announcement: "It is believed at Bangor that the present situation calls for a reappraisal of the teaching of materials and it is for this purpose that the subject of Materials Technology is being introduced. The course draws on the methods of physics, chemistry, metallurgy and engineering, as and when appropriate, but the whole treatment is integrated in terms of modern theory of solids and in the light of technological needs. It is believed that a sound discipline can be provided, a discipline which makes a valuable contribution to the education of all undergraduate engineering students. In the early stages of these developments of Materials Technology the main emphasis is on electrical materials as there is already at Bangor some considerable electrical background with a strong research effort on applied semiconductors. Later on, when the present plans have been fully realized and consolidated, there should be a widening of the course to include other aspects of materials."

It is pleasing to note that electronics materials are to be given initial priority, and we congratulate those concerned with the structure of the course on their determination to lay a foundation of basic principles which will illuminate future developments as well as providing a better understanding of existing materials.

STORAGE TUBES

A SURVEY OF TYPES AND FUNCTIONS

By W. R. DANIELS*

STORAGE tubes had their origin well over 30 years ago. Television was probably one of the prime movers, for the sensitivity of camera tubes could be increased by over fifty times by integration and storage of the picture-element signals for a whole frame. Since these early days storage tubes have diversified considerably. It is the author's intention to review the present state of the art and to point out some limitations.

Mechanism of Storage

The modern storage tube employs the fundamental principle of capacitance to store electronic information, i.e., a sequence of signals. The electrode on which the storage takes place, generally called the target, can be considered as a very large number of tiny capacitors having one common electrode normally formed by the conductive support of the dielectric (see Fig. 1). This conductive support may be a flat plate or a mesh and the dielectric is a very thin, uniform insulator. The special feature of this capacitor is the fact that the side opposite to the common electrode has two terminals; i.e., the electron beam, for electrons arriving at the capacitor and discharging it, and the collector, for electrons leaving the capacitor and thus causing it to acquire a positive charge. The collector is a conductor some distance away from the free side of the target and can be a wall coating, a ring or another mesh, or any combination of the three. Basically, there are only two conditions governing the design of the collector:—

(1) It must induce a field as even as possible at the surface of the dielectric. To this end additional electrodes are used to even out the field and when these do not act as part of the collector they are referred to as "shading" electrodes.

(2) It must cause a minimum of obstruction to the electron beam which is directed on to the free surface of the dielectric.

Charge patterns are created on the target which are some function of the information to be stored. They are built up, or destroyed, by the action of one or more electron beams and the building up and destruction is done by secondary emission or bombardment-induced conductivity.

Secondary Emission.—All insulators have secondary emission characteristics similar to the curve shown in Fig. 2. At low primary electron velocities the secondary emission factor is less than unity and the surface of the insulator will gain more electrons than it loses, i.e., it will acquire a negative charge. Equilibrium under these conditions will be reached when the potential of the surface of the insulator equals the cathode potential. As the electron velocity of the incident beam is increased the secondary emission factor increases, passes through unity, keeps on increasing to reach a maximum and then decreases again until finally it becomes again less than one. The two points where the curve passes through unity secondary emission factor are very important, being called the first and second cross-overs. As negative charges can be deposited on the insulator surface at electron velocities lower than the first cross-over, it follows that, at electron velocities between the first and second cross-over, we have a loss of electrons from the insulator surface, and the surface consequently acquires a positive potential. The secondary electrons produced are gathered up by the collector electrode, and in the case of the secondary emission factor being greater than one, equilibrium is reached when the positive potential at the insulator surface equals the potential of the collector electrode. Secondary emission of this kind has its origin in and just below the surface and at low electron velocities the primary electrons do not possess energy sufficient to knock out of the surface more than one secondary electron for every incident one: the disturbance they cause does not reach deep enough. Then, after reaching a velocity corresponding to an optimum thickness (from which a maximum of secondary electrons can be extracted), the secondary emission ratio falls again. It is unity again at the second cross-over and then less than one.

Bombardment-induced Conductivity.—Keeping in mind the picture of the primary electrons reaching deeper and deeper into the insulator, the point is

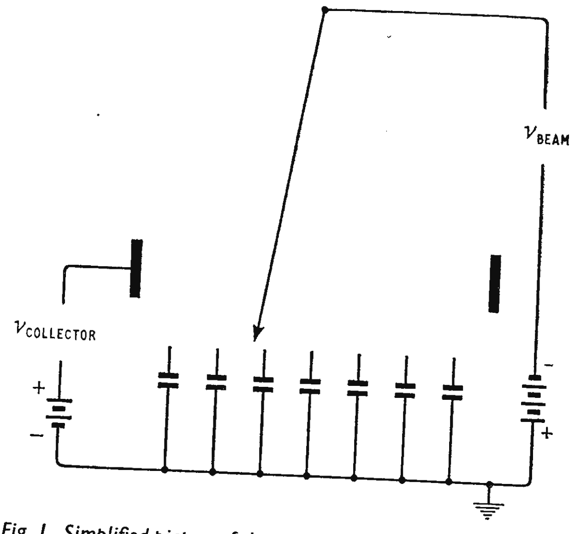


Fig. 1. Simplified picture of the way in which storage is achieved.

* 20th Century Electronics Ltd.

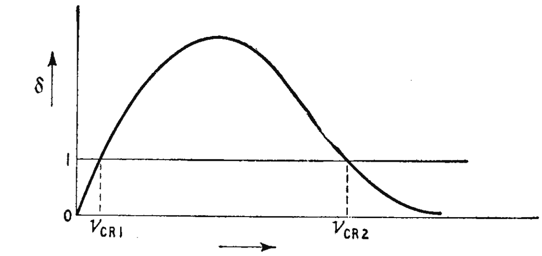


Fig. 2. Secondary-emission characteristic

reached where the primary electron creates a disturbance, or track, right through the thin insulator. This track, for a fraction of time, allows electrons to pass from the backing surface through to the other side of the insulator. This is a state of affairs totally different from secondary emission and is called bombardment-induced conductivity. This "track" must allow the passage of electrons for a short time and be "self-healing," otherwise a permanent change in the characteristics of the dielectric has been brought about which is called "burn." These characteristics vary with the material of the insulator. The electron velocity required to achieve bombardment-induced conductivity is very high for the known suitable materials, being of the order of 10,000eV for an insulator 1,000Å thick.

Equilibrium Conditions.—The conditions at the first and second cross-overs, where there is a secondary emission ratio of unity, imply that there is an equilibrium at these points. It has been shown that at electron velocities below the first cross-over the dielectric gains electrons until its potential equals that of the cathode, whereas at electron velocities above the first cross-over the dielectric tends to lose more and more electrons until, the collector voltage permitting, the second cross-over is reached where the process is reversed. The first cross-over therefore represents a state of unstable equilibrium and the second cross-over a state of stable equilibrium.

Read-out.—The read-out is obtained by modulating a uniform electron beam (or its secondary emission) by the stored charge pattern. In the direct-display tube modulation is obtained by flooding the stored pattern with an even, diffuse stream of electrons whereas in tubes with electrical output an unmodulated electron beam is scanned over the target. Read-out is said to be destructive if in the process of modulating the reading beam the charge pattern is destroyed, whether immediately in one single read-out or slowly by a number of read-outs.

When it is required to destroy one charge pattern on the target so as to make room for a new one, the term "erasure" is used. Often this is destructive read-out at such a rate that the time taken is short.

Frequently erasure does not leave the target at a potential which is suitable for the inscription of a new charge pattern: it has to be "primed." Again, this is done by secondary emission.

The operations of forming a charge pattern (writing), modulation of a uniform beam by this charge pattern (reading), cancellation of the charge pattern (erasure) and bringing the target to such a potential that writing can take place again (priming) all rely upon secondary emission and/or bombardment-induced conductivity. The knowledge of the facts illustrated by Fig. 2 is therefore essential to the understanding of the functioning of storage tubes.

It is necessary to elaborate on the statement that the target can be considered as being a very large number of elemental capacitors. As the dielectric has some conductivity the presentation in Fig. 1 is over-simplified: all the target elements are resistance-capacitance connected as shown in Fig. 3 and it is evident that, because time-constants are present, there are optimum running conditions.

Types of Storage Tubes

Storage tubes fall into the following categories:—

(1) electrical input—optical output
(2) electrical input—electrical output
(3) optical input—electrical output
(4) acoustical input—electrical output
(5) optical input—optical output

Devices in the first group are called "direct-viewing" storage tubes and the second "electrical-output" storage tubes. For the third group the term "camera tube" is employed. The fourth category covers a special type of camera tube which is made by 20th Century and in which a quartz "window" forms the target sensitive to ultrasonic vibrations so that a television type of display may be used for ultrasonic "shadowgraphs*."

In the last group are special image converters—a field that is not usually encountered—such as Lallemand's camera in which an electron-sensitive emulsion is used to store an image for subsequent "development" and optical display.

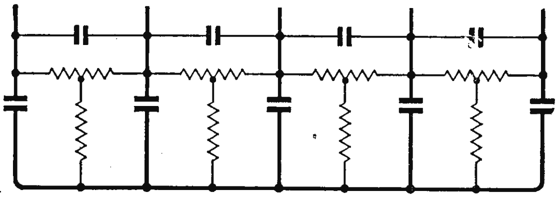


Fig. 3. Equivalent circuit of part of storage tube target.

This article will deal only with devices of the first and second categories as nowadays the term "storage tube" seems to apply to them in particular.

The storage tube with optical output—the direct-viewing storage tube—can be looked upon as a sophisticated form of cathode ray tube; the storage tube with electrical output, by comparison, is associated with circuits which are common in video technique. However, storage tubes with simultaneous electrical and optical output have been made.

Direct-viewing Storage Tubes.—Most types of direct-viewing storage tubes follow the general design of Fig. 4. Secondary emission is employed to form a charge pattern on the dielectric coating of the storage mesh, the field mesh collecting the secondary electrons emitted during this process. Reading is carried out by modulation of a uniform

* See, for instance, *Wireless World*, p. 361, Vol. 64 (1958).

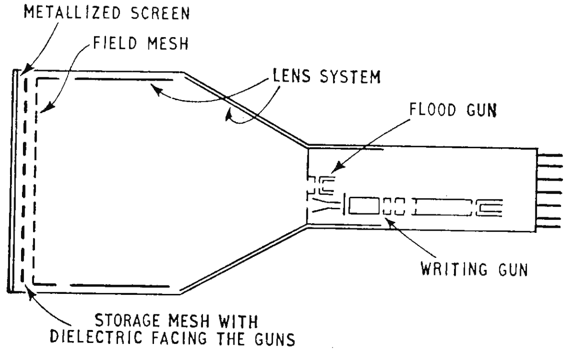


Fig. 4. Direct-viewing storage tube based on flood-gun principle where electrons reaching the screen are controlled by charges on storage mesh.

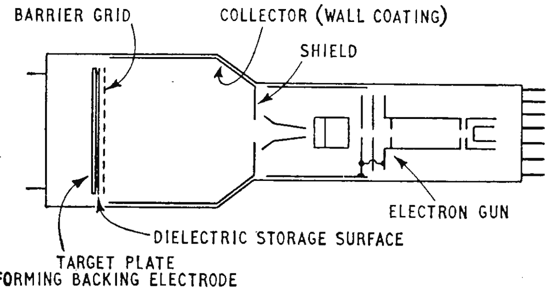


Fig. 5. Barrier-grid type of tube. Storage in this depends upon the beam penetrating the barrier grid and leaving a charge on target. Secondary electrons are collected by the barrier.

diffuse beam generated by the flood gun: the charges on the dielectric of the storage mesh act like iris diaphragms in the tiny openings of the mesh and so regulate the number of electrons allowed to pass through the storage mesh in each elemental area. These electrons are then accelerated by the electric field between the storage mesh and the metal backing of the fluorescent screen upon which they finally impinge. The field mesh fulfils a number of important functions: it generates a uniform field in the neighbourhood of the storage mesh; it acts as collector of secondary electrons produced by the writing beam; it is the decelerator for the flood beam, without which the velocity of these electrons would be too high to allow the charges on the storage mesh to act as elemental irises, and finally, but not least important, it helps to collect ions which might cancel the charge pattern on the storage mesh. Erasure of the charge pattern is carried out by adjusting the potential of the meshes in such a way that electrons are allowed to land on the storage mesh at high velocity. Secondary emission causes the whole storage target to assume a uniform positive potential, and priming is carried out by a pulse which induces a reduction of the potential of the dielectric on the storage mesh.

One of the outstanding features of direct-viewing storage tubes is the high brightness of the display. The reason for this is that the phosphor is excited continuously by flood-gun electrons, thus dispensing with the scanning mechanism, which increases the time available for excitation by a factor of the order of 10^5 as compared with scanning at, say, television rates. Storage tubes of this direct viewing type are manufactured by a number of firms including English Electric and Mullard, in England, R.C.A., Dumont and I.T.T. in the U.S.A., and C.S.F. in France.

Storage Tubes with Electrical Output.—The number of possible permutations of basic principles leading to the essential feature of storage tubes with electrical output has produced a greater variety of designs of these tubes as compared with the direct viewing tube.

Barrier-grid Storage Tube.—The target plate of this storage tube supports a thin film of dielectric material (Fig. 5). A charge pattern is formed by the action of a writing beam with a velocity sufficient to give a secondary emission greater than unity. Secondary electrons are collected on the barrier grid or on the collector wall coating. The read-out signal, which is the difference of charge between peak-white and the charge of the individual picture element is assessed by scanning with an unmodulated beam which brings the whole target to the same positive potential. This potential is determined by the barrier grid and the collector. The important function of the barrier grid is to oppose any redistribution of charges on the dielectric and so fix the charge pattern. Simultaneous writing and reading can be carried out if the tube is fitted with at least two separate electron guns.

The signal can be extracted from either the target or the collector, the former being preferred as it provides better signal-to-noise ratio, because it is smaller and is thus less subject to stray pickup and is easier to screen.

The stored information may be read out at television speeds for seconds or even minutes with this type of tube. Erasure of the stored pattern can be produced within one second by suitable switching and pulsing, but tubes of this type are not "fast erasers."

There are a number of manufacturers of barrier-grid storage tubes, including R.C.A. (Radechon), E.M.I. and 20th Century Electronics. A variation of the barrier-grid storage tube is the "Tenicon" made by Mullard. By operating the scanning beam above the first cross-over in the writing mode and below the first cross-over in the reading mode most of the stored information can be extracted in one scan, which provides a good grey scale and fast erasure.

Storage Tube Using Bombardment-induced Conductivity (Fig. 6).—The target of this tube is a very thin film of insulating material with metal backing towards the writing side. A positive uniform charge is produced on the reading side under the action of the unmodulated reading beam operating at a velocity such that the secondary emission factor is greater than one. The maximum positive potential that can be built up in this way is determined by the potentials of the collector and shading electrodes. The writing beam is accelerated to a velocity high enough to cause bombardment-induced conductivity in the thin insulator, and a charge pattern that is negative with respect to the insulator surface appears on the reading side of the film, corresponding to the charge pattern of the writing beam multiplied by the gain due to bombardment-induced conductivity. This

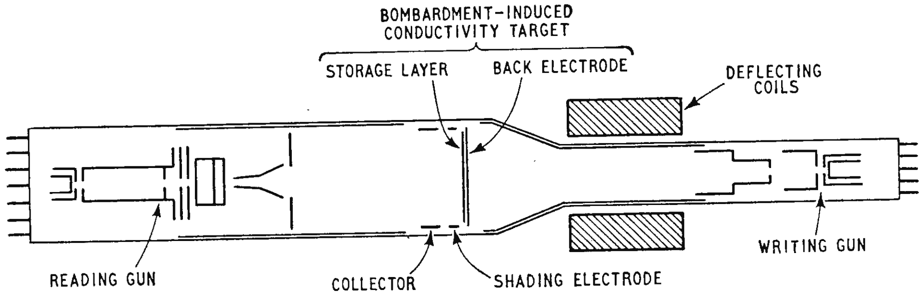


Fig. 6. Bombardment-induced-conductivity tube in which storage is achieved by causing electrons to penetrate through storage layer from writing to reading side.

charge pattern modulates the number of secondary electrons emitted at each "picture" point when the target is scanned by the reading beam and the signal appears on the collector electrode; but it can also be extracted from the target.

One of the advantages of this type of tube is the fact that due to the diametric opposition of the two guns their interaction is negligible, even if both guns employ the magnetic focusing and deflection. Further, by sacrificing storage time a reasonable grey-scale performance can be obtained. Erasure time can be shortened by increasing the beam current of the reading gun; but again this tube is not a "fast eraser." Storage time can vary from a few seconds to several minutes, under television-scan read-out conditions. As this tube is fundamentally a simultaneous read-in read-out device, it has found many applications as scan converter of p.p.i. to orthogonal. There are a number of manufacturers of the bombardment-induced conductivity target storage tube, including RCA (Graphecon), C.S.F. (France) and 20th Century Electronics.

Electrical-output Storage Tube with Storage Mesh.—Such is the number of possibilities and variations in the design of storage tubes that Fig. 7 can represent two different tubes, depending whether the dielectric on the storage mesh faces the electron gun or the signal plate.

In the first case the storage tube is the electrical version of the direct-viewing tube and can be fitted with more than one gun in order to obtain simultaneous read-in and read-out. Its principles of operation correspond then to the direct-viewing storage tube, including fast erasure. In the second case, where the dielectric faces the collector, some advantages are obtained when this tube is compared with the previous type: positive ions are virtually barred from reaching the charge pattern on the dielectric and thus affecting storage; the voltages for the different modes of operation of the tube lie close together so that the circuits required to carry out this switching are not too difficult to design. The erasure time is short. However, it is not possible, at the present state of the art, to write-in and read-out at the same time without a serious loss of resolution. The number of manufacturers includes Raytheon (U.S.A.) and 20th Century.

Construction Techniques

The assembly of storage tubes is, perhaps, more of an art than a science and requires the making of mechanical adjustments of the highest standard. A particular complication with the mesh-using tubes, of which the direct-viewing type is possibly the most common, is the difficulty of producing and handling the fine meshes required, especially in the large sizes.

These meshes are produced from glass masters which themselves are made on ruling machines. This method of manufacture is extremely reliable and the master-makers have got their work to a fine art; but it is the size of these ruling machines which limits the production of larger areas of mesh as most machines can go only to about 6in square.

It is thus possible to strike a balance point where costs are not uneconomic and this appears to be with tubes of about five inches diameter. Larger tubes have been produced recently and the outlook is not completely hopeless.

Naturally, larger and finer meshes are the obvious solution, but it is possible that use of a mesh can be eliminated. Work is, of course, in progress at the author's company as it is elsewhere, but much remains to be done.

Choice of Tube Type

One of the things which has bedevilled the storage tube's development is the fact that the field of applications is so large and varied that it seems impossible, at the present state of the art, to cover the whole

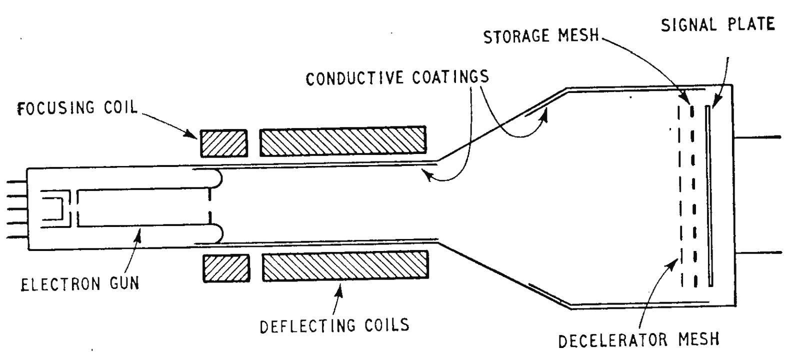


Fig. 7. Here signal to be stored is held as charges on a mesh, like that in the direct-viewing tube.

TABLE

Application	Typical Example	Type of Display	Simultaneous write and read	Half-tone requirement	Typical storage time (signal available for read-out)	Input-output
Scan-conversion	Television	Indirect	Yes	Yes	One or two fields	Both TV standards
	Picture transmission over telephone lines (band-width compression)	Both	Useful	Yes	Up to 15sec	One end of chain is fast in slow out and other is reverse
	P.p.i. to orthogonal	Indirect	Yes	Yes	Up to 3min	As example
Coding and decoding		Indirect	Yes	No	Up to 3sec	Raster type
Storage of transients	Nuclear experiments Medical research	Both	Useful	No	Up to 3min	Very fast input scan
Integration	Nuclear experiments, medical research, astronomy	Both	No	Yes	Several hours or longer	Fast scan in—slow scan out or slow scan in—fast scan out
High-brightness display	Special radar displays	Direct	Yes	Yes	Up to 30secs	Optical output only

field with one and the same tube. Admittedly it is possible to vary the operation conditions of a particular storage tube to cover a band of characteristics, but this band is relatively narrow in relation to the whole field that storage tubes are capable of covering. Generally, the choice is dictated not by one characteristic alone but by a decision as to which groups of characteristics have priority over others. As an example, an application which does not call for simultaneous writing and reading can be solved with a single-gun storage tube; but whether the tube still has two separate guns for writing and reading or if it is done by switching one gun from one operation condition to the other is at present not a technical question but, instead, one of economics. The table lists applications where storage tubes have become increasingly important and also shows a range of brief specifications for such applications.

Coding-decoding and track-plotting can be considered to be sub-sections in the field of scan-conversion, and transient storage is the reverse of integration. Problems of high-brightness display may sometimes be solved by scan-conversion, which allows display on large-size simple monitors.

In the computer field the storage tube has not been as successful as has magnetic storage. Access to information stored on a single element by an electron beam presents severe registration problems and has been found not to be so fast as in magnetic arrangements, in addition to the problems of maintaining a wide-range full-on full-off characteristic for digital storage. Hope has not been given up, however, and computers using storage tubes have been constructed.

The table shows that in most cases the storage tube can be of either the electrical- or optical-output type. As the end product nearly always has to be displayed somewhere it seems logical to go to optical output straight away. At present, however, the product of size and resolution of direct-viewing tubes is considered unsatisfactory for many applications.

The storage tube with electrical output, on the other hand, seems to have greater possibilities. From experience with camera tubes it is known that very high resolution can be achieved. The possibility of a number of simultaneous displays is very attractive, and such an installation has an inherent flexibility.

Conclusions

The choice of a particular storage tube from the user's point of view must always be a compromise between the main characteristics required, their order of importance and then any other considerations. Quite apart from mechanical aspects one can list (not in any order of preference):—

Simultaneous read and write, or read after write only.
Length of storage time (in the reading and non-reading mode).
Electrostatic or electromagnetic guns.
Halftones.
Resolution.
Writing Speed.
Reading Speed.
Erasure characteristics.
Priming characteristics.

Storage tubes are a relative newcomer amongst the "special" tubes; but already they have shown their value in many applications. The original idea of writing and reading is only part of the picture, these tubes are not just a sort of electronic note-paper on to which we can write memoranda very much faster; they are devices which can open up new techniques in nearly every field of electronics.

Acknowledgment

For further reading reference may be made to the book, *Storage Tubes and their Basic Principles*, by M. Knoll and B. Kazan.

P.M.G. Examination Fees

From July 1st increased fees will be charged by the Post Office for the examinations for the various types of Certificates of Competency in wireless telegraphy and radio telephony issued by the P.M.G. The present fee for W/T certificates is £2, and for R/T certificates £1. The new scale of fees is £3 and £5 respectively for parts I and II of both the first and second class W/T certificates, £4 for the special certificate and £3 for "re-tests." The fee for both the general and restricted R/T certificates will be £2.

TECHNICAL NOTEBOOK

Mechanical display device, developed at Elliott Brothers, adds yet another example to the long list of ingenious devices. Elliott's intriguing apparatus uses an array of assemblies each of which consists of a test-tube, a half-black and half-white ball, a coil of wire and a transistor. The ball contains a small magnet and is placed in the rounded end of the tube. The coil, into which current is switched by the transistor, is sited behind it. Appropriate magnetization of the coil can thus turn over the ball so that either its black or white face is presented to view through the end of the tube. A matrix of these simple devices can represent figures or letters by appropriate switching and, made up on a large enough scale, might even be used for half-tone reproduction.

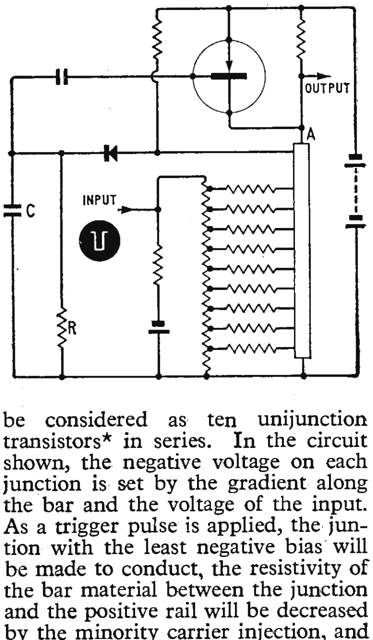
Blood flowmeter using ultrasonic pulses is described by D. L. Franklin *et al.* in the I.R.E. *Transactions on Bio-Medical Electronics* for January 1962. A pulse train, at a p.r.f. of 400c/s, is transmitted diagonally across a blood vessel, the direction of propagation being reversed once per cycle. The relative velocity of propagation, and therefore the time between transmission and reception is dependent on the velocity of the blood. Pulses taken from both the receiving and transmitting transducers are used to trigger a bi-stable toggle, the output of which is a rectangular wave with a pulse width equal to the propagation time. The pulse is used to gate-on a ramp generator, which produces a linear waveform rising at a constant rate. The voltage reached by the ramp is dependent on the gate pulse width, which in turn is determined by the blood flow velocity. Alternate peaks are of different amplitudes, as the direction of propagation is reversed, so that a capacitor, charged through a diode to the peak ramp voltage and reset after each cycle, will develop a 400c/s waveform across it, which has an amplitude proportional to flow velocity and a phase relationship with the 400c/s master waveform which indicates phase.

"Semimetals" is the term used to refer to materials that have a behaviour between that of a semiconductor and the conducting metals. Semimetals, of course, have particular application in thermoelectric devices, where their performance is conveniently defined by a "figure of merit" which is the ratio of the square of the thermoelectric power to the product of resistivity and thermal conductivity. Increased cooling or power-generating ability is reflected by a higher figure of merit. A value of $5.2\times10^{-3}/°K$ was achieved for a bismuth-antimony alloy at the Bell Telephone Laboratories by Wolfe and Smith; but the gain, and their work, did not end there. Semimetals, with their equal numbers of highly mobile electrons and holes, are particularly prone to influence by magnetic fields. Wolfe and Smith have found that the placing of a junction in a magnetic field increases its figure of merit. The most noticeable effect is that resistance increases, as it does in semiconductors, but the thermoelectric power also increases. In a weak field the figure of merit, which B.T.L. have designated Z, rises because the thermoelectric effect increases; but as the field becomes stronger the resistance rises so much that Z depends mainly on temperature and, in fact, the lower the temperature, the smaller the field necessary. An example from results achieved at Bell is a $Z=6.4\times10^{-3}$ at 200°K with a field of 12kG, compared with $Z=2.4\times10^{-3}$ with no field. The best result achieved so far is $8.6\times10^{-3}/°K$ at 100°K in a 1kG field. The field was applied perpendicular to the current flow in single-crystal specimen of bismuth-antimony alloy.

Double triode type 7247 (Telefunken, marketed in U.K. by Tellux Ltd.) has one half of high-gain, high-resistance characteristics (ECC83) and the other half, medium-gain low-resistance (ECC82). This valve could be used in a push-pull power amplifier where the low-resistance half would be employed as the waveform inverter, allowing the application of low-resistance grid leaks in the output stage, without loss of efficiency. Also the 3-W anode dissipation of the half-ECC82 system allows its use as a bias and erase oscillator in a tape recorder, where the high-gain section would be used for signal amplification.

"Noise" can make its appearance in photographic recordings of c.r.t. traces and the potential resolution of the c.r.t. can be reduced by the presence of "coarse" particles of phosphor in the c.r.t. screen. An apparatus for the comparison of phosphor screens has been developed at the Royal Radar Establishment: in this an area of the screen is evenly illuminated by the defocused spot and a ten-times-enlarged image of this is scanned by a 75-μ diameter hole 4mm off-centre in a motor-driven disc. The light passing through the disc falls on a photomultiplier which, through a train of amplifiers, deflects the spot of a c.r.t. vertically. The horizontal scan is synchronized with the rotation of the disc whose speed is adjusted to allow a high-frequency cut-off in the amplifiers of only 200c/s. In this way much of the photomultiplier noise, which would be a serious problem with such a small light input, is limited to an acceptable level. Another use of the machine is trace-width measurements, where any desired "number of dB down" can be taken from that display: this produces far more consistent results than does visual estimation using a travelling microscope.

Semiconductor decade counter is described by A. Ambroziak in *Electronics* for February 9th, 1962. The device, known as the Semdectron, consists of a bar of n-type material with ten p-n junctions along it; ohmic contacts are at each end of the bar. Effectively, the device can



be considered as ten unijunction transistors* in series. In the circuit shown, the negative voltage on each junction is set by the gradient along the bar and the voltage of the input. As a trigger pulse is applied, the juntion with the least negative bias will be made to conduct, the resistivity of the bar material between the junction and the positive rail will be decreased by the minority carrier injection, and the second junction will be at a suitable bias voltage for triggering. The tenth junction acts as a monostable multivibrator, the duration of the quasi-stable state depending on the values of C and R. The pulse obtained from C is used to switch the transistor on, which then short-circuits the counter load resistor and resets it ready for the eleventh pulse. The waveform at A is one-tenth the frequency of the input trigger pulses.

*"Double-base Diode Oscillator." P Lloyd. *Wireless World,* September 1961.

MONTREUX TELEVISION SYMPOSIUM

DELEGATES attending the 2nd International Television Symposium at Montreux, Switzerland, at the beginning of May must have thought that the U.K., although in the vanguard 26 years ago when introducing the world's first public high-definition television service, now had nothing to contribute to the science. There was but one U.K. paper out of a total of nearly 50, and only one piece of British equipment to be seen at the exhibition organized in conjunction with the symposium, and that, incidentally, was part of an American unit. It was stated that the papers presented were selected from the very large number submitted, but it was learned on enquiry that there was only one British paper received. It is a matter for congratulation that the paper by George Partington (of Marconi's) on "New trends in the development of television studio equipment" was selected. Fifteen papers were from Germany, 11 from the U.S.A., 8 from members of international organizations, 7 from France and 6 from Holland.

Before discussing the papers themselves, mention must be made of the awards presented at the end of the symposium. The recipients of these awards, "in recognition of their outstanding contribution to the advancement of television," were Dr. F. Schröter, of Telefunken, Isaac Shoenberg, director of Electric and Musical Industries, Georges Valensi, until 1956 director of the International Telephone Consultative Committee of the I.T.U., Dr. H. Yagi, who was until 1960 president of the Musashi College of Technology, Tokyo; and Dr. V. K. Zworykin, of R.C.A.

The symposium (April 30th-May 4th), attended by some 280 delegates from 20 countries, opened with several survey papers covering the development of television and the basic problems of frequency allocation. Dr. Gerber, in stressing the problems of sharing the "but one single radio wave spectrum" mankind has at his disposal, quoted a figure of "probably less than 5%" for the efficiency of the present use of the radio channels available for world communications.

Several sessions were devoted to communication problems. The first, covering international relaying, was devoted in the main to the use of earth satellites and the contributions were from Americans. One paper dealt with the possibility of using a satellite-borne transmitter to give direct reception of sound and television broadcasting to the general public over vast areas of the world. Such a scheme would be possible only if an internationally uniform television standard was adopted, unless of course the satellite was equipped for multi-standard transmission. This scheme is really an extension of the system introduced in the American mid-west in which an aircraft flying at an altitude of 4 or 5 miles is used for educational broadcasts. During the symposium a paper was presented by the president of the U.S. National Educational Television and Radio Centre on educational television in general in which he dealt at some length with the "flying classroom" introduced in Indiana, where there are 17,000 schools with a potential "classroom" of 7,000,000 students.

Satellite Video-tape Recorder

The use of tape recording and reproducing equipment in a satellite presents many problems, the greatest being the necessity for a drastic reduction of the size and weight of the tape transport and still provide survo facilities for the precise control of tension, velocity and speed of recording on 2in tape. Alan Grace, project engineer of Ampex, described the problems encountered in developing a video-tape recorder which weighs only 30 lb, occupies less than 3/4 cu ft and requires less than 40 watts of power. The tape is carried on counter-rotating hubless take-up and supply reels mounted co-axially. They are driven by rubber rollers that engage "V" grooves in their rims. Only two video heads are used instead of the normal four. In

Delegates from 20 countries attended the second International Television Symposium in Montreux at the beginning of May.

order to produce the "writing" speed of 1,500 in/sec required for a 4 megacycles video bandwidth, the heads are themselves rotated at a rate of 240 r.p.s. counter to the direction of the tape which follows a helical path over the plane of the video head. Helical scan recording utilizing a single head was dealt with in another Ampex paper.

While discussing video tape recording, mention should be made of the latest facility, that of editing without splicing, which was demonstrated during the symposium. Large screen Eidophor equipment was used for the demonstration, which showed how tape can be wiped electronically and a new recording inserted without any visible break.

Several papers dealt with various aspects of television transmission and reception in the u.h.f. bands. Particular interest was shown in those papers covering propagation problems. E. W. Allen, chief engineer of the United States Federal Communications Commission, gave a report on tests conducted in New York city using the American channel 31 (572-578 Mc/s). Directional and omni-directional transmitting aerials providing either horizontal or circular polarization were used for the tests. No significant advantage of one mode of polarization over the other was shown except at very low field strengths when circular polarization showed a slight advantage. Dr. H. Kösters, of the Hamburg Institut für Rundfunktechnik, gave a most interesting survey of tests using a pulse system in Bands IV and V to investigate reflections in the Bavarian Alps and in the Moselle region. Results showed that because of the movement of trees on wooded slopes, reflections varied by as much as 10 dB by comparison with un-wooded slopes. Directivity was found to be more important than high gain in the aerial.

Both of the papers devoted to camera tubes were concerned with vidicons, but with a difference. In the first, Dr. E. F. deHaan, of Philips, described the "plumbicon" tube, in which the photo-sensitive layer is an evaporated micro-crystalline layer of lead monoxide. The most significant advantages of this lead oxide vidicon are the low dark current, the high speed of response which is independent of light intensity and the high sensitivity. The author of the second paper, Professor W. Heimann, of Wiesbaden, demonstrated in complete darkness an infra-red video pick-up tube with very convincing results, the subjects being a person, a plant and a glass of water. The heat source was a 300°C radiator.

While in Europe manufacturers have pioneered remote control of cameras by the introduction of more and more stable circuitry, in the United States, where so many stations rely on packaged programmes, they have concentrated on applying automation to the programming of television and sound broadcasting. A description was given and a film shown of a punched tape or card system by which a whole day's programmes (whatever the mixture of tape, film, slides or networking) can automatically be fed into the transmitter at the appropriate time.

Colour Television

Dr. V. K. Zworykin was chairman of the session devoted to colour television, and he opened with a review of the present situation in the United States. He stated that of the 208 television stations affiliated to the National Broadcasting System, 87% are equipped to re-broadcast network colour programmes and many of them can originate live or film colour programmes. Similar figures presumably apply to the other two television networks. Dr. Zworykin referred to the development of the 90° shadow mask tube by R.C.A., which is 6in shorter than the present 70° tube. Development models may be available to set designers this year, but they are not likely to be on the market before the spring of 1963. Questioned on the value of colour in television, Dr. Zworykin expressed the opinion that it was more important for educational and medical purposes than for broadcasting.

The problems of colour transmission over international micro-wave links were reviewed by Dr. J. Müller, of Darmstadt, who gave details of a series of tests carried out over the 1,500 km Rome-Berne-Darmstadt circuit which forms part of the permanent Eurovision network. A full report on the tests was given in *NTZ* for April 1962.

It has been impracticable to do more than very briefly summarize a few of the papers presented at this international meeting. The organizing committee intends publishing in book form all the papers, particulars of which will be obtainable from the chairman, John H. Gayer, of the International Telecommunications Union, Geneva.

It is planned to dissociate next year's symposium and exhibition from the television programme contest, which together have in the past formed the International Television Festival. The provisional dates of the 1963 symposium and exhibition are May 20th-25th. A weakness of this year's symposium, which it is hoped will be avoided next year, was that preprints of the papers were not available, which meant that there was very little discussion. The publication of preprints permits the delivery of a more or less extempore summary at the meeting itself, thereby allowing time for open discussion.

We shall be glad to send a list of the titles of the papers to interested readers, who are asked to send a stamped addressed envelope.

Exhibitors from France, Japan, Switzerland and the U.S.A. participated in the exhibition run in conjunction with the Symposium.

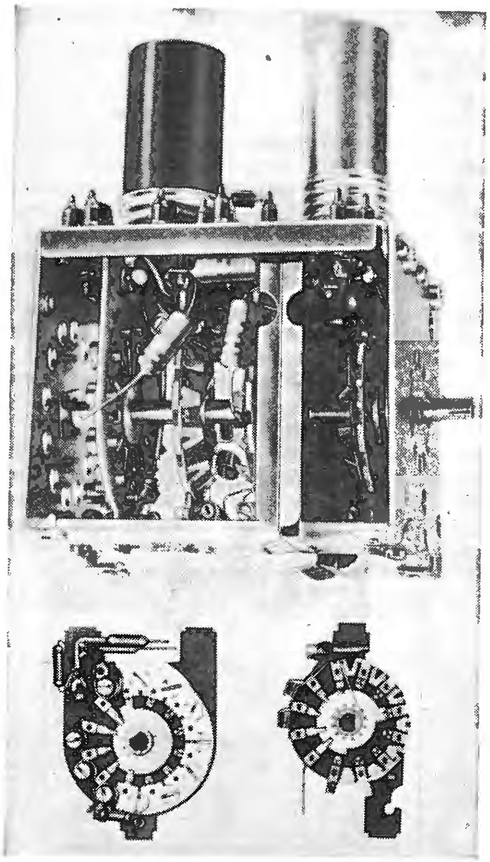
DOMESTIC TELEVISION AND RADIO RECEIVERS AT HANOVER FAIR

THERE is no full-scale radio exhibition this autumn in Germany, but the annual Hanover Fair is traditionally the place where German receiver manufacturers announce new models for the forthcoming season. In the eight months which have elapsed since the Grosse Deutsche Funkausstellung in Berlin there has been no fundamentally new development in design, but some trends and many detail refinements of design are worth noting.

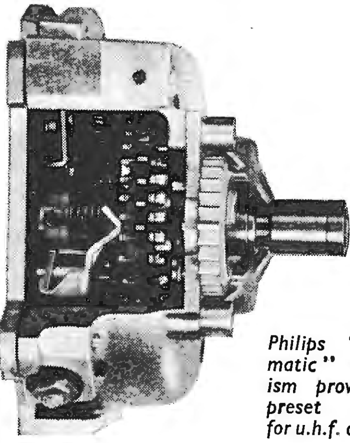
Television Receivers

The so-called "asymmetrical cabinet" which has long been a feature of British television sets seems now to have become a vogue also in Germany. Most firms make three classes of receiver which may be translated as "standard," "high-performance" and "luxury." Following the lead given by Saba with their optical diffusion screen, most sets now have switchable "line free" viewing which in the cheaper sets is obtained by spot elongation and in the others by spot wobble. The luxury class includes fully automatic tuning, and in some cases motor-driven station searching on u.h.f. as well as v.h.f. The commonest screen size is 59 cm (23 in) and many sets (e.g. Körting, Schaub-Lorenz, Wega) were fitted with convex plastic gold-toned filter screen covers which attracted favourable attention for their wide-angle viewing and anti-reflection characteristics.

The design of "front ends" shows some interesting variations. Graetz have abandoned the usual cascode input stage in favour of the PC 97 shielded triode for their v.h.f. tuner. This valve has the very low grid-anode capacitance of 0.48 pF and in a neutralized circuit gives a gain comparable with that of a cascode but with a lower noise level. Graetz have also changed from a turret to a switch-wafer incremental tuner for v.h.f. Inductances take the form of V-shaped thin metal pressings between the switch contacts, and adjustment is made by bending these towards the switch plane (reducing) or away (increasing inductance). In the oscillator circuit greater precision is given by the use of a fixed plate with stamped serrations. Ordinary cheese-head screws, concentric but not in contact with the plate indentations, adjust the inductance by changing the distribution of r.f. current paths.



Graetz v.h f. switch tuner, with (below, right) input wafer and (left) oscillator wafer.

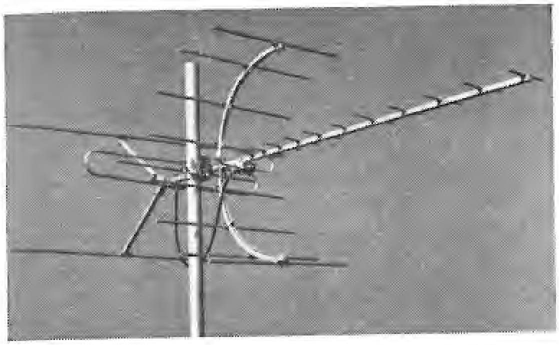


Philips "Memomatic" mechanism provides 40 preset positions for u.h.f. channels.

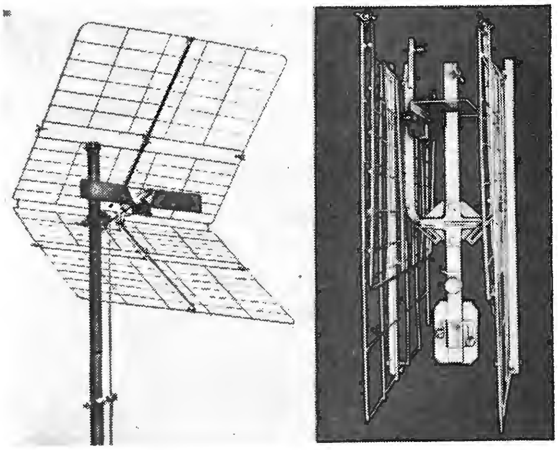
Grundig sprang a last-minute surprise by showing a prototype u.h.f. tuner with a mesa transistor (AF 139) r.f. stage. They are also using transistor sound i.f. stages in several current models.

Mechanically pre-set "tuning memories" for station selection are now provided in all but the cheapest sets, and may take the form of a rotary mechanism (e.g. Philips "Memomatic") or a rank of push buttons (e.g. Blaupunkt "Optimat," Grundig, Telefunken), with independent adjustment by small knurled screws which pull out of the centre of each button. In the Telefunken sets neat plastic sliding caps cover the adjusters when not in use.

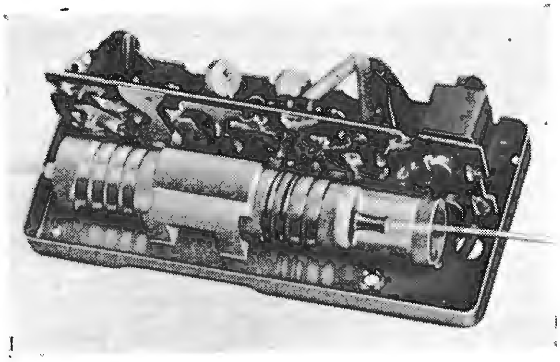
Although the claims of instantaneous programme selection by push buttons are attractive, the fascination of motor-driven station searching, with electronic automatic fine tuning when a worth while programme is found, are not to be denied. This



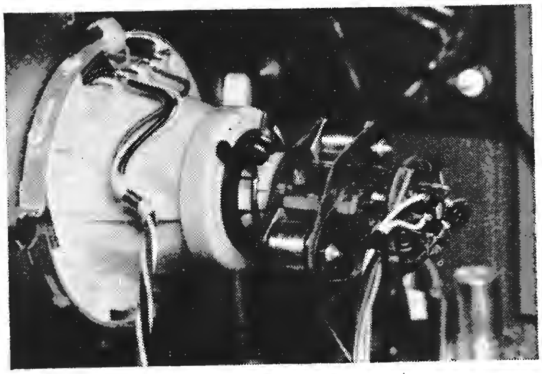
" Fuba " FSA1U24 universal (v.h.f/u.h.f.) aerial.



The " Fesa Corner 3 " broad-band (IV and V) corner aerial (Hirschmann) can be folded for ease of packing and transport.



UKW inductive tuner (with screen removed) as fitted in the Nordmende " Transita-Export " portable.



Electromagnetic deflection coils for switchable spot elongation in Grundig " standard " class TV sets.

feature is provided for v.h.f. in the Loewe-Opta luxury sets, and for both v.h.f. and u.h.f. in some Schaub-Lorenz receivers which employ no fewer than 3 motors (1 for v.h.f. and 2 for u.h.f.).

Optional suppression of horizontal line structure—now universal in German 625-line receivers—is achieved in four ways. In the luxury class, spot wobble is employed with a quartz-controlled oscillator operating at 13.56 Mc/s (the frequency allocated for industrial and scientific purposes). In the lower-priced sets the usual method is to fit pairs of electromagnets to the neck of the c.r.t. to give vertical elongation of the spot and to switch the energizing current (obtain, e.g. in Grundig sets, from the h.t. supply to the sound output valve). There were two notable exceptions: in the Deutsche Philips "standard" sets the magnets are permanent and they are applied to or removed from the neck of the tube by a push-button-controlled link mechanism, and in some Loewe-Opta sets the spot is electrostatically de-focused by changing the potential of one of the gun electrodes.

The alternative programmes on u.h.f. were so long in starting in Germany that aerial manufacturers had plenty of time to make preparations in advance. Two interesting new designs were, however, shown at Hanover for the first time. The "Fesa Corner 3" by Richard Hirschmann covers the whole of Bands IV and V and is designed to fold into a small volume for ease of distribution and installation. The FSA1U24 by Fuba covers all the v.h.f. and u.h.f. channels with a gain of 8-10dB. The technique adopted is to use the reflector rods of the u.h.f. aerial as directors for the v.h.f. folded dipole, which is placed behind them.

Sound Receivers

As in most other countries, the centre of interest remains with transistor portables, ranging from the so-called *Zwergtaschengeräte* (dwarf pocket sets), of which the Siemens RT 31 (with built-in flashlamp) and the Telefunken "Ticcolo" (with built-in, spring-watch programme switch) are good examples, to the high-sensitivity *Koffergeräte* (handbag portables) with telescopic external aerials. The trend, noted at last year's Berlin exhibition, to include a short-wave range (25-49 metres) for reception of home news bulletins when on extended journeys to foreign parts is now established practice. The Nordmende "Transita-Export" is a typical example and is also noteworthy for the well thought out and accessible design of its chassis, in which the inductively tuned input circuits form a compact and well-screened unit.

Stereophonic reproduction of disc records is universal in all the larger domestic radio-gramophones, and for export to America and in anticipation of possible future adoption of F.C.C. and C.C.I.R. standards for stereophonic broadcasting in Europe, adapter units are already in production by Graetz, Grundig and Saba.

WORLD OF WIRELESS

U.H.F. Broadcasting in the U.K.

SIR HAROLD BISHOP, C.B.E., Director of Engineering, B.B.C., addressing the 300 delegates to the annual Radio and Television Retailers' Association Conference held recently at Bournemouth, outlined the Corporation's proposal for the extension of broadcasting in the U.K. This includes a second television programme, a change from 405 to 625 lines, extension into the u.h.f. bands, development of colour television, an extension of sound radio and the introduction of a fourth service for local broadcasting, and continued experiments with stereophony. To carry out this programme of development, the B.B.C. would need to receive between £5 and £6 of a licence fee (at present it receives about £2 16s out of the £4 radio and TV licence).

With regard to engineering problems facing the broadcasting authorities, he said they were all vitally interested in the performance of u.h.f. transmitters and most particularly in reception difficulties. There would be a need for better aerials which would have to be erected high over roofs and carefully sited to avoid ghosts. The cost of these would be considerably higher than for v.h.f. television aerials.

It was revealed that the B.B.C. with the close co-operation of the G.P.O., I.T.A. and industry, is to carry out further trials from Crystal Palace with a u.h.f. transmitter of 160 kW e.r.p. and later on with a second transmitter of the same power on the same site. At first the transmitters would be in Channels 34 (vision 575.25Mc/s) and 44 (vision 655.25Mc/s) and later would be changed to two of the four frequencies allocated to the London area at the European Broadcasting Conference at Stockholm last year. It was planned that trials would start in August and that there would be monochrome and colour transmissions. The second transmitter would be added early in 1963 with the frequency changes made about next April. Sir Harold said: "The reason for using two transmitters for these trials is that there is space in the u.h.f. bands, we think, for four programmes. But the four transmitters serving a particular area would have to be on the same site. We want, therefore, to satisfy ourselves that we are aware of all the problems that may arise in transmitting this number of programmes from one site." In spite of the high power, perhaps 1,000 kW e.r.p., which is contemplated for the main u.h.f. transmitters to provide a national service, there would have to be about 64 main stations and about 150 satellite stations with additional wired relay services to serve the difficult areas.

Delegates to the R.T.R.A. conference were also addressed by P. A. T. Bevan, C.B.E., Chief Engineer of the I.T.A., who said that he was in close agreement with what Sir Harold had said. He thought that there must be a large degree of co-operation between the broadcasting authorities and that they did not want to be rushed into u.h.f. too quickly. He said that in the first five years about ten stations could be built to give 70% coverage in the U.K. The remaining 30% was the difficult and long-term task.

***Design Centre Award** of the Council of Industrial Design has been presented to the designers of this S.M.E. pick-up. The judges stated "... this arm offers an outstanding performance. It also looks what it is, a fine piece of precision engineering".*

Audio Amplifier Certificates

THE Audio Manufacturers' Group have recently introduced a scheme for certifying audio amplifier specifications. Under this scheme a certificate indicates that certain parameters of the amplifier have been measured according to standard procedures by an independent testing authority and that the manufacturer's claims for these parameters have been confirmed. The parameters which must be measured include the harmonic distortion, output power, sensitivity, frequency response, hum and noise, damping factor, cross-talk and power consumption. All this data must be quoted in technical publicity material, and any other data given in such material must also be checked under this scheme. The manufacturer must also undertake that all production models are made to the same standards as the tested sample, and a procedure is laid down for checking this in the event of a complaint. Any manufacturer can take part in this scheme: he does not have to be a member of the Audio Manufacturers' Group. Unfortunately this scheme was introduced too recently for any certificates under it to be shown at the recent International Audio Fair.

Brit.I.R.E. Research Students

DESIGNED to encourage fundamental research in radio and electronic engineering, Mountbatten Research Studentships are being established by the British Institution of Radio Engineers. It is intended to award one studentship in October, the second in October 1963, and thereafter as they become vacant. Each studentship will have an annual value of £500 plus university or college tuition fees, and will normally be tenable for two years, with the possible extension of one further year. Potential candidates for the studentships, who must be graduates or holders of diplomas in technology, may obtain application forms from the secretary of the Brit.I.R.E. at 9 Bedford Square, London, W.C.1.

The Pilkington Committee has, it is understood, told the Government that it can expect to receive the committee's report and recommendations on the future of broadcasting in the U.K. in June. It is reported that the Government intends to issue a White Paper giving its decisions on the recommendation early in July.

No Paris Radio Show.—It is announced that the Paris Radio and Television Show arranged tentatively for September 13th-24th, will not now be held.

International Television Conference.—London is the venue of the International Television Conference (May 31st-June 7th) organized by the Electronics and Communications Section of the I.E.E. in association with the Institute of Radio Engineers (N.Y.), the Television Society and the British Kinematograph Society. The association of the I.E.E. with the Institute of Radio Engineers in the conference provides an important example of Anglo-American co-operation in the professional electronics field which, it is hoped, will set a pattern for the future. About 1,500 delegates are attending, representing some 23 countries, and arrangements have been made for delegates to visit industrial organizations during the conference.

Television transmissions from the B.B.C.'s existing v.h.f. sound broadcasting station at Llanddona, Anglesey, North Wales, began on May 15th. Programmes are transmitted on Channel 1 (vision 45Mc/s, sound 41.5Mc/s), using vertical polarization. The B.B.C.'s new television station near Manningtree, Essex, was brought into service on May 22nd. Programmes are transmitted on Channel 4 (vision 61.75Mc/s, sound 58.25Mc/s) with horizontal polarization.

Beckley Transmitter.—The v.h.f. sound radio transmitters at the B.B.C.'s television station at Beckley, near Oxford, were brought into service on May 28th. As the service area for sound radio transmissions includes parts of the B.B.C.'s Midland and West Regions, the Beckley Station transmits both the Midland (93.9Mc/s) and West of England (95.85Mc/s) Home Services in addition to the Light Programme (89.5Mc/s), and the Third Programme and Network Three (91.7Mc/s). Horizontal polarization is used.

Common Market Tariffs.—Mr. John M. Howard, Parliamentary private secretary to Mr. Edward Heath, Lord Privy Seal, told delegates to the R.T.R.A. conference that in the short term, entry to the Common Market is not expected to result in any significant rise in the imports of either television or sound radio sets from European Economic Community members. Our present tariff on these goods is 20 per cent which on entry we would expect to cut by about half. In retail prices this would be equivalent to a drop of only about 5 per cent to 6 per cent.

Silver Medal of the Television Society for 1961, which is awarded "for outstanding artistic achievement in television," was presented to Richard Cawston, the B.B.C. senior documentary film producer, at the Society's annual dinner on May 11th. His outstanding documentary in 1961 was "Television round the world" for which he travelled through 20 countries studying the effect of television. When acknowledging the award he remarked that nowhere, no matter what the line standards—had he found television comparable with that in the U.K.

British Association's annual meeting in Manchester (August 29th-September 5th) will be presided over by Sir John Cockcroft, F.R.S The programme for the engineering section lists a number of subjects in our field, including semiconductors, new uses of computers, and industrial applications of data handling and processing.

V.T.R. in Europe.—Of Europe's 193 video recording installations 70 are in the U.K. The next biggest concentration is in Germany, where there are 52. Ampex installations total 163.

Cranfield Open Day.—The College of Aeronautics, Cranfield, Bedfordshire, is holding an Open Day on Saturday, June 30th. There will be an air display and flights from the airfield for members of the public. Lunch and tea will be available.

"Scaling of Analogue Computers": on page 219 of the May issue, in line 26 of the right-hand column, the two δ's should be deleted.

Video Tape Recorder Demonstrations.—An invitation is extended by RCA Great Britain Ltd. to readers of *Wireless World* to see the RCA transistor television tape recorder in operation at the studios of Iris Productions Ltd., Broom Road, Teddington, during the period May 31st to June 9th. The engineer responsible for the design of this switchable three-standard recorder (TR-22) will be in attendance. Readers should write to RCA Great Britain Ltd., Lincoln Way, Windmill Road, Sunbury-on-Thames, Middx., for an invitation card.

R.E.C.M.F. Officers.—At the recent A.G.M. of the Radio and Electronic Component Manufacturers' Federation Dr. G. A. V. Sowter was re-elected chairman. The new council is as follows: G. J. Taylor (Bakelite), N. D. Bryce (Belling-Lee), A. F. Bulgin (Bulgin), R. F. Collinson (Colvern), S. H. Brewell (A. H. Hunt), J. Thomson (Morganite Resistors), S. E. Jones (Mullard), R. Arbib (Multicore), P. M. Denham (Painton), J. A. Clark (Plessey), L. T. Hinton (S.T.C.), and Dr. G. A. V. Sowter (Telcon Metals).

E.E.A. Council.—Representatives of 15 member companies of the Electronic Engineering Association make up the new council for 1962. They are: V. M. Roberts (A.E.I.), C. H. T. Johnson (Decca Radar), C. Metcalfe (E.M.I. Electronics), W. R. Thomas (Elliott Brothers), J. O. Trundle (English Electric), W. D. H. Gregson (Ferranti), R. J. Clayton (G.E.C.), G. J. Kelsey (Marconi's), R. R. C. Rankin (Mullard), K. S. Davies (Murphy), M. W. Clark (Plessey), J. R. Brinkley (Pye Telecommunications), J. S. Turner (Redifon), C. G. White (S. Smith & Sons, Kelvin & Hughes Division), and L. T. Hinton (S.T.C.).

A memorial seat in recognition of the work done for experimental radio communications by the late Gerald Marcuse, is to be presented to the parish of Bosham, near Chichester, Sussex, where he lived for many years. The seat is being given by the Radio Amateurs and Old Timers' Association and the Radio Society of Great Britain. In addition a plaque has been fixed to the house at 14, Queens Park Road, Caterham, Surrey, from which Gerald Marcuse carried out his pioneer Empire broadcasts.

Seventy U.K. electronics firms in the component and instrument field have already expressed interest in participating in the British Electronic Component & Instrument Exhibition, which is to be held in Basle, Switzerland, from October 15th-20th this year under the auspices of the R.E.C.M.F. Full details are available from the organizers, Industrial Exhibitions Ltd., 9 Argyll Street, London, W.1. (Tel.: Gerrard 1622).

Receiving Licences.—The number of combined television and sound radio licences throughout the U.K. increased by 51,564 in February and a further 88,703 in March bringing the total to 11,833,712. Of the 3,538,507 sound only licences at the end of March, 495,699 were for sets fitted in cars.

East German television set production is planned to reach 500,000 this year. There are two state-owned set manufacturing companies in East Germany where the majority of sets have 17in screens. The average retail price is equivalent to about £145—there are no hire purchase or rental facilities.

Dutch Show.—W. van der Horst, editor of *Radio Electronica,* of Holland, has advised us that as there will not be a Firato in Amsterdam this year he is organizing a show of electronic equipment in the Apollo Hall, Amsterdam, from October 1st-6th.

Berlin will again be the venue of the next German Radio Show which will be held from August 30th-September 8th, 1963.

Television Society Premiums.—The following awards have been made by the Television Society to the authors of the papers quoted, which were read before the Society in 1960-61:—

Electronic Engineering premium to I. J. P. James (E.M.I.) for "Colour Television Camera Problems."

E.M.I. premium to Dr. W. E. Glenn (General Electric, New York) for "Thermoplastic Recording."

Mervyn premium to Dr. D. E. N. King (Hirst Research Centre, G.E.C.) for "Transparent Phosphor Screens."

Mullard premium to D. C. Brothers (B.B.C.) for "Contrast Law Correction in Television Picture Generators."

Pye premium to E. R. Rout and R. F. Vigurs (B.B.C.) for "A Wide Range Standards Converter."

T.C.C. premium to Dr. H. Barnes (The Marine Station, Millport) for "Underwater Television in Marine Biology," and

Wireless World premium to J. Roizen (Ampex International, Switzerland) for "The Use of Video Tape for Colour Television Recording."

Mullard Educational Service has added five more pamphlets to its "Demonstrations and Experiments in Electronics" series. They are: No. 17, A Transistor Ratemeter; No. 18, Valve and Transistor Characteristic Displays; No. 19, A Transformer with Exchangeable Windings; No. 20, The Mullard Pegboard Circuit System; and No. 21, A Transistor Tester for Schools. Requests for copies of these pamphlets should be addressed to Mullard Educational Service, Mullard House, Torrington Place, London, W.C.1.

Educational services of the International Nickel Company (Mond.) Ltd., Thames House, Millbank, London, S.W.1, are described and illustrated in two new booklets available free of charge on application to the company. Publication 2414, directed at lecturers in universities and technical colleges, describes Inco Mond educational aids in metallurgy, physics, chemistry and engineering and lists literature describing the properties and applications of nickel-containing materials used in electronics. Publication 2415, directed at science masters teaching at G.C.E. O and A levels, lists specimens, photographs and samples, wall charts, films and literature dealing with nickel production and applications.

The Nuffield Foundation has set aside £250,000 towards the cost of a comprehensive long-term programme to improve the teaching of science and mathematics in schools. Co-ordination of the whole programme will be undertaken by the director of the Foundation, Dr. Leslie Farrer-Brown, in consultation with the Ministry of Education, professional institutions and industry.

Rutherford Scholarship.—The Council of the Royal Society has appointed K. S. Imrie, of the University of New England, Armidale, New South Wales, to a Rutherford Scholarship for three years, to work at the Nuffield Radio Astronomy Laboratories, University of Manchester.

Personalities

P. P. Eckersley, M.I.E.E., F.I.R.E., on his retirement from the Telephone Manufacturing Company, has taken up consulting work. In this capacity he is engaged by T.M.C. to look after, notably, educational work. He has also been appointed chairman of Communication Consultants Ltd., a company which undertakes consulting services relating to telecommunications. The Canadian Overseas Telecommunications Corporation has engaged Mr. Eckersley as inspector for equipment purchased in this country by the Corporation.

E. F. Woods, M.B.E., B.Eng. (Hons), assistant to the superintendent engineer, lines, has retired after nearly 33 years' service with the B.B.C. He has been concerned with many developments in the Lines Department, in both the sound and television fields, and was awarded the M.B.E. in 1959 in recognition of his services to broadcast engineering. In 1956 Mr. Woods was seconded temporarily to the European Broadcasting Union to assist with the technical arrangements for Eurovision programme exchanges.

The B.B.C. announces the appointment of **B. Weisman,** B.Sc.(Eng.), A.M.I.E.E., as head of the L.F. Studio Section, Planning and Installation Department, in succession to **O. H. Barron,** M.B.E., B.Sc., A.M.I.E.E., who retired recently after nearly 40 years' service. Mr. Weisman joined the Corporation in 1932 as an assistant maintenance engineer in the London control room. He went into the Planning and Installation Department in 1941 when the L.F. Studio Section was formed and has been concerned with many of the B.B.C.'s major studio and control room developments during the post-war years.

R. J. Mildwidsky, B.Sc.(Eng.), A.M.I.E.E., chief engineer of Rank Relay Services Ltd., has been elected president of the Society of Relay Engineers and **A. Burke,** A.M.Brit.I.R.E., of British Relay Wireless, has been elected vice-president.

R. M. Barnard, B.Sc., A.M.I.E.E., has been appointed to manage the Magnetic Materials Division of Standard Telephones and Cables. He joined S.T.C. in 1928 as a student and after spending some time on various radio receiver projects, ranging from ship-to-shore radio links and aircraft receivers to domestic types, published a book, "Radio Receiver Measurements." On transfer to the S.T.C. Transmission Division in 1934 he studied the measuring problems associated with circuits for multi-channel telephone systems and television.

R. M. Barnard

Dr. G. N. Roberts

G. N. Roberts, B.Sc., Ph.D., A.M.I.E.E., has been appointed manager of the Capacitor Division of the Components Group of Standard Telephones and Cables Ltd. at Paignton, Devon. Dr. Roberts, formerly chief product engineer with S.T.C.'s Transistor Division at Footscray, Kent, which he joined in 1957 after three years with Plessey, has taken over the management of the division following the appointment of its former manager **D. Stevenson** as European Sales Manager for Components, for the International Telephone and Telegraph Corporation.

G. D. Smith, A.M.Brit.I.R.E., chief electronics engineer of Plessey Nucleonics Ltd., has received from the City and Guilds of London Institute the Insignia Award in Technology (C.G.I.A.). His thesis was entitled "Electronic Methods of Measuring Nuclear Radiation Hazards." After leaving the Wireless College, Colwyn Bay, in 1944, he joined the Test Department of E. K. Cole Ltd., at Malmesbury, where he was a "founder member" of the nucleonics development department set up in 1947. **Mr. Smith,** who is 35, joined Plessey in 1957.

The C.G.I.A. has also been conferred upon **J. W. Stark,** A.M.Brit.I.R.E., a member of the B.B.C. Research Department. Mr. Stark commenced his career with the Post Office Engineering Department and while there was seconded to Germany and Nyasaland. He also served with the Cyprus Inland Telecommunications Authority as a senior executive engineer. Mr. Stark is currently working on tropospheric propagation.

K. J. Powell, a 21-year-old Marconi technician apprentice, has been presented with the 1961 Goldup Prize by the Institution of Electrical Engineers. This prize is awarded annually to the student who obtains the best result in the Higher National Certificate examination taken throughout the country. In the H.N.C. telecommunications examination he achieved 97% in mathematics, 96% in electrical engineering and 85% in radio engineering. On completion of his five-year apprenticeship in September of this year, he hopes to spend three years at Bangor University and then return to the Marconi Company as a development engineer.

R. P. Henegan, Assoc.Brit.I.R.E., has been appointed commercial manager of Technograph Electronic Products Ltd., of Fleet, Hants. A member of the Society of Instrument Technology, he served in the Radar Branch of the Royal Navy during the war and was subsequently with E.M.I. Research Laboratories and Decca Radar. Joining the technical sales staff of Gresham Transformers in 1953 he was appointed commercial manager of the Electronic Transformers Division in 1956, which position he relinquished to take up his new appointment.

T. S. Woodget, M.Brit.I.R.E., and **A. J. Minns** have been appointed to the board of the M-O Valve Co. Ltd., a wholly owned subsidiary of the General Electric Company. Formerly works manager, Mr. Woodget is now production director of M-O Valve, having been associated with the company since 1934. Mr. Minns is managing director of Watson & Sons (Electro-Medical) Ltd., with which company he has been associated for 36 years. He is also on the board of Machlett X-Ray Tubes (Great Britain) Ltd., another of the G.E.C. subsidiary companies.

A. P. C. Thiele, B.Sc., A.Inst.P., has been appointed head of scientific information services of Gulton Industries (Britain) Ltd. of Brighton. Mr. Thiele will also be responsible for the information services of Gulton associated companies, West Instrument Ltd., and Mervyn Instruments Ltd. Until recently he led the Applied Solid State Physics Group of Cossor Radar & Electronics.

R. J. F. Howard has been appointed a director of Metal Industries Ltd., the parent company of the group which includes Avo, Taylor Electrical Instruments and Lancashire Dynamo. He joined Lancashire Dynamo Electronic Products (then British Electronic Products) as chief engineer in 1947 and has been a director since 1954. After initial training with Harries Thermionics he joined Mullard as engineer-in-charge of receiving valve quality control and in 1945 went to English Electric where he took charge of the industrial electronic equipment development laboratory.

G. G. E. Blagdon, A.M.I.E.E., has joined the staff of the Operations and Maintenance Department of the Independent Television Authority as assistant to the Senior Engineer (Operations). He was previously employed by Standard Telephones & Cables Ltd. on the development and installation of radio and television transmitters and spent one year in Sweden installing equipment at the Stockholm broadcasting station.

Managing Director of Decca Radar since its formation 12 years ago, **Group Captain E. Fennessy,** C.B.E., B.Sc., for 25 years intimately connected with radar and electronics in both Government service and commerce, has been appointed to the board of Decca Ltd., the newly formed holding company for the Decca Group. Grp. Capt. Fennessy is also a director of the British Space Development Company.

C. W. Robson, B.Sc.(Eng.), M.I.E.E., A.M.I.Mech.E., who is retiring shortly from his post as vice-principal and head of the department of electrical engineering and applied physics, South East London Technical College, Lewisham, is taking up an appointment as educational officer of the Scientific Instrument Manufacturers' Association, 20 Queen Anne Street, London, W.1, in succession to **S. C. Laws,** who has retired from the position.

Kenneth B. Hogg was recently appointed general works manager of Electronic Instruments Ltd., of Richmond, Surrey. He is 40. In 1946, after demobilization from the Royal Artillery in which he was a major, he joined Ferranti at Edinburgh where, three years later, he became manager of the General and Electrical Engineering Department. In 1957 he joined A.E.I. as works manager of three factories (valves, cathode-ray tubes and batteries) at Brimsdown, and since 1958 has been general works manager of the five factories of A.E.I.s Radio and Electronic Components Division.

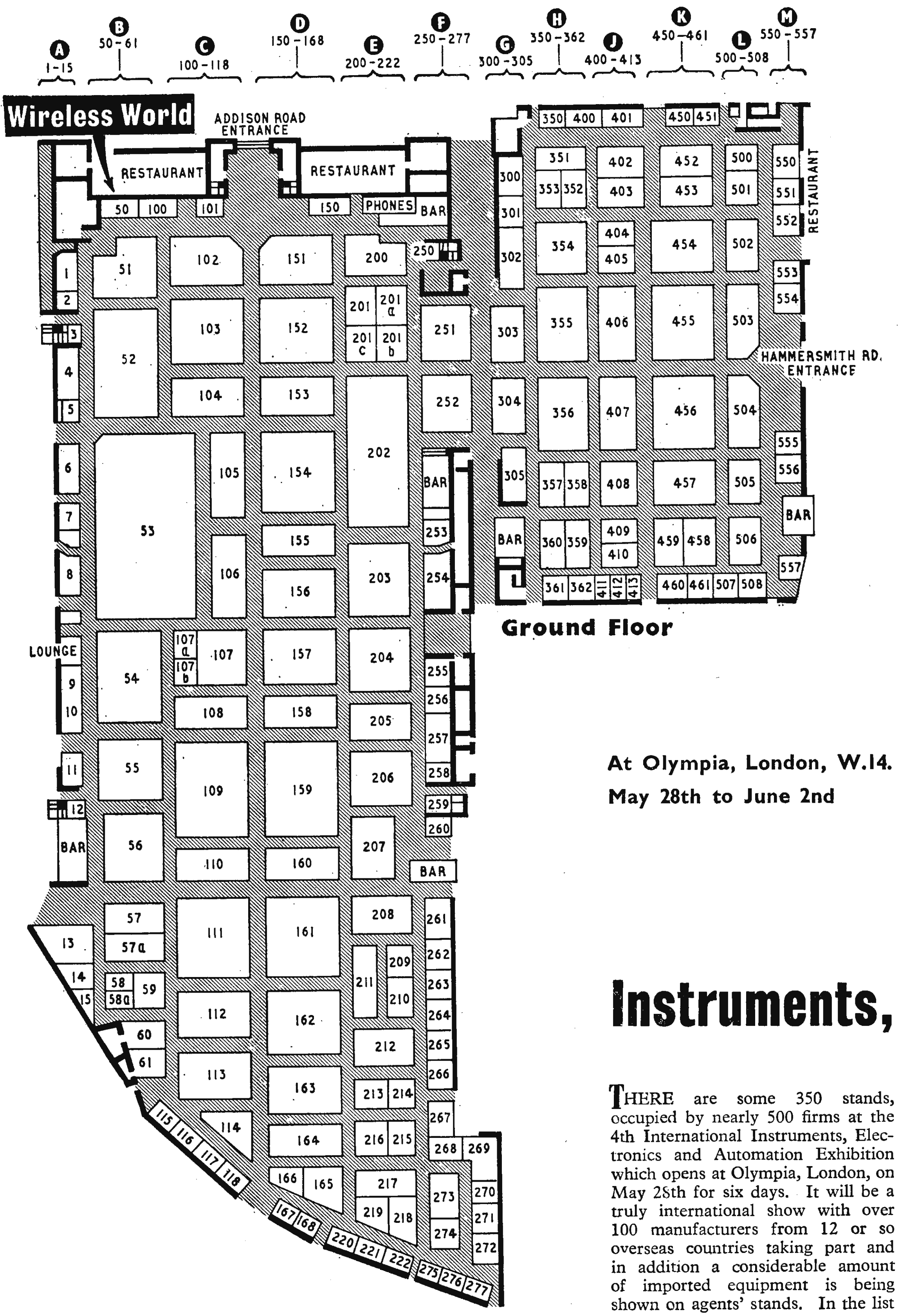
OUR AUTHORS

W. R. Daniels, C. de G., whose article on storage tubes is published in this issue, was educated at the Sorbonne in Paris and worked on photomultipliers, camera tubes and related devices under Professor A. Lallemand at the Observatoire de Paris. He came to this country in 1949 and since 1956 has been with 20th Century Electronics where he is senior development engineer on photoelectric devices and radiation detection tubes. He is at present investigating new target systems for storage tubes. Between 1949 and 1956 he was first with Cintel and then Cathodeon.

A. L. Hands, B.Sc.(Eng.), author of the article in this issue on automatic relay stations has been employed by the B.B.C. since 1955 in the transmitter equipment section of the Planning and Installation Department. Prior to that, apart from absence on National Service, Mr. Hands was for ten years at the Post Office Research Station, Dollis Hill, working mostly on light electrical contacts and magnetic materials for relays.

OBITUARY

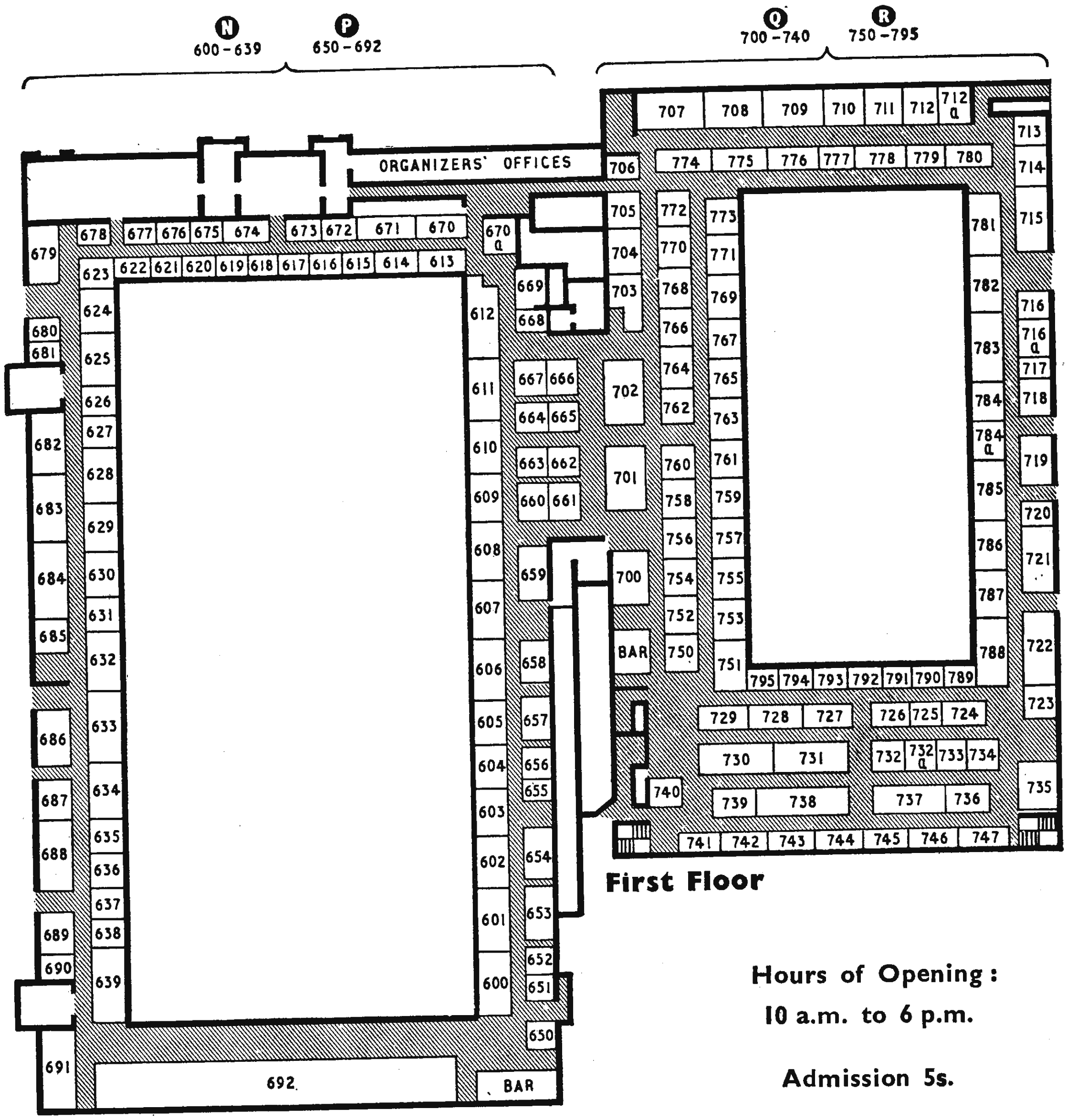
Cuthbert George Withey, A.M.I.E.E., technical manager of International Marine Radio Company, which he joined as a radio officer in 1932, died on April 28th, in his 56th year. He was a member of the staff of *Queen Mary* on her maiden voyage in 1936. Mr. Withey represented I.M.R.C. at many international conferences and was well known in international maritime circles.



At Olympia, London, W.14.
May 28th to June 2nd

Instruments,

THERE are some 350 stands, occupied by nearly 500 firms at the 4th International Instruments, Electronics and Automation Exhibition which opens at Olympia, London, on May 28th for six days. It will be a truly international show with over 100 manufacturers from 12 or so overseas countries taking part and in addition a considerable amount of imported equipment is being shown on agents' stands. In the list



First Floor

Hours of Opening:

10 a.m. to 6 p.m.

Admission 5s.

Electronics and Automation Exhibition

of exhibitors on the following pages we have included the country of origin of most overseas manufacturers, and in many cases their U.K. agents' names in parentheses.

The title of the show is all-embracing and it is very apparent from announcements made by exhibitors that there will be a wide diversity of equipment at the exhibition which will be by far the largest of the series. Although the Radio and Electronic Component Manufacturers' Federation is not one of the sponsors, many component manufacturers are, in fact, participating.

It is hoped that with the above plans and the list of exhibitors visitors will readily be able to find particular manufacturers' stands. It will be seen that the stand numbers are keyed to letters which are marked at the top of the plans.

We hope to review in our next issue some of the outstanding equipment shown at the exhibition which is organized by Industrial Exhibitions Limited, on behalf of five industrial associations.*

Admission to this biennial exhibi-

* British Electrical and Allied Manufacturers' Association, British Industrial Measuring & Control Apparatus Manufacturers' Association, Drawing Office Material Manufacturers' and Dealers' Association, Electronic Engineering Association and Scientific Instrument Manufacturers' Association.

tion, which occupies both the Grand Hall and National Hall, costs 5s, or 10s for the week. The hours of admission are from 10.0 to 6.0. It will be opened officially by L. A. Woodhead, of Cossor Instruments, who is chairman of the exhibition committee, at 11.30 on the 28th.

An electronics conference was held during the last show in 1960, but this year the organizers are concentrating on the exhibition itself.

LIST OF EXHIBITORS

Exhibitor	Stand No.
A. K. Fans	N 614
A.P.T. Electronic Industries	P 666
Acbars	R 793
Accurate Recording Instrument Co.	Q 742
Adar (S.A.R.L.), *France*	R 767
Addo	N 601
Advance Components	G 302
Air Control Installations	Q 741
Aircraft-Marine Products	L 502
Airflow Developments	C 101
Airmec	D 152
Alexander Controls	E 214
Alma Components	F 263
Alston Capacitors	F 263
Alto Instruments	P 655
Ampex Great Britain	E 211
Amphenol-Borg	R 763
Analac, *France*	Q 737
Analytical Measurements	M 557
Ancillary Developments	R 790
Anglo-American Vulcanized Fibre Co.	R 765
Appareils Lhomargy, *France*	P 692
Ardente Acoustic Laboratories	P 670
Armstrong Whitworth	D 163
Arrow Electric Switches	Q 730
Associated Automation	B 53
Associated Electrical Industries	E 202
Associated Iliffe Press	B 50
Association des Ouvriers en Instruments de Precision, *France*	Q 739
Ateliers de Construction de Bagneux, *France* (Electro Mechanisms)	H 358
Atlas Mess- und Analysentechnik	C 107a
Atlas Plating Works	N 617
Atohm Electronics	R 785
Aumann W.K.G., *W. Germany* (R. H. Cole)	P 654
Automatic Control Engineering	Q 703
Automatic Information Data Service	H 362
Automation Systems & Controls	D 159
Autronic Developments	P 690
Aveley Electric	C 113
Avery, W. & T.	A 13
Avo	B 57a
BEME Telecommunications	N 607
B. & K. Laboratories	D 156
B. & R. Relays	P 683
Bach-Simpson, *Canada* (Aveley Electric)	C 113
Bailey Meters & Controls	D 153
Baird & Tatlock (London)	Q 722
Baldwin Industrial Controls	A 8
Balzers High Vacuum	Q 712
Barden Corporation	B 59
Barr & Stroud	Q 713
Beaudouin, *France*	P 692
Beckman Instruments	E 207
Belclere Co.	P 672
Belix Co.	Q 743
Belling & Lee	D 151
Bellingham & Stanley	A 3
Bendix Ericsson	E 200
Bernstein-Werkzeugfabrik, *W. Germany*	J 411
Beulah Electronics	J 411
Blackburn Electronics	D 163
Boulton Paul Aircraft	R 781
Bradley, G. & E.	C 114
Brandenburg	R 788
Bribond Printed Circuits	N 609
Bristol Aircraft	N 606
Bristol's Instrument Co.	B 53
British Aircraft Corporation	N 606
British Electric Resistance Co.	L 508
British Insulated Callender's Cables	P 684
British Physical Laboratoreis	K 450
British Pitometer	R 792
British Rototherm	A 7
Brooks Instrument	R 745
Brown, Neville & Co.	Q 706
Brown, S. G.	N 613
Brush Crystal	N 624
Bryans Aeroquipment	F 265
Budenberg Gauge Co.	F 257
Bulgin, A. F., & Co.	E 201b
Burgess Products Co.	P 682
Burndept	D 167
Burtonwood Engineering Co.	Q 712a
Bush Beach & Segner Bayley	P 660
C.R.E.I. (London)	Q 728
C.Z. Scientific Instruments	E 206
Cambridge Instrument Co.	C 102
Cannon Electric (G.B.)	Q 710
Carr Fastener Co.	J 402
Casella, C. F., & Co.	F 262
Cathodeon Crystals	L 500
Cawkell Instruments	E 205
Chapman Ultrasonics	N 607
Chesterman, James, & Co.	Q 747
Clarke, H., & Co. (Manchester)	R 783
Cobham, Alan, Engineering	N 618
Cole, R. H. (Overseas)	P 654
Colvern	R 778
Communication Systems	Q 702
Comoy, H., & Co.	N 635
Compagnie de Regulation et de Controle Industriel, *France*	P 692
Compagnie des Computeurs, *France*	P 692
Compagnie Francaise Thomson-Houston, *France* (M.C.P. Electronics)	R 756
Compagnie Generale de Metrologie, *France*	P 692
Compagnie Generale de T. S. F., *France*	Q 737
Compagnie Industrielle des Telephones, *France*	P 692
Connollys (Blackley)	N 608
Consolidated Electrodynamics Corporation	K 461
Constructeurs d'Appareils de Controle, *France*	P 692
Constructeurs de Compteurs et Transformateurs de Mesure, *France*	P 692
Constructeurs Francais de Relais Electriques, *France*	P 692
Constructions Radioelectriques et Electronics du Centre, *France*	P 692
Continental Connectors	P 680
Control	P 686
Control Instruments	Q 720
Control de Chauffe, *France*	P 692
Cooke, Troughton & Simms	R 769
Cossor Group	H 355
Counting Instruments	P 659
Crompton Parkinson	E 213
Crosby Valve & Engineering Co.	K 458
Crouzet England	P 664
Croydon Precision Instrument Co.	R 775
Crystal Structures	N 622
Cybermeca, *France*	P 692
Dartronic	R 784a
DEAC (Great Britain)	P 657
Datum Metal Products	D 159
" Davu " Wires & Cables	M 555
Dawe Instruments	E 205
Daystrom	N 602
De Havilland Aircraft Co.	D 163
Degussa Hanau, *W. Germany* (Bush Beach & Segner Bayley)	P 660
Delta Technical Services	Q 717
Department of Scientific & Industrial Research	B 51
Deutsche Export-und Import-gesellschaft, *W. Germany* (C.Z. Scientific Instruments)	E 206
Deutscher Innen-und Aussenhandel Elektrotechnik, *E. Germany* (Telemechanics)	N 633
Devar Controls	B 53
Dewrance & Co.	N 629
" Diamond H " Switches	F 267
Direct T.V. Replacements	J 411
Direct T.V. Windings	J 411
Dobbie McInnes (Electronics)	C 117
Doran Instrument Co.	N 607
Dowty Group	R 781
Drayton Controls	E 203
Dubilier Condenser Co. (1925)	N 611
Dr. Duerrwaechter-Doduco-K.G., *W. Germany* (Joseph Electronics)	N 600
Dynatron Radio	N 637
E-A Automation Systems	B 53
E.M.I. Electronics	K 454
Egen Electric	Q 729
Ekco Electronics	C 105
Elcom (Northampton)	Q 716
Electrical Development Assn.	J 403
Electrical Remote Control Co.	M 553
Electro-Logic Corpn.	R 785
Electro Mechanisms	H 358
Electroflo Meters Co.	B 53
Electrolube	N 620
Electronic Associates	Q 700
Electronic Technology	B 50
Electronic Instruments	C 102
Electronic Machine Co.	R 752
Electronic Vibrators	N 607
Electronics & Automation (London)	P 657
Electrosil	L 503
Electrovac, *Austria* (Joseph Electronics)	N 600
Electroweighters (Birmingham)	P 658
Elga Products	A 5
Elliott-Automation	B 53
Elliott Brothers (London)	B 53
Elliott Brothers (London)	Q 745
Emeco Electronics Co.	P 657
Endecotts (Filters)	F 260
English Electric Co.	D 157
English Electric Aviation	N 606
English Electric Valve Co.	E 208
English Glass Co.	Q 734
English Numbering Machines	F 271
Epsylon Industries	K 460
Equipment & Services	M 553
Erg Industrial Corporation	Q 727
Ericsson Telephones	E 200
Erie Resistor	P 661
Etablissements Brion Leroux et Cie, *France*	P 692
Ets. Edouard Bouty et Cie, *France*	P 692
Etablissements Jules Richard	P 692
Etablissements Maxant	P 692
Etablissements Pierre Fontaine	P 692
Ether Langham Thompson	D 159
Evans Electroselenium	A 9
Everett, Edgcumbe & Co.	J 404
Evershed & Vignoles	H 356

	Stand No.	
Fairchilds Camera & Instrument Corp. U.S.A.	C	113
Fairey Engineering	H	359
Farnell Instruments	R	791
Farris Engineering	B	53
Ferranti	C	112
Fielden Electronics	K	457
Filhol, J.P.	P	651
Fireye Controls Co.	N	628
Fischer & Porter	A	4
Fisher Governor Co.	B	53
Flexonics	H	358
Floform Parts	R	782
Flow Developments	P	656
Formica	H	360
Fortiphone	D	168
Foster Instrument Co.	J	410
Foxboro-Yoxall	J	407
Friden	Q	709
Fuchs, Arno L., *W. Germany* (R. H. Cole)	P	654
Furzehill Laboratories	R	760
G.E. Electronics (London)	P	691
Gauthier-Villars (Pergamon Press)	N	615
General Controls	C	116
General Electric Co.	K	456
General Post Office	N	625
General Precision Systems	P	667
General Radio Co.	N	610
General Radiological	R	786
Gilmor Control Systems	B	53
Glass Developments	A	12
Gloucester Controls	Q	723
Goodman, George	R	782
Goodmans Industries	L	504
Gordon, James, & Co.	B	53
Graph Instruments	Q	718
Graviner Manufacturing Co.	R	789
Grundy & Partners	K	451
Gruner, W., K.G.	P	691
Guest, Keen & Nettlefolds	R	782
Gulton Industries (Britain)	A	10
Guyson Industrial Equipment	N	630
H.J.S. Industrial Instruments	R	774
Haefner & Krullmann	P	654
Halex Inc.	R	785
Hall Harding	D	161
Hallam, Sleigh & Cheston	F	254
Hallikainen Instruments	B	53
Harper & Tunstall	R	762
Harris Plating Works	E	220
Harwin Engineers	P	687
Hassett & Harper	P	678
Hatfield Instruments	M	552
Hawker Siddeley	D	163
Headland Engineering Developments	N	631
Heathway Machinery Co.	F	272
Hellermann	Q	719
Hendrey Relays	E	209
Henry & Thomas	P	670a
Herbert Publishing Co.	A	6
Hilger & Watts	R	751
Hirschmann Richard	R	678
Hirst Electronic	R	755
Hivac	Q	702
Honeywell Controls	E	204
Houston Instrument Corp.	R	785
Hughes International (U.K.)	N	604
Hunt, A. H., (Capacitors)	B	57
Hunt & Mitton	L	501
I.D.M. Electronics	R	759
I.G.A. (Electronics)	N	619
Ide, T. & W.	F	250
Ilford	N	639
Imhof, Alfred	Q	701
Imperial Chemical Industries	R	771
Industrial Control Valves	R	774
Industrial Pyrometer Co.	R	774
Industries de Materiel Professionnel Electronique et Radio-electrique, *France*	P	692
Industries de l'Optique et des Instruments de Précision, *France*	P	692
Infra Red Development Co.	R	751
Instron	N	605
International Electronics	Q	704
International Gas Detectors	R	777
International Systems Control	K	456
Intertechnique, *France*	P	692
Ionic Plating Co.	R	782
Isora Illuminating Ceilings	H	358
Jackson Brothers (London)	Q	733
Jenaer Glaswerk Schott & Gen., *W. Germany*	N	632
Joseph Electronics	N	600
Joyce, Loebl & Co.	F	276
K.D.G. Instruments	F	266
K.L.G. Sparking Plugs	H	354
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Kumag A.G., *Switzerland* (R. H. Cole)	P	654
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L.P.S. Electrical Co.	M	555
LSB Components	N	607
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M-O Valve Co.	K	456
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Societe Europeene des Semiconducteurs *France*	R 756
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Woden Transformer Co.	E 201
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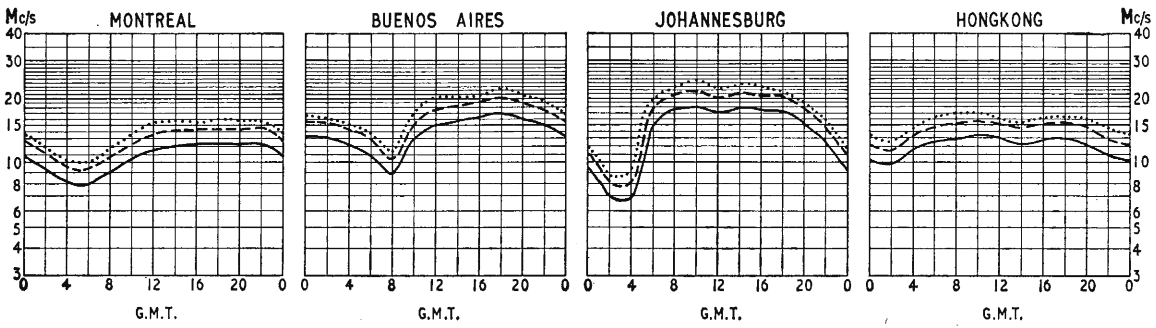
X-Lon Products	J 413
Zeal, G. H.	H 357

SHORT-WAVE CONDITIONS

Prediction for June



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

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

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

— — — PREDICTED MEDIAN STANDARD MAXIMUM USABLE FREQUENCY

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

Industrial Electronics

DISCUSSION OF RECENT DEVELOPMENTS AT THE BRIT.I.R.E.

THE arbitrary confinement of branches of electronic engineering into "classes" is becoming increasingly more difficult to justify and the one called "Industrial Electronics" is already in an advanced state of disintegration.

This was amply demonstrated at the symposium on industrial electronics recently held by the British Institution of Radio Engineers. The papers presented were in four classes, with enough left over for a "special" section, and covered subjects ranging from analogue computers to milk delivery trucks.

Possibly the best-represented facet of the art was that concerned with equipment for automatic manufacture and processing. A paper by D. Hinchliffe *et al* described a machine for the automatic assembly of printed boards. Components such as resistors, tubular capacitors, diodes and, in some cases, transistors are loaded into hoppers, from where they are selected one by one and transferred to a testing station where punched-tape-programmed tests are applied. Further taped instructions cause two component holes to be drilled in the printed board, and the component is inserted, the polarity being checked in the case of diodes or electrolytic capacitors. The machine is designed to effect greatest economies in small batch production rather than in large runs, and is ten times as fast in operation as a human, who would take about 30 seconds to insert a component and clinch the wires. Programming takes about 1½ hours for a 50-component board.

The extension of computer control from a single process to a complete plant is attended by many problems. For instance, as computers increase in size, the results of a fault become more serious, and "down" time is increased. The onset of a fault in, say, the control centre, would disorganize the whole process, and, in any case, to handle all the information required by, and furnished by, a complete works, would require a very fast computer.

In an effort to render the problem more tractable, a different philosophy of organization has been evolved, and was described by J. F. Roth. Known as the Hierarchy System, it is modelled on the normal system of human management in that separate, simpler computers are employed at each level of "authority." Thus, if a fault occurs in one computer, the effect is less, it is easier to remedy, and it is possible to transfer the function to some other computer on the same level. The only on-line equipment is that directly concerned with plant operation; other sections, which do not operate in real time, are provided with magnetic film stand-by stores to provide up to eight hours of emergency operation.

In spite of reduced labour costs, the material content of an automatically produced object is not affected, and scrap costs are still important. Also, apart from the fact that customers are coming to expect higher quality, many automatic assembly machines just will not work with out-of-tolerance components; their limited intelligence simply cannot realize that they will "do themselves a mischief" if they try. Automatic inspection of components is now seen to be necessary, and John A. Sargrove described some ways of achieving it.

The main section of his paper was concerned with cybernetic or conscious machines which, to some extent, are able to make decisions on the results of measurement. For example, in the case of a taper bearing or a nozzle, the exact dimensions at different points on the taper are not as important as the shape of the component. The machine has to decide, on the result of the first measurement, whether a measurement somewhere else is acceptable. If the first measurement is on or near one of its limits, the second measurement must be given a new set of limits. In cases where many measurements are needed, the object is moved along a number of test stations, the results being stored and later used to formulate a pass/reject decision. Mr. Sargrove made the point, in passing, that the various types of logic block, together with their different connectors, that are now being produced are all very fine, but in dire need of rationalization.

A paper by D. Shaw brought into much finer focus the somewhat woolly term "reliability." The paper contained a full specification which is used by the author's firm when extending invitations to tender and when placing orders. The fact that the overwhelming majority of electronic equipment is intended for either laboratory use, where skilled engineers are available, or for domestic use, where operating time is short and an evening without the "telly" no disaster, is responsible for a pronounced dearth of information or guidance on the conditions under which industrial equipment must operate. Furthermore, those responsible for planning courses on electronic engineering, or lecturing in them, are usually engaged in occupations far removed from the vibrations of the drop forge, or the fumes of the coke ovens, and little weight is placed on these considerations. The specification is intended to ensure the use of equipment which, while replacing two men, does not require three to maintain it.

High-Quality Sound Production and Reproduction

THIS new *Wireless World* book was written by H. Burrell Hadden of the Central Programme Operations Department of the B.B.C. for both technical and non-technical B.B.C. personnel to enable them to obtain the best possible results from their studio equipment. However, any amateur or professional in this field should also find this book of great value.

The book is divided into three parts. The first of these covers the basic theory of sound, electricity, and musical and studio acoustics. The second part discusses both the theory and practice of studio equipment, including microphones, loudspeakers, tape and disc recorders, control desks, and outside broadcast and public address systems. The third part of the book deals with programme control—the placing of microphones, sound effects, and stereophony.

This book has 274 pages, which include 175 diagrams and 46 photographs. It costs 42s, and is published by Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.1.

G.P.O. Satellite Communications Station

A SERIES of experiments to assess the technical feasibility of long-distance communication by artificial earth satellites is to be undertaken during the next few months by the British G.P.O. and other European administrations in co-operation with United States National Aeronautics and Space Administration (N.A.S.A.). Television, telephone, telegraph and other signals are to be transmitted between ground stations in the U.S.A. and the U.K. satellite communication ground station at Goonhilly Downs, Cornwall, which is now nearing completion.

N.A.S.A. are to launch two experimental satellites of the active type during 1962. The first satellite, called "Project Telstar" and described on page 208 of last month's issue, is expected to be launched this month (June). The second satellite, known as "Project Relay," is due to be launched later in the year.

The site of the Goonhilly experimental station was chosen to be as far west as possible to obtain a maximum period of visibility to the U.S. via the satellite; also its latitude is convenient for satellites in equatorial orbits. In addition, it was selected so as to be remote from sources of radio interference, and also to provide an unobscured view to the horizon so that, whatever the orbit, contact with the satellite is the longest possible (10 to 35 minutes).

The station is equipped with an 85ft diameter paraboloidal-reflector dish aerial with full steerability, either by manual or automatic control, over the hemisphere above the horizontal plane. Testing and experimental facilities are lavish. The following facilities are among those being provided: a 5kW transmitter operating at 6,390 Mc/s for Project Telstar; and a 10 kW transmitter (1,725 Mc/s) for Project Relay; low-noise receiving equipment for the 4,170 Mc/s communications signals and the 4,080 Mc/s beacon signal transmitted from the satellite; terminal equipment for the transmission and reception of multi-channel telephony and television signals; a two-way microwave link to the main U.K. television network; multi-channel telephony and teleprinter links; and time and frequency standards.

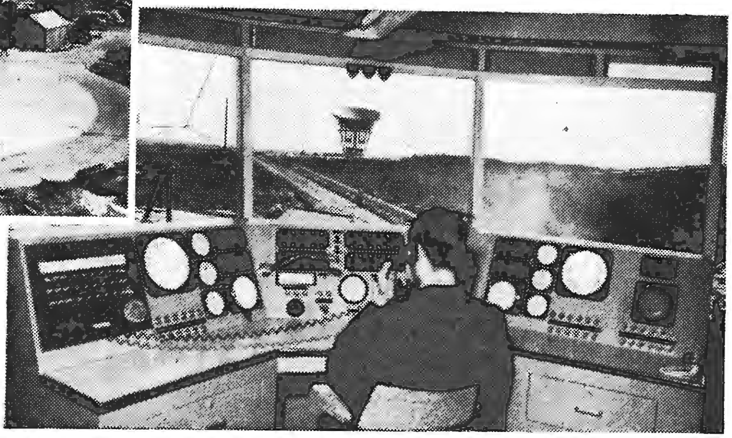
Because of the very narrow beam, only one-fifth of a degree in width, the aerial has to be pointed at the satellite with great precision, and in order to maintain this in high winds, the aerial is very massive and of sturdy construction. The rotating part of the aerial weighs nearly 900 tons and is driven by electric motors of some 100 horse-power. Nevertheless, this large structure is so well balanced and moves so smoothly that it requires less than two horse-power to move it under reasonable weather conditions. With wind velocities of above 75 m.p.h. it is necessary to clamp the aerial with the axis of the reflector in a vertical position.

Orbital information for steering the aerial is obtained over a telegraph circuit from the National Aeronautics and Space Administration Goddard Space Flight Control Centre in the U.S.A., and an electronic computer is provided in the Goonhilly station to process the data into a suitable form for accurately steering the aerial.

Since signals received from the satellite would be very weak, an extremely low-noise amplifier is used to amplify the signals. This is, in fact, a ruby travelling wave maser amplifier operating at 4,170 Mc/s, with which figures of 20dB power gain over a bandwidth of 25 Mc/s have been exceeded. The signal applied to the maser input is expected to be of the order of 10^{-12}W or even less. The maser is located in a cabin at the back of the dish aerial, and is immersed in liquid helium and nitrogen. Microwave transmitters, producing outputs of 5 to 10kW, are located in the cabin on the aerial turntable.

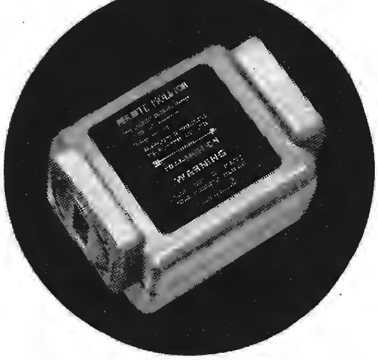
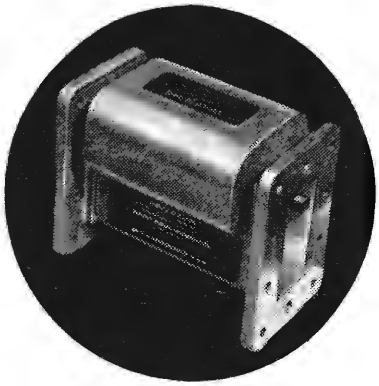
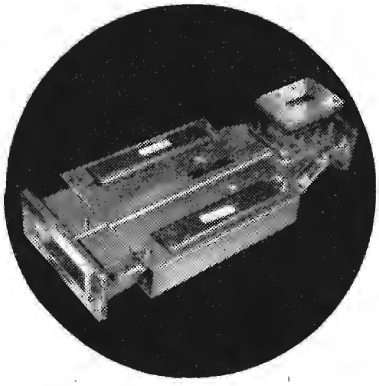
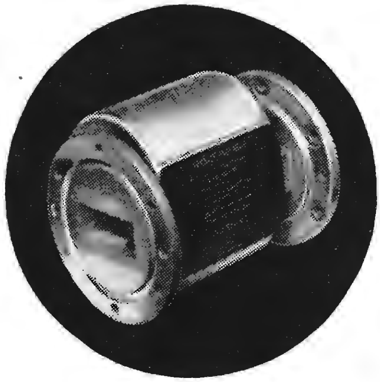
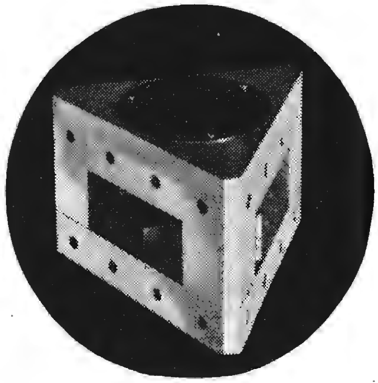
A great deal of complex test equipment is provided in the station for carrying out tests over the satellite link. This includes equipment for generating both still and moving pictures using British, European and American line standards. Test equipment is also provided which enables up to 600 telephone circuits to be simulated for transmission over the satellite link. Almost all the equipment at Goonhilly is of British design and manufacture.

During the setting up of the installation in the next few weeks the radio emissions from the radio star in Cassiopeia will be used for calibration purposes.



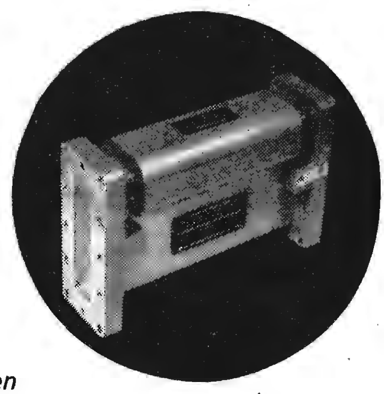
Rigidity is essential for the 900-ton paraboloid which has a beam width of only one-fifth of a degree.

Movements of the automatically steered aerial are metered in the console room in the control tower.

FERRITE COMPONENTS

More than sixty ferrite components are now available from Marconi's. The list includes isolators and circulators for operation at frequencies from 380 Mc/s to over 10,000 Mc/s. Special designs can be produced to meet individual requirements.



The Specialized Components Catalogue lists over 110 Marconi Components, the design and manufacture of which are undertaken only when no suitable alternative is available, and in almost every case Marconi components are designed for higher performance and are made to closer tolerance than any available alternative.

MARCONI

SPECIALIZED COMPONENTS

Please address your enquiries to: **SPECIALIZED COMPONENTS DIVISION**
MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED, CHELMSFORD, ESSEX, ENGLAND

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INTERNATIONAL AUDIO FESTIVAL

RECENT DEVELOPMENTS IN SOUND REPRODUCTION

THE main developments shown at this year's exhibition seem to have been in the field of tape recorders and their accessories—if we may include microphones among the latter.

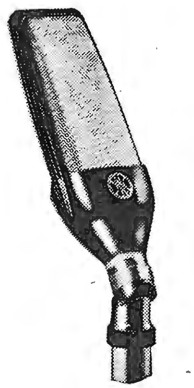
Microphones

The most noticeable development in microphones was the widespread emergence of new ribbon designs, of which several were in the low-price category. Improvements in the magnetic system by use of new materials were responsible for one trend. The traditional soft-iron pole pieces with massive energizing magnets at the ends, or covering one face of the ribbon, have disappeared and in their place are bar magnets, magnetized across their width. The result is generally a smaller slimmer structure with, consequently, a better frequency response. Tannoy's "Slendalyne" and "Slendalyne Cardioid" use metallic magnets, and the cardioid polar response is obtained by coupling to the back face of the ribbon a tuned and loaded cavity. Lustraphone's VR70 "Micridyne" uses ceramic magnets and achieves a volume of 0.6in^3—it is $\frac{15}{16}$in wide, $1\frac{5}{16}$in high and $\frac{5}{16}$in deep. Two of Grampian's new ribbon units, mounted at right angles to each other, were used in an experimental stereo microphone, but matrixed as a sum and difference system. This tends to reduce the effects of slight differences in coloration between the two units. Reslo were showing a prototype ribbon design—the SR1—for professional use. This has a new magnet and a longer ribbon to give greater output.

A new differential (noise-cancelling) microphone, AKG's D58, uses double-diaphragm construction to provide protection against dust and can be supplied on a "boom" mounting attached to A.K.G.'s K50 headphones, when the type number becomes K58.

The lead is always a nuisance when the microphone is hand-held or used on a lanyard. A radio link is an obvious answer, and Lustraphone have designed a pocket, transistor, crystal-controlled f.m. transmitter for such applications.

Lustraphone's miniature ribbon microphone: the "Micridyne". Legs are removable for stand-mounting.



Tannoy "Slendalyne" pressure - gradient (velocity) microphone.

Tape Recorders

After some false starts more transistors seem to be replacing valves in low-level stages (so as to reduce hum). One of the many examples of this trend was noted in the Philips EL3514 "Starmaker" 4-track $3\frac{3}{4}$in/sec recorder which continues the unusual vertical styling of their EL3585 fully transistorized recorder.

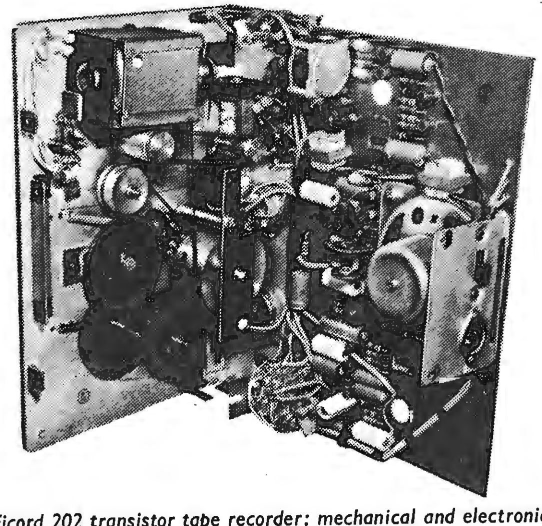
Double-gap (side-by-side) erase heads are used increasingly to produce more efficient erasure.

Editing facilities—chiefly the facility of "inching" the tape—were also increasingly emphasized. In the new 3-speed 4-track Grundig TK40 inching is provided by spring loading the fast wind control so that it can be readily switched on for only a short time. In the Stuzzi (Recording Devices Ltd.) 2-speed 4-track 401 the fast forward/rewind control mechanically moves the appropriate spool against the appropriate drive wheel, thus allowing a relatively smooth transition between the two winds.

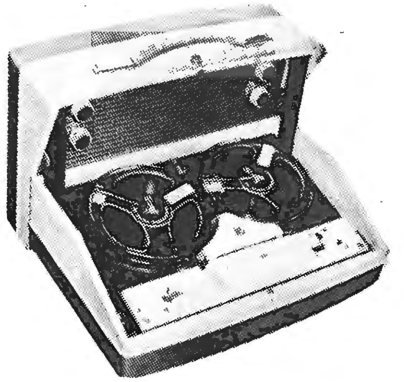
Several new fully transistorized battery recorders were shown.

One of the most elaborate of these is the $7\frac{1}{2}$ and $3\frac{3}{4}$in/sec Ficord 202, which can be used with a mains unit and has the unusual feature of an automatic audio level control (if desired). A meter is provided for checking the motor battery voltage on playback, the electronics battery voltage on record and, also on record, with a deflection in the opposite direction, the signal level. 4-in spools are used.

A mains converter is also available for the new Butoba (Denham and Morley Ltd.) MT7 (3-in spools) $3\frac{3}{4}$in/sec and $1\frac{7}{8}$in/sec 2-track transistor recorder. This uses a high-frequency bias source but permanent magnet erase—a signal-to-noise ratio of 40dB is claimed.



Ficord 202 transistor tape recorder: mechanical and electronic chassis are joined by a hinge for ease of servicing.



Bang and Olufsen "Belcanto" recorder showing hinged construction.

Up to 4½-in diameter spools can be taken by the single-speed (3¾in/sec) Loewe-Opta (Highgate Acoustic Co.) "Optacord 412." This uses high frequencies both for bias and erasure and features a one-watt output.

For public address purposes, a new version of the 2-speed Butoba MT5, the MT5S, has an extra transistor amplifier (8 or 18-W versions are available) fitted in the battery/mains unit compartment: the recorder is intended to be run from a 6-V car battery.

A mains-operated all-transistor professional 7½ and 3¾in/sec recorder—the 777—was shown by Sony (Tellux Ltd.). A special feature of this is that all functions can be remotely controlled (by a wire-connected unit). Up to 7-in diameter reels can be used and the power output is 10 watts.

Mixing facilities are, of course, now very frequently provided in tape recorders, but two unusually elaborate examples were noted in the Tandberg 6 (distributed in this country by Elstone Electronics) and Revox stereo recorders (shown by Mordaunt). In the Revox the two inputs each can be at any of three alternative impedances (which are altered simply by switching different input resistances into the transistor first stage). In the Tandberg 6 as many as four inputs can be mixed.

Voice-operated start/stop control of the Stuzzi Tricorder is possible by addition of the Dictamet transistor unit. This takes its power supplies as well as input signal level from the Tricorder. By varying the Tricorder monitor level, the level at which the Dictamet starts the Tricorder can thus be altered. The Dictamet automatically switches off the Tricorder if no signals above this starting level have been received for a pre-set time.

Recording in the new Telefunken (Welmec Corp. Ltd.) "Magnetophon Automatic" (3¾in, 2-track) model has been simplified both by leaving the valve heaters permanently on (so that a single switch can instantaneously start both the electronic and mechanical recording mechanisms) and also by the provision of automatic audio-level control. This level control appears to operate on the peak input signal and to have a short rise time and relatively long decay time (the latter is of the order of a minute). This level control thus produces relatively little distortion or apparent loss of dynamic range.

In the single-speed (3¾in/sec) 2-track B & O "Belcanto" recorder the electronics section can be hinged (see photograph) over the tape transport mechanism for compactness when not in use. This recorder also features a push-pull output amplifier and erase oscillator and uses transistors in the record/replay pre-amplifier.

New tape decks were shown by Planet and (outside the exhibition in prototype form) by B.S.R. The latter —the TD4—is a 1⅞ and 3¾in/sec battery model and is essentially a scaled-down version of their Monardeck TD2 mains deck. The Planet U1 deck is a 3-speed mains model and features the use of metal fingers to keep the tape in contact with the record and replay heads: this should produce a more suitable wear characteristic than the flat which is produced by a pressure pad. Prototype valve and transistor amplifiers for use with this deck were shown.

Tape Recording Accessories

Jason's tape link type JTL contains the basic "electronics" necessary for use with either a twin- or four-track two-head (plus erase) tape deck and is designed to work as the link between the usual pre- and power-amplifier assembly. A push-pull bias and erase oscillator is fitted and twin "magic eyes" can be switched to indicate bias or signal. The Vortexion record/playback unit has three input channels, carries tone controls and also provides for use of the "monitor" or playback head as a source of simple (one time delay, depending on record-to-playback head spacing and tape speed) echo.

Gevaert have introduced 10-in plastic reels. Recorders which can use spools as large as this are the Revox and Brenell Mark 510—the latter can even take 10½-in N.A.B. professional reels.

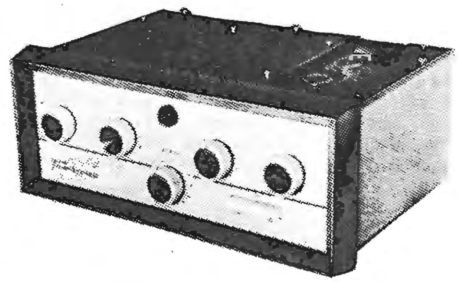
A useful tape calculator was shown by B.A.S.F. For any playing time from 5 minutes up to 250 minutes, this shows the length of tape as well as the minimum size of spool required with standard, long-play or double-play tape playing at 7½, 3¾ or 1⅞in/sec.

To prevent spillage of their tape Sony use a semi-circular plastic clip round the outer part of the reel.

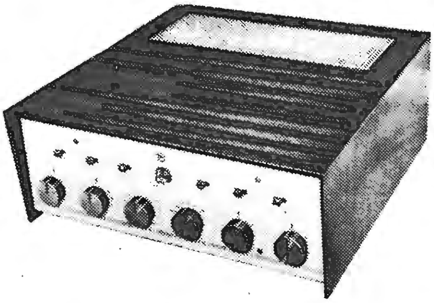
An automatic photographic slide-changing unit for operation by a tape-recorder (which would supply a spoken commentary and/or musical background) was shown by Philips (EL3769). This is a transistorized unit which both records and replays 1kc/s slide control signals on an unused tape track. In this unit the same head is used for all three functions—replaying, recording and erasing—it is not necessary to erase an existing pulse when another is needed in the same place. Grundig's TK40 carries a socket for connection of a ciné sound head: record, erase, bias and playback are available.

Amplifiers

Perhaps the most surprising thing about this year's show was that there were no fully-transistorized domestic "hi-fi" amplifiers on public show in the Hotel Russell (Pye were showing privately the prototype amplifier seen last year together with a new pre-amplifier) and we had to go across the road to find one. Here, at the Royal Hotel, D.J.T. Industrial Developments were demonstrating an all-transistor transformerless amplifier for stereo (10W per channel) developed from the design of Tobey and Dinsdale (*Wireless World*, November and



All-transistor integrated stereo amplifier pre-amplifier (D.J.T. Industrial Developments).

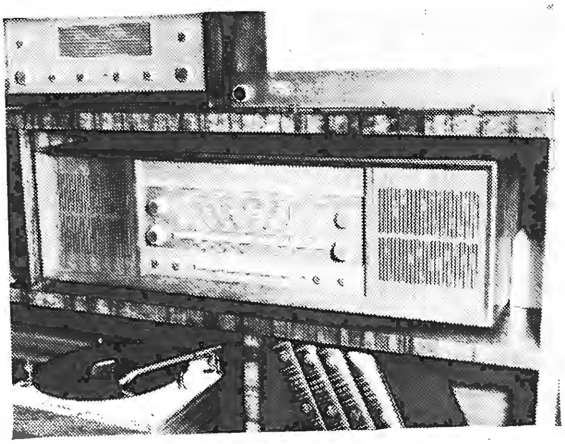


Lowther 10+ 10W stereo amplifier integrated with transistor pre-amplifier.

December, 1961). One modification of the original design is the provision for the use of the two push-pull stereo amplifiers in push pull with each other on a mono signal. In this way the output is raised to 40W when the loudspeakers are bridged between the pair of push-pull output stages.

In the Hotel Russell transistors were displayed only in the pre-amplifier parts of domestic high-fidelity a.f. equipment. For instance Bang and Olufsen and Lowther, were showing "integrated" (pre-amplifier and output stages in the one box) units where transistors were used for all functions except the power stages. In the Lowther 10-W design a pair of ECL86s take over for each channel.

The ECL86 seems generally to have become very popular and appeared in many amplifiers of widely varying ratings: Rogers were using them, for instance, in a double 6-W design (Cadet 2) whose separate pre-amplifier and control unit is designed only for ceramic or crystal pickups.



B & O's Grand-Prix radio receiver uses loudspeakers with plastics-edged diaphrams and provides for echo unit (on shelf above, at right).

Filters and tone controls seem to have followed well-trodden paths but one novel idea in an Armstrong design was the coupling back to the treble tone control of the feedback that determines the filter characteristic: thus variable slope and roll-off characteristics are given by the treble tone control.

The tone control to end all tone controls was found on the Leevers Rich stand: its main purpose is the matching of "coloration" in diverse sound sources. This unit allows by variation of negative feedback networks the relative amplitude response of six bands centred on frequencies between 63c/s and 6.3kc/s (arranged in a logarithmic series with $n=2.5$ so that there are no kinks in the curve) to be varied by ± 8dB.

An unusual phase-splitter was found in the Radford CMA15 15-W power amplifier, which is available either ready built, or as a kit. A triode-pentode is used as a long-tailed pair splitter, with the pentode accepting the input signal, to provide better balance. The Miller capacitance of a high-gain triode can cause even the long-tailed pair to go out of balance at high frequencies; in the pentode this effect is reduced by the screen grid. The pentode requires a slight increase in anode load to compensate for the division of current between the anode and screen.

Complete Equipments

One of the trends in recent years has been towards the integration of high-quality apparatus for the luxury "radio-gram" market; but a reversal was noted in the case of Decca, who are now marketing "Decola Separates", comprising the separate parts, including loudspeakers, of the Decola machine.

The Canadian "Clairtone" company (represented by Argelane Ltd.) were showing "hi-fi" radiograms. The top-of-the-range "Signature" S1001 model has amplifiers capable of 70W peak-power output and provision for remote radio control. This latter is achieved by a transistor transmitter working at about 27Mc/s: it causes clutches to be engaged with the selected control, winding it up or down. The ghostly movement of the control knobs confirms the impression that this machine is not for ordinary mortals, but for a super breed that wants to listen to Kreisler in the kitchen and Shostakovitch in the sitting room, both to be changed to stereo records and then to switch off automatically after the last side, all at the touch of a button.

In some of Bang and Olufsen's range of integrated apparatus there was provision for connecting an echo unit which could be used, in the extreme, to make the

"Signature S1000" from Clairtone range. Bass and middle speakers face shaped reflectors: treble is transduced by horn units. (Radio control is ringed).

news sound as if it were being read in the bathroom. B & O's echo unit uses a wire delay line with torsional magnetic excitation and pick off: a switch on the line box selects various delays and a level control is fitted on the receiver. Grampian, too, were showing a reverberation unit: theirs provides simulated multiple echoes and employs the Hammond spring device.

An outcropping of transistor receivers was seen: novel items were receivers, giving cover of the l.w. navigation-beacon bands and having a meter for tuning and battery checking (B & O), a simple m.w. transistor tuner with preset tuning for the long-wave Light programme (Stuzzi) and push-button switching for changeover from the ferrite rod to an external aerial (Sony).

Pickups and Turntables

Side-thrust caused by a tilted mounting board can be countered by dynamic balancing of the pickup arm; but this requires a counterweight, rather than a spring; though a spring may be used for the downward stylus pressure (B & O and some Ortofon—Metro-Sound Mfg. Co. Ltd.—arms). This has the advantage that the stylus force remains normal to the record even when the board is tilted. Also a downward pressure from the spring can help when warped discs have to be played.

Dynamic balancing requires the elimination of the twisting moment about the pivot caused by the head offset. B & O do this by offsetting the counterweight whereas some Ortofon arms and the arm on the Braun PC5 unit are made S-shaped.

Even in delicate low tracking-weight pickup heads there seems to be a trend to making the stylus assembly easily replaceable.

An unusual construction is used for the variable-reluctance generating system in the B & O stereo head. This consists of a light Mumetal cross which branches from the stylus arm (in a plane at right angles to it). The motion of the stylus causes each arm of the cross to move within the magnetic field of two pole pieces near its ends. This balanced system reduces distortion, as well as any unbalance between channels which might otherwise be produced by any permanent stylus displacement (due, for example, to side thrust) and also largely cancels any hum picked up in the pole-piece coils.

To reduce rumble transmitted through the driving mechanism from the motor a belt rather than the normal idler rim drive was used both by Philips in their AG1016 and by Braun in their PC5—it remains to be seen whether these two units are to be regarded as the forerunners of a new trend.

Loudspeakers

We had thought that the recent introduction by K.E.F. and Wharfedale* of relatively shallow slim line cabinets presaged a trend towards this shape. However, at this exhibition we could only find two other such "slim" cabinets—made by Braun and Goodmans.

Two attractive examples of the also frequently-used column shape were shown by Connoisseur. Compressed fibre board is the cabinet material—this allows the cabinet to be made cylindrical (giving it greater rigidity than the normal rectangular shape) and also reduces its cost. A port is provided at the top of each unit near the upward facing loudspeaker which gives an omni-directional sound characteristic. To reduce resonances the cabinets are lined with bonded acetate fibre—a layer of this is also inserted one-third of the way up to reduce the third harmonic air-column resonance. The Minor enclosure uses a single 8-in loudspeaker—the Major is fitted with an additional 3-in tweeter.

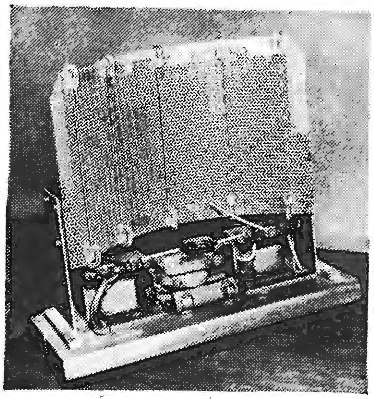
Loudspeakers themselves can be made slimmer by making their magnets of the new ceramic materials (e.g. Feroba) and this is an increasing trend—in fact Goodmans now fit nearly all their speakers with such magnets.

The unusual rectangular flat shape (with rounded corners) for a loudspeaker diaphragm introduced recently by K.E.F. in their K1 speaker system mentioned above is continued by them in their new K2 Celeste. In this the bass unit has a 9 by $5\frac{1}{2}$in flat diaphragm made of expanded polystyrene with aluminium outer skins for increased rigidity. Together with the same $1\frac{1}{2}$-in tweeter as is used in their K1, this is fitted in a totally-enclosed box measuring only 18in by $10\frac{3}{4}$in by $6\frac{1}{4}$in.

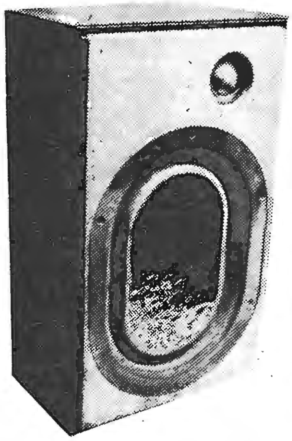
A push-pull electrostatic tweeter—the Audistatic—was used by Mordaunt in a new system.

This company also uses an unusual crossover network in their Arundel system since the rate of low frequency roll-off (12dB per octave) differs from the rate of high-frequency insertion (as rapid as 24dB per octave). Another unusual feature of this system is that the bass unit voice coil has a metal former. This tends to act as a shorted turn and thus gives improved electromagnetic damping.

* *Wireless World*, January 1962, pp. 46 and 44.

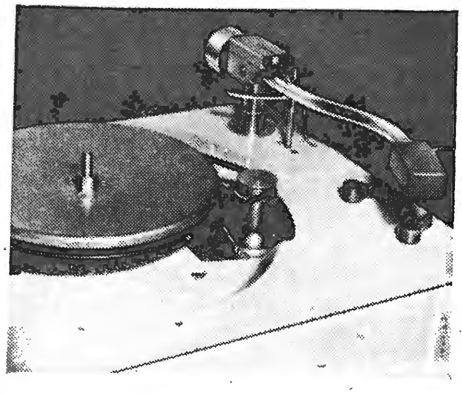


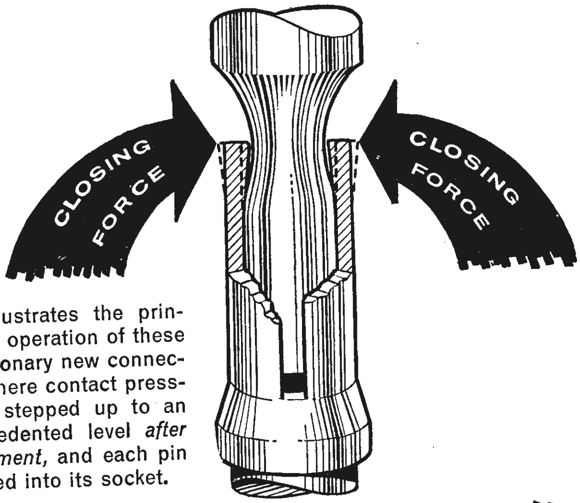
Audistatic push-pull electrostatic tweeter with cover removed (shown by Mordaunt).



K.E.F. K2 Celeste compact loudspeaker system.

Braun PC5 belt driven turntable and S-shaped pickup arm.





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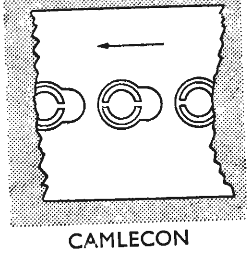
This means that while the closing force is maintained, it is impossible for the pins to be disengaged from their sockets, which grip them round the waist.



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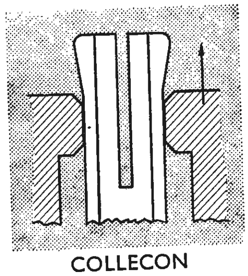

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The response rate of such a device is controlled by its thermal capacity and losses, by any in-built mechanical resistance (such as a toggle mechanism, which may be fitted to ensure a quick make-and-break action), and by the rate at which heat is generated and supplied. Its major advantage is that the action can be delayed by several minutes, if desired, but the mechanism can also be made extremely sensitive, so that it will function on as little as 10% increase of current above the permitted value.

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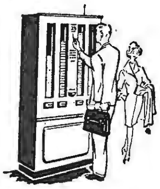

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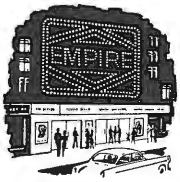

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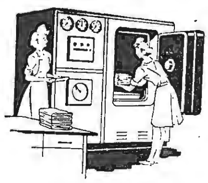

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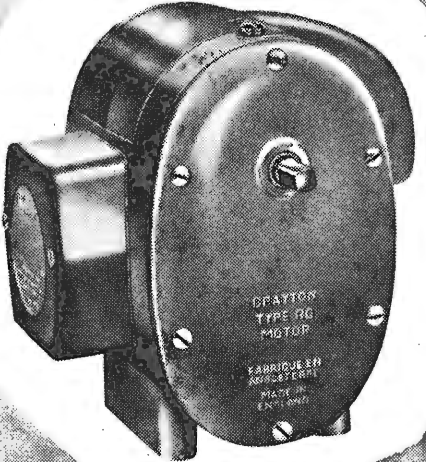

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Routh's Criteria

STABILITY TESTS WITHOUT SQUARED PAPER

By THOMAS RODDAM

MOST readers must be familiar with the conventional Nyquist and Bode plots for determining the stability of feedback amplifiers. They have been discussed in these columns and elsewhere by myself and other writers until we are all heartily sick of them. It is true that a new reader of *Wireless World* is born, not every minute but, if my calculations are correct, every eight hours. The one-and-a-half readers who do not pay for the copy they dog-ear, or steal, are excluded: cash customers only. They, I imagine, learn all these things at school nowadays, as soon as they progress beyond the indoor tree climbing and mud pie design which we in our time studied out of doors and without assistance from the rates and the Minister. But then, unlike the Minister, our boots were always dirty.

About half a century before Nyquist published his classic paper on negative feedback, rules for the stability of mechanical systems had been given by Routh. Oliver Heaviside once wrote, "Even Cambridge mathematicians deserve justice", and I feel that it is only just that Routh's criteria should be more widely known, especially as they do lead to some very compact solutions for some of our problems. The designers of servo-mechanisms are indeed much more aware of the virtues of the sort of algebraic treatment we shall adopt: it is the run-of-the-mill amplifier designer who has, I feel, got bogged down in a technique which is not always the most convenient.

Standard Stability Tests

The simple way of predicting whether an amplifier will be stable with a certain amount of negative feedback is to plot the frequency response in amplitude and phase, most conveniently as two separate graphs and most easily by the use of straight line approximations. I described this method long long ago in these columns and you can find the whole thing summarized in Langford-Smith's "Radio Designer's Handbook". I feel no temptation to go into this matter again: only money, indeed, would so tempt me. This method, however, becomes rather complicated if there are several feedback loops, although by a thoroughly tedious process these can be treated. If you then want to change an inner feedback loop, however, you need to go right back to the beginning.

You may feel that multiple feedback loops are pretty recondite anyway, and none of your business. There is, however, one special case which has fairly wide use, the amplifier with a local positive feedback loop arranged to give a very low, zero, or even negative output impedance. Obviously an amplifier of this kind will also have a good deal of negative feedback too, because you worry about distortion before you start worrying about loudspeaker damping.

Shock Excitation

The content of this article is really only an introduction to a much wider range of techniques and although I do not at present feel disposed to go very far it is probably desirable to make sure that the foundations will bear any future development. We start off with a simple parallel LC circuit, an anti-resonant circuit, which we can observe conveniently by using a high impedance oscilloscope. If we shock excite this circuit we know what happens: we observe a damped train of oscillations which with fairly typical component values will die away in, perhaps, one hundred cycles. The same experiment carried out using a piezoelectric crystal will give us a train of thousand or tens of thousands of oscillations. The rate at which the oscillations decay is usually measured by the Q-factor of the circuits.

We can connect a valve or a transistor so that it increases the Q-factor of the tuned circuit and in one circuit which I have described in the February 1954 issue of this journal the Q can be controlled by a variable resistance to the point where it becomes infinite. Just a little more, and instead of dying away with finite Q, or remaining constant with infinite Q, the oscillations grow. Even the circuit noise is enough to start the system off and it is, of course, an oscillator.

You may remember that the standard expression for a damped wave is $e^{\sigma t}\cos \omega t$, where ω is the usual angular frequency and σ the damping coefficient. If the wave really is damped σ is negative, while a positive value for σ means that the oscillations are growing. Mathematicians believe that printers dislike e^x and prefer to print $\exp(x)$. They also prefer to write the standard expression as Real Part $[\exp\ (\sigma + j\omega)t]$, which of course is exactly the same thing. The advantage of this is that we can go on to write this as R.P. $[\exp\ pt]$ where $p = \sigma + j\omega$ and we can call p the complex frequency without worrying about the sign of σ.

The quantity p describes the way a system behaves when it is shock excited. If the system is an amplifier we want the oscillations to die away: we want them to die quickly, but I feel that is a bit beyond our scope at the moment. The values of p are the characteristic frequencies of the system; there may be several of them. They are also given by the roots of the characteristic equation. They can be marked out as points defined by σ, ω and since all must have negative values of σ for the corresponding resonance to be damped we say that the roots must lie in the left-hand side of the plane. We need to know the rules of the game now.

Routh's Criteria

The procedure is best illustrated by a simple example. We shall consider a three stage valve amplifier having three identical stages. The load resistance is R, and is shunted by a capacitance C, and these values are such that we can forget the valve impedance and work with the mutual conductance g_m. Each stage has the same gain, which is just $g_m R/(1 + j\omega CR)$. We write now $CR = \tau$ and since we want to work with complex frequencies, not the usual ω, we replace $j\omega$ by p, giving the stage gain as $g_m R/(1 + p\tau)$ and the amplifier gain as $g_m^3 R^3/(1 + p\tau)^3$ which we shall call k. At sufficiently low frequencies we can neglect the effect of the shunt capacitance and the gain, k_o, is just $g_m^3 R^3$. The feedback we want to apply is β, a constant.

Now we consider the expression

$$1 + k\beta = 1 + k_o\beta/(1 + p\tau)^3$$

and we obtain the characteristic equation by putting this equal to zero (thus, by the way, making $k/(1 + k\beta)$, the usual gain with feedback form, infinite). Then

$$\tau^3 p^3 + 3\tau^2 p^2 + 3\tau p + 1 + k_o\beta = 0$$

a cubic in p having all the τ terms positive. We can apply Routh's criteria to see when this amplifier will be stable.

1.—All the coefficients must be positive. The τ terms satisfy this already, so we need only consider the term $(1 + k_o\beta)$. This will be positive unless β is negative, which with the sign conventions I use means positive feedback, and then only if $|\beta| \geqslant 1/k_o$, which means too much positive feedback.

2.—The coefficients must satisfy an inequality which we shall give in its general form later. For the cubic form

$$a_o p^3 + a_1 p^2 + a_2 p + a_3 = 0$$

the system will be stable if

$$a_1 a_2 > a_o a_3$$

so that in the specific amplifier example we have

$$9\tau^3 > \tau^3(1 + k_o\beta)$$

$$\text{or } k_o\beta < 8$$

This is, of course, a standard textbook result and it corresponds to the condition in which $|k\beta| = 1$ when the stage phase shift has reached 60°. We know that we can get better results, that is we can apply more feedback, if we make one stage have a different bandwidth from the other two. This is very easy to analyse by this method, for we just take two stages having $CR = \tau$ and a third having $C'R' = n\tau$. If n is less than unity we have a wider band, while if n is greater than unity the stage is a relatively narrow band one.

For this example

$$1 + k\beta = 1 + \frac{k_o\beta}{(1 + p\tau)^2(1 + np\tau)}$$

and the characteristic equation becomes

$$n\tau^3 p^3 + (1 + 2n)\tau^2 p^2 + (2 + n)\tau p + 1 + k_o\beta = 0$$

Applying the second criterion and manipulating the result we reach the limiting condition

$$k_o\beta < 2(n + 2 + 1/n)$$

I have written it in this form to show the complete symmetry between n and $1/n$: we get the same answer by using a double width stage as we do from a half width stage. No other method I can remember will give the limiting condition above nearly so quickly. Even with three different stages the work is not really tedious.

Life is not just a cubic equation. The full form for Routh's second stability criterion is in the determinant form:

$$\begin{vmatrix} a_0 & a_{-1} & a_{-2} & \ldots\ldots & a_{-n} \\ a_2 & a_1 & a_0 & \ldots\ldots & a_{2-n} \\ a_4 & a_3 & a_2 & \ldots\ldots & a_{4-n} \\ \ldots & & & & \\ \ldots & & & & \\ a_{2n} & a_{2n-1} & a_{2n-2} & \ldots\ldots & a_n \end{vmatrix} > 0$$

in which any term a_m for which $m > n$ or $m < 0$ is put equal to zero. The general form of the characteristic equation is

$$a_o p^n + a_1 p^{n-1} \ldots\ldots + a_n = 0$$

When $n = 4$, the determinant gives

$$a_1 a_2 a_3 > a_4 a_1^2 + a_0 a_3^2$$

Beyond this you are on your own, but after all, you have got a fairly complicated amplifier.

It is, I hope, almost unnecessary to point out that the procedure for the stability at the low end of the pass band, which depends on the coupling capacitor and output transformer, will follow exactly the same lines except that you will find the equation starts off in $1/p\tau$ instead of in $p\tau$. The treatment is left as an exercise for the reader.

Internal Feedback Loop

The method really begins to pay dividends when we put in an internal feedback loop as well. Let us consider an example in which the amplifier is cut into two sections which have gains k_1 and k_2 and we apply feedback of β_1 round the k_1 section and β_2 round the whole amplifier. For this system the characteristic equation is

$$1 + k_1\beta_1 + k_1 k_2\beta_2 = 0$$

A simple example is obtained by considering three identical stages having a gain, as before, of $k/(1 + p\tau)$. Between the first and second cathodes we provide positive feedback β_1 and in β_1 we take account of the loss to the second cathode. In this form only the response shape of the first stage has to be taken into account. The characteristic equation becomes

$$1 + \frac{k\beta_1}{(1 + p\tau)} + \frac{k^3\beta_2}{(1 + p\tau)^3} = 0$$

and this can be multiplied up and rearranged to give the form:

$$\tau^3 p^3 + (3 + k\beta_1)\tau^2 p^2 + (3 + 2k\beta_1)\tau p + 1 + k\beta_1 + k^3\beta_2 = 0$$

As we are using positive feedback β_1 is negative and we must look first at Routh's first criterion, from which we find that $3 + 2k\beta_1$ must be positive, or $-\beta_1 < 3/2k$.

A convenient choice will be $-\beta_1 = 1/k$, which will bring the inner amplifier just up to infinite gain. Now we consider the second criterion, substituting $k\beta_1 = -1$ as we go, and we find that $2 > k^3\beta_2$.

With an infinite gain front end we cannot put more feedback round the whole loop than given by $k^3\beta_2 < 2$ in which, of course, k^3 is the total forward gain. The overall gain with this amount of feedback will be just one-half the gain without feedback. This particular example was selected because it is extremely simple and it does not represent a useful situation. A more practical example is not really more difficult, although it is naturally more complicated. The algebra is never as complicated, however, as the attempt to render stable an amplifier which you could have proved would never be stable.

I had reached this point when I came across a paper in *Electronics* (18 Nov., 1960, p. 102, "Positive Feedback Provides Infinite Input Impedance", by E. Katell) in which the writer describes the use of two d.c. operational amplifiers with positive feedback round the whole loop. He does not discuss the problem of stability in our sense at all, probably because it has been built in to the operational amplifiers. If you happen to have a few such units about the house the method used by Katell involves just connecting them up with some resistance boxes and you can, for example, watch the very slow decay of the charge on a polystyrene capacitor. A much simpler approach, if you are starting from scratch, is to build a three stage amplifier and put the positive feedback in as an internal loop with overall negative feedback. For this sort of application the stage around which positive feedback is applied will conveniently be made to have a very narrow bandwidth in order to allow for a good deal of negative feedback.

The algebraic treatment is especially important when using positive feedback because the result you are trying to get depends on a factor $(1-x)$ in which x is meant to be exactly unity but includes the amplification of an active device. If $(1-x)$ is going to be really small a good deal of stabilization will be needed and the system may have to be trimmed regularly. It is always as well to be prepared for your troubles.

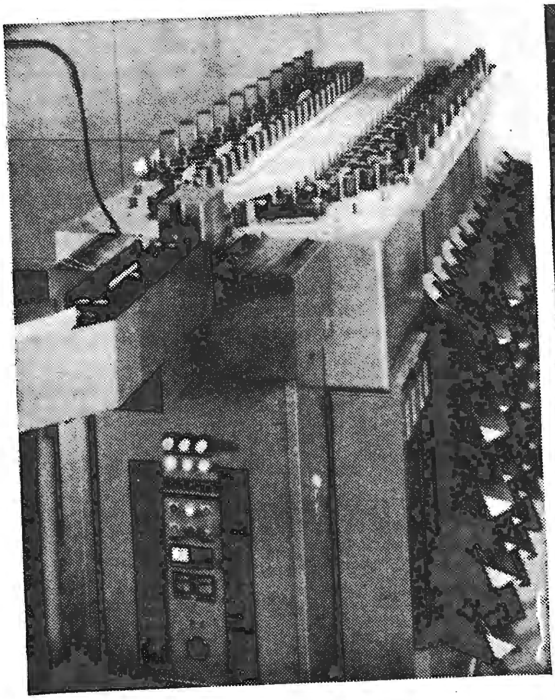
AUTOMATIC LETTER SORTING

FEDERAL GERMAN POST OFFICE INSTALL HIGH-SPEED MACHINE

DESIGNED by the Posttechnischen Zentralamt at Darmstadt in conjunction with Telefunken, the letter-sorting machine shown in the photographs is capable of working at a speed of 20,000 letters/hr for 100 different places.

The incoming post is sorted by machine into "standard" letters, and other items which have to be sorted by hand. A "facer" then turns the letter to the correct position by finding the stamp (which is treated with ultra-violet-fluorescent dye). Next, the letters are presented to an operator who reads the place names and prints almost invisible dot-codes on the envelopes. From this point the machine takes over full control, reading the code and directing the letter to the appropriate bin. The dot code used is self-checking, consisting of four characters of five bits each.

Work is at present in progress on a reader for typewritten addresses.



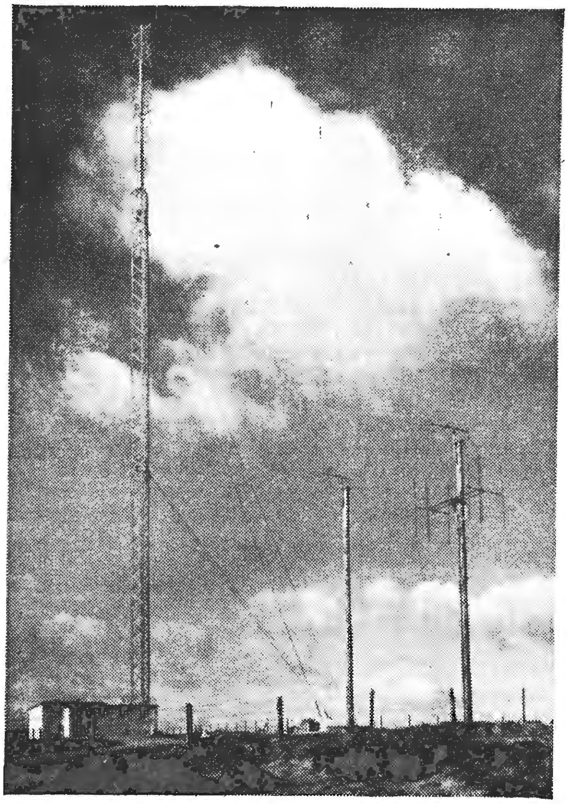
Above: Operator reading address and imprinting four-character code.

Left: Head of sorting machine. Letters entering at the left pass through the reader and are then carried against rollers by a travelling band to be dropped down the appropriate chute and so into one of the stacks of bins.

AUTOMATIC RELAY STATIONS

FIRST OF A NEW SERIES EXTENDS B.B.C. TELEVISION AND SOUND SERVICES TO MID-WALES

By A. L. HANDS *, B.Sc. (Eng.), Grad. I.E.E.



Transmitting mast and, in the foreground, the receiving aerials at Llandrindod Wells.

THE new B.B.C. relay station at Llandrindod Wells, Radnorshire, which was brought into service on 4th December last, and radiates television transmissions and the Home, Light and Third Programmes on v.h.f./f.m., represents a new development in the design of automatic relay stations, being very compact and economical to run. Similar stations are planned for other areas where there is a need for extending and improving the coverage of the B.B.C.'s television and v.h.f. sound broadcasting services, which already reach nearly 99% and 98% of the population of the United Kingdom respectively.

Relay stations are designed for automatic operation and to rebroadcast programmes obtained by direct reception of other transmitters. At most stations, as at Llandrindod Wells, this is achieved by combined receiver-transmitters known as translators. In design translators are similar to conventional receivers up to the intermediate frequency amplifier. The i.f. signal is, however, not demodulated, but fed into a second frequency changer where it is converted direct to the output frequency of the relay station and amplified to the required output power. As the original modulation is not separated from the carrier, complicated monitors are not required and it is sufficient to check the output of the translator by means of a simple relay, sensitive to carrier level.

The need for a relay station inevitably means that it must be built in an area of poor reception. A site must be found where satisfactory signals can be received, and at the same time it must be in a favourable position to serve the area required. The most suitable locations will certainly be on high ground, often on prominent hill tops. In obtaining the consent of the Town and Country Planning authorities, due consideration must be given to the natural beauty of the area, and this may place restrictions on the building and on the height and complexity of the masts and aerials. Another requirement is for the site to be reasonably close to an existing electricity supply.

Relay stations are already in extensive use on the Continent, but they are generally of very low power and for television frequently translate from Band I to Band III or vice-versa. Continental television transmission standards employing f.m. sound permit a considerable simplification in the design of translators as it is possible to use a common amplifier for both sound and vision. However, with a.m. sound, the signals have to be separated at an early stage to avoid intermodulation between the sound and vision signals.

The first of the B.B.C.'s television relay stations was brought into service at Folkestone in July 1958.† It uses translators, designed by the B.B.C., and has an e.r.p. of 7W peak white vision and 1.75W sound carrier. Folkestone was followed in 1960 by television relay stations at Sheffield and Hastings. The power of the Llandrindod Wells station, though considerably higher than that of Folkestone, Sheffield and Hastings, is still limited because of the need to

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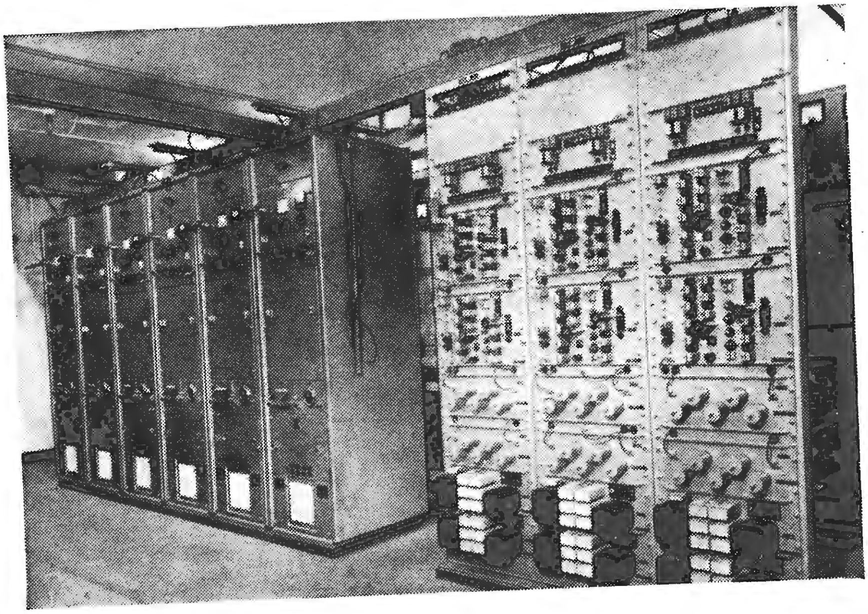
* Planning and Installation Department, B.B.C.

† "Folkestone's Television Transmitter."—*Wireless World*, Sept. 1958, Vol. 64, No. 9.



V.H.F./F.M. installation. The six 1-kW amplifiers are in the cabinets on the left and the translators on the right. At the top of each bay on the right is the control panel with duplicate translators, aerial filters, and power supply units.

avoid co-channel interference with existing B.B.C. stations. It rebroadcasts the Wenvoe services with e.r.p.'s of 1.4kW peak white for television and 1.3kW carrier for each of the three v.h.f. sound programmes. All the programmes, both television and v.h.f. sound, are radiated from the same mast.

Details of the received and transmitted frequencies are given in the Table.

Service	Received Frequency	Transmitted Frequency
Television	Channel 5 Sound 63.25 Mc/s Vision 66.75 Mc/s	Channel 1 Sound 41.5 Mc/s Vision 45.0 Mc/s
Light Programme ...	89.95 Mc/s	89.1 Mc/s
Third Programme ...	96.8 Mc/s	91.3 Mc/s
Welsh Home Service...	94.3 Mc/s	93.5 Mc/s

The station is 1,420ft above sea level and although its range is restricted by mountainous country it serves some 23,000 people in the Llandrindod Wells area of Central Wales (Fig. 1).

The station, which operates without staff being in continuous attendance, has been planned for maximum reliability. This is a matter of fundamental design and cannot be attained merely by adding extra supervisory apparatus, as unnecessary complication would increase the overall fault hazard. All equipment in the programme chain is duplicated and has been arranged in two sections fed from independent supplies. During mains failures the service is maintained by a self-starting diesel alternator set.

Routine preventative maintenance, such as checking meter readings, often enables a potential fault to be cleared before the actual failure. At Llandrindod Wells, an engineer, who lives in the area, visits the station several times each week for this purpose, and is available on call at other times if needed. When the station is unattended engineers are able to check that the plant is functioning correctly by telephoning the station. An automatic unit answers the call and indicates in code which translators and amplifiers are working. Major maintenance is carried out by visiting transmitter maintenance teams.

In the interests of economy the output amplifiers are closed down when they are not carrying programmes. Time switches cannot be employed for this purpose because of the need to cater for programmes which may be arranged at short notice outside normal transmitting hours. However, because the power consumption of the translators is quite low, they are powered continuously and the amplifiers are controlled by the received signals from Wenvoe. Referring to the television section of the simplified block schematic (Fig. 2) it should be noted that in the absence of signals from Wenvoe, the carrier-operated relays in the translators will have released and switched off the amplifiers. When transmissions begin, these relays close and the

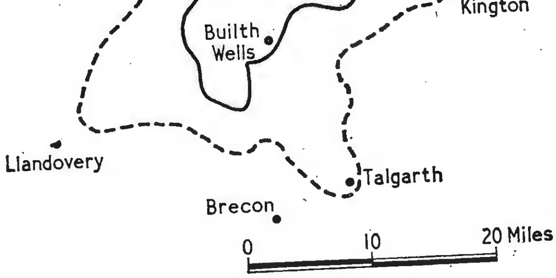


Fig. 1. Television field strength contours in mV/m at 30 ft above ground level. The 0.1 mV/m contour is not a rigid boundary of the area served since the quality of reception will depend upon local conditions and 3 : 1 variations in field strength may occur from point to point.

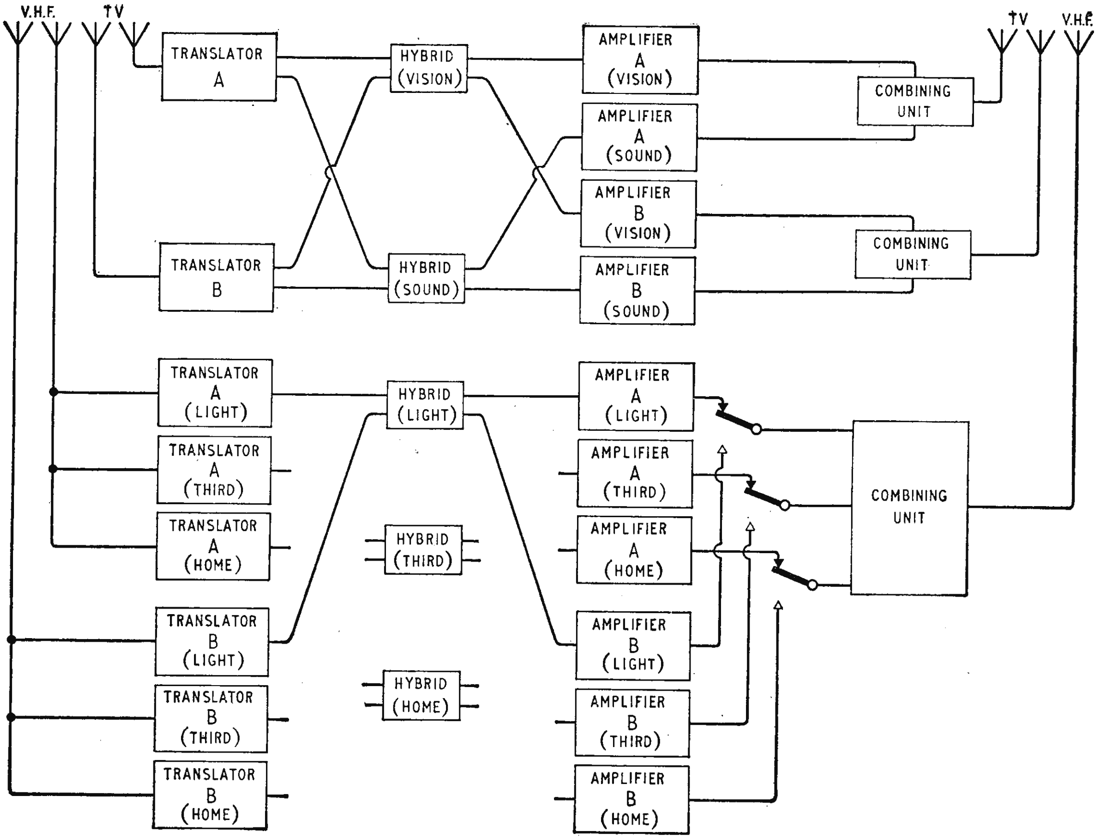


Fig. 2. Simplified schematic of the duplicate chains of equipment at the mid-Wales relay station.

amplifiers are switched on. After a short pause, a relay in the "A" translator mutes the "B" translator by removing its h.t. supply. Should "A" be unserviceable or fail during programme, "B" immediately takes over. This method of control enables the spare translator to be tested at the beginning of each transmission and the results are registered by the automatic telephone unit.

The television translators are rated at 10W peak white vision and 2.5W sound carrier. They are connected to the parallel amplifiers by hybrid networks which permit both amplifiers to be fed from either translator with minimum interaction between units. The separate sound and vision amplifiers, which are identical in design, have ratings of 500W peak white vision and 125W sound carrier. The peak power outputs are the same and the apparent difference in rating arises from the practice of specifying vision transmitters in terms of peak output and a.m. sound transmitters in terms of carrier power. If an amplifier fails, the service is maintained by the remaining one, but as each amplifier feeds one half of the aerial, the e.r.p. drops by 6dB due to the combined loss of amplifier and aerial gain. This split aerial system ensures continuance of transmission in the event of a fault in either half of the aerial.

The arrangement of the v.h.f./f.m. installation is similar to that used for television except that the amplifiers are not run in parallel, the required power being available from a single amplifier. If the first amplifier should develop a fault the spare is automatically powered, its output being switched by a coaxial relay. The ratings of the v.h.f./f.m. sound translators and amplifiers are 10W and 1kW respectively. All the translators and amplifiers used at Llandrindod Wells were supplied by Marconi's Wireless Telegraph Company, to B.B.C. specifications.

With the exception of the diesel, the technical equipment on the station is housed in the transmitter hall which measures 17ft × 29ft.

The transmitting aerials, manufactured by E.M.I. Electronics, are carried on a pole at the top of a 200-ft mast erected by J. L. Eves. Both the television and the v.h.f./f.m. sound transmissions are horizontally polarized and similar two-tier super turnstile aerials are used for the two services. The receiving aerials are supported on wooden poles 230ft from the main mast and, because of the negative height gain at this site, the aerials are mounted at the optimum height of 25ft.

This station is an example of the economic advantages that have been made possible by the development of automatic translator stations designed to give a high degree of reliability without being continuously staffed. A comparable conventional station would require a full-time staff of six men. The floor area required for the equipment is only 660 sq ft, compared with 2,500 sq ft at earlier stations with the same number of transmitters of similar power.

FUNDAMENTALS OF FEEDBACK DESIGN

6.—THE MU-BETA EFFECT CALCULATOR

By G. EDWIN

It is rarely sufficient in designing an amplifier with negative feedback to be satisfied merely with its stability. Nothing can be more discouraging than to find that the stable amplifier has not got the performance, and particularly the frequency response, which was required. More subtle but in the long run more disturbing is the discovery that although the design centre amplifier is stable, the effect of valve and component tolerances is to push the amplifier into instability as components age,

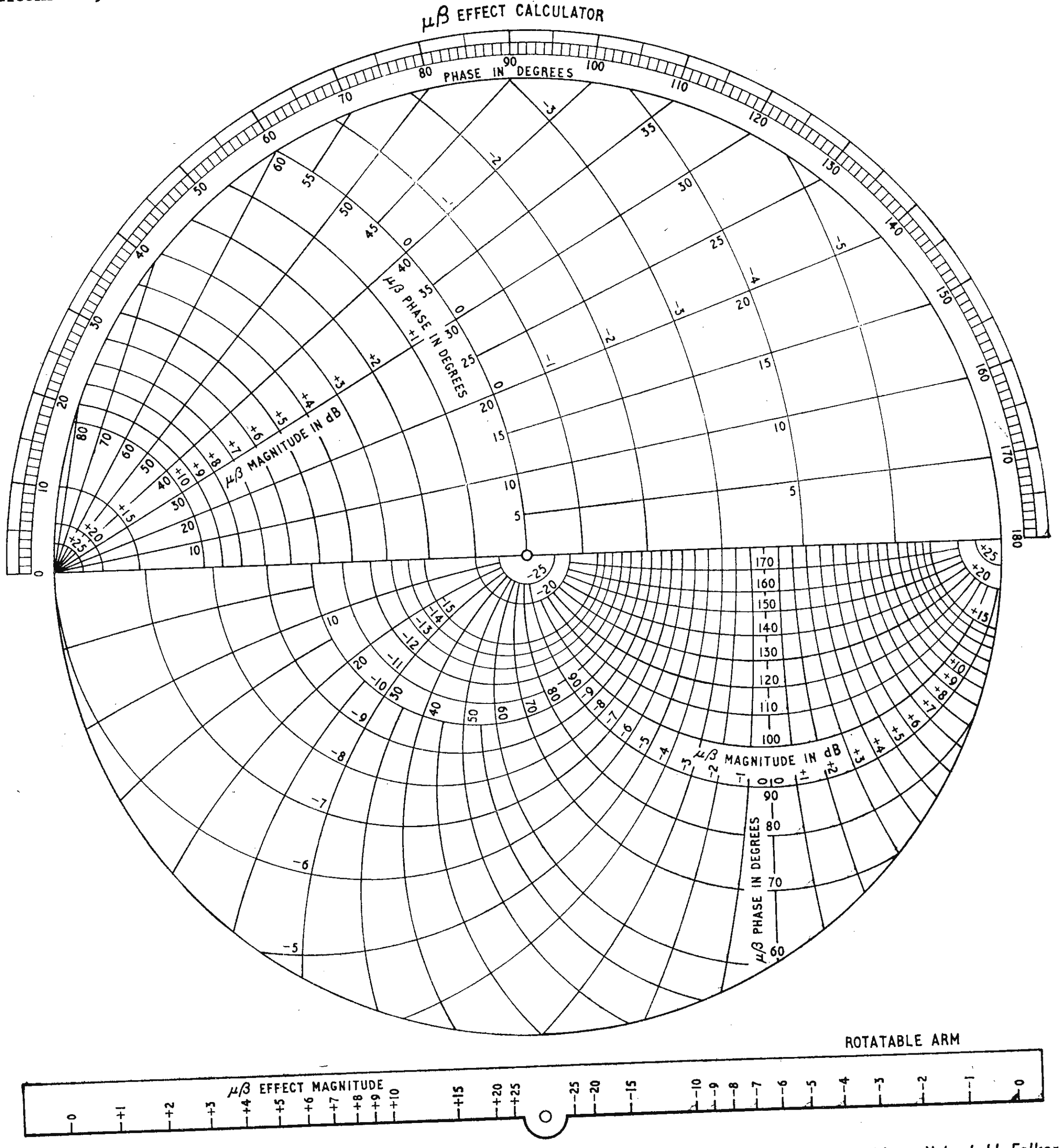


Fig. 28. Mu-beta effect calculator (based on Fig. 1 of the article " Calculator and Chart for Feedback Problems " by J. H. Felker in the Oct. 1949 issue of Proc. I.R.E.).

when valves are replaced, or when the tenth or hundredth model of the amplifier is constructed.

The mu-beta effect calculator is an extremely useful tool for studying the behaviour of feedback amplifiers. It was described by J. H. Felker* and is, or was, commercially available†. Early versions indicated that a patent was applied for but it is not known whether this was granted.

We begin with the basic expression for a feedback system having a gain without feedback of μ, an amount β of the output fed back to the input and a gain with feedback of G. Then as we have already seen:

$$G = \mu/(1-\mu\beta) = -1/\beta\left[\frac{-\mu\beta}{1-\mu\beta}\right]$$

This is the form and notation used on the calculator. The quantity in the square brackets $[-\mu\beta/(1-\mu\beta)]$ is the $\mu\beta$ effect. When $\mu\beta$ is very large compared with unity the $\mu\beta$ effect is very close to unity and the gain of the amplifier is just $-1/\beta$. This is the ideal feedback case with the whole amplifier performance fixed by the passive elements in the feedback network. There are two important deviations to be considered. An amplifier might have, at band centre, a forward gain of 1,000 times and what we loosely call 20dB of feedback, bringing the gain down to 100 times. Then $-1/\beta = 100$ and $\mu\beta = -10$

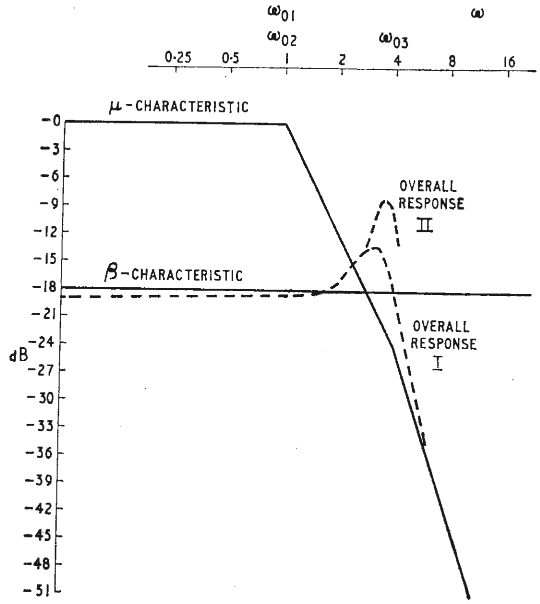


Fig. 29. The full lines show the linear approximation amplitude response without feedback (μ) and the feedback characteristic (β) of a system having two $[1+j\Omega]$ terms with characteristic frequencies at $\omega = 1$ and a third at $\omega = 4$. The dotted line labelled I shows the over all response with 18dB of feedback, and that labelled II the overall response in the critical region when the gain without feedback increases by 3bB.

so that the $\mu\beta$ effect is 10/11. If the amplifier is to be used for measurement purposes this factor of about 10% will be serious and must therefore be known. The second deviation comes at the edge

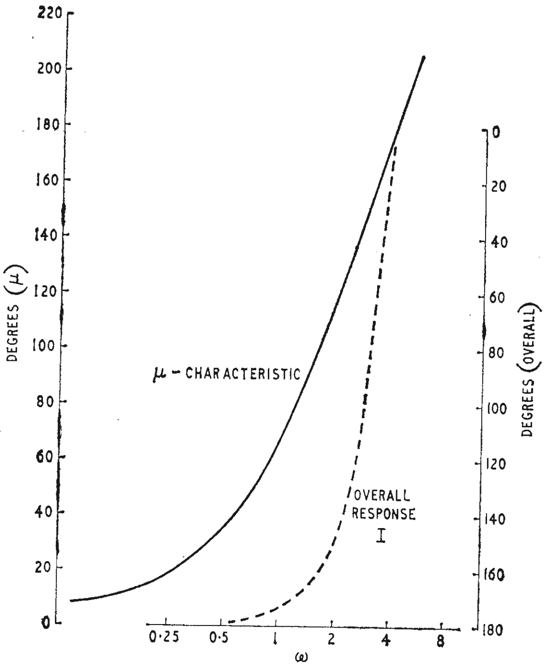


Fig. 30. Phase characteristics corresponding to amplitude responses of Fig. 29.

of the amplifier response. The value of μ falls away in the manner we have calculated previously and at the same time the phase becomes significant. We shall see that the $\mu\beta$ effect becomes very important indeed in determining the performance of the amplifier.

Before we go any further it is probably worth while to look at Fig. 28 which shows the $\mu\beta$ effect calculator. The device consists of a circular chart which carries at its centre a rotating arm. In using the calculator we simply read off from our response curves the values of the amplitude and phase of $\mu\beta$ at each frequency, set them into the calculator, and read out the $\mu\beta$ effect. This operation will be most easily followed if we provide ourselves with an example.

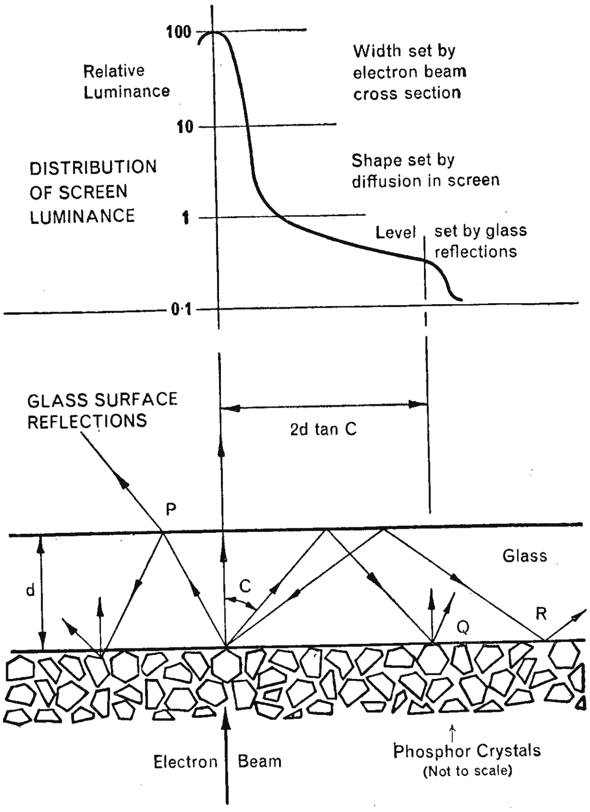
A linear approximation amplitude response is shown in Fig. 29 for a three-stage system having two $[1+j\Omega]$ terms with characteristic frequencies at $\omega = 1$ and the third at $\omega = 4$. Needless to say, ω is a normalized frequency. The phase characteristic in Fig. 30 is an exact one: the work on any really practical problem will use the exact amplitude response, too, and will include some of the decoupling terms, possibly all, in the way we have already discussed. Let us assume that we can just afford to put 18dB of feedback on this amplifier. Away on the left, then, the quantity $|\mu\beta|$ will be 18dB, falling above $\omega = 1$. It is easily read off Fig. 29 as the height of the μ line above the 18dB line. We now notice that at the extreme left, where the phase angle, excluding valve phase reversal effects, approaches zero for the amplifier networks, the sign of $\mu\beta$ will be negative, so that the overall phase angle must be $2n\pi+180°$. We therefore add the scale on the right of Fig. 30 and set the $\mu\beta$ rotor arm to 180°, and then read off against $|\mu\beta| = 18$dB, $\mu\beta$

(*continued on page 283*)

*"Calculator and Chart for Feedback Problems", J. H. Felker, *Proc.I.R.E.*, Vol. 37, p. 1204, Oct. 1949.
†Graphimatics, 201 North Taylor Avenue, Kirkwood, Missouri, U.S.A.

Aspects of design . . . 39

PICTURE QUALITY AND TWIN PANEL TUBES - Part I



Built in Picture Quality

The quality of the picture reproduced on a monochrome television screen can be analysed into factors which are under the control of the designer of the video and scanning systems and those characteristics of sharpness and tonal rendering which are largely built into the design of the cathode ray tube itself and cannot be changed by the circuit designer. These latter are the subject of this article and, since the tonal rendering will be shown to depend upon the contrast possible under any particular set of conditions, the factors controlling contrast are discussed first.

Contrast

The sharpness of a picture depends upon the contrast obtained at boundaries between light and dark areas. In many scenes occurring naturally the range of surface brightness measured (correctly called luminance) is as great as 10,000 : 1, and all improvements in a reproducing system that allow more of the original contrast range to be seen will be recognised as an improvement in the quality of the picture.

The contrast seen on television screens is often less than that of the original scene because of the inherent limitations of conventional cathode ray tubes. The reasons for these limitations and the way in which the All Glass Twin Panel tube offers the possibility of an improved contrast range will now be examined.

The phosphor screen is composed of several layers of small crystals deposited in a random manner on the inside surface of the cathode ray tube face-plate, as shown in the diagram. Each bright point in the picture is formed by light emitted from those particles of phosphor which are excited by the beam of electrons which scans the screen, so that the area of a bright spot can never be less than the cross-section of the incident electron beam. The illumination on the screen always extends further than this and reduces the contrast otherwise possible: this occurs by the diffusion of light within the screen material and because of reflections from the surfaces of the cathode ray tube face-plate and safety panel. *These two processes will be considered separately.*

Diffusion

Each particle of phosphor excited by the electron beam emits light in all directions. Some of this light, particularly if emitted in directions nearly in the plane of the screen, is reflected from one crystal to another within the screen. Since there is some absorption of light at each successive reflection, the result is a diffuse bright area whose luminance falls rapidly with increasing distance from its centre.

Internal Reflections

Much of the light leaving a phosphor crystal, however, will be able to enter the glass of the tube face and will in general pass through the outer surface at a point such as P, where a small fraction of it is reflected back towards the screen and illuminates it. As the angle made with the normal increases, so the distance travelled through the glass increases. The illumination on the screen falls and with it the luminance of the screen away from the centre of the spot. If the angle exceeds the critical angle C no light is transmitted by the front surface and all is reflected towards the screen. Since the angle of incidence there is the same, the light cannot pass through the surface to illuminate the screen except at those points where the phosphor is in intimate optical contact with the glass, as at Q. Other particles such as those at R are not illuminated and light approaching the surface is reflected a second time and is indeed trapped within the glass until it reaches a surface through which it can pass.

The observed effect of these reflection processes is, then, to give a diffusely illuminated disc around each picture point whose luminance falls gradually until, at a radius of 2d tan C, a clearly defined edge is produced by the critical angle effects. At radii of 4d tan C and 6d tan C very faint rings can often be seen due to light returning to the screen after two and three sets of reflections at the critical angle.

With most television C.R.T.s it is necessary to provide an implosion-proof screen in front of the tube which gives another two surfaces to reflect light back to the screen and so may double the general reflected illumination on it. The use of a glass twin panel, cemented to the tube so that no appreciable reflections occur at the interface, removes the need for the extra screen and its unwanted reflections and at the same time removes the front reflecting surface to twice its original distance. Since the glass is chosen to absorb some of the light passing through it, the luminance of the halo surrounding a bright point is reduced five times below that of an ordinary unprotected tube and considerably more than for the same tube installed in a television cabinet with protective screen.

Dust and Ambient Lighting

In use, the ordinary tube attracts dust to its surface, scattering light generally and detracting further from the available contrast. The separate implosion screen prevents easy access to this surface for cleaning and receivers are frequently operated in this condition. The glass twin-panel tube does not suffer this disadvantage and, because of its greater absorption of light, the luminance of its screen in a normally lit room is lower than that of the equivalent ordinary tube. Since this sets not only the black level (and contrast) in the picture but also the shape of the characteristic of luminance versus drive voltage, this allows the latter to be defined more clearly for twin panel tubes.

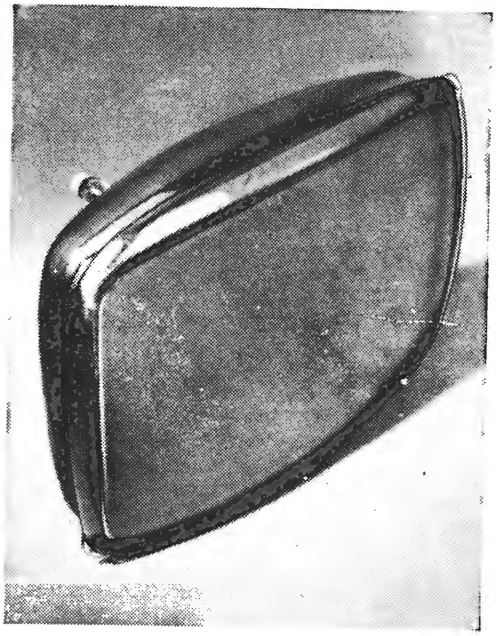
To achieve these improvements in picture quality, Thorn-A E I Radio Valves & Tubes Limited has introduced the new range of All Glass Twin Panel Cathode Ray Tubes CME 1906/A47-13W and CME 2306/A59-13W.

MAZDA *VALVE COMMERCIAL DIVISION* 155 Charing Cross Road, London WC2 Telephone GERrard 9797

EDISWAN *EXPORT DIVISION* Thorn House, London, WC2 Telex: London 21521 (Thorn Ldn)

THORN—AEI RADIO VALVES & TUBES LTD

MAZDA twin panel tubes



110° 19" and 23" twin panel

SHORT TELEVISION TUBES

CME1906/A47-13W
CME2306/A59-13W

These new tubes differ from previous 19in. and 23in. tubes of the Mazda range in that each has a moulded safety panel of tinted glass bonded directly to the front face of the tube. In neck length and electrical characteristics these tubes are identical to CME1903 and CME2303 respectively, having 110° deflection angle and using magnetic deflection and electrostatic focus.

General Details

Twin Panel	Tinted Grey Glass
Rectangular Face	110° Deflection Angle
Aluminised Screen	Silver Activated Phosphor
Electrostatic Focus	Magnetic Deflection
Short Neck	Straight Gun—non ion trap

External Conductive Coating
Heater for use in Series Chain
Heater Current I_h 0.3 A
Heater Voltage V_h 6.3 V

	Symbol	CME1906	CME2306	
Design Centre Ratings				
Maximum Second and Fourth Anode Voltage	$V_{a2,a4(max)}$	17	17	kV
Minimum Second and Fourth Anode Voltage	$V_{a2,a4(min)}$	13	13	kV
Maximum Third Anode Voltage	$V_{a3(max)}$	+1 to −0.5	+1 to −0.5	kV
Maximum First Anode Voltage	$V_{a1(max)}$	550	550	V
Maximum Heater to Cathode Voltage-Heater Negative (d.c.)	$V_{h-k(max)}$	200	200	V
Inter-Electrode Capacitances				
Cathode to All*	c_{k-all}	3.5	3.5	pF
Grid to All*	c_{g-all}	8.5	8.5	pF
Final Anode to External Conductive Coating (approx.)	$c_{a2.a4-M}$	1250	2000	pF

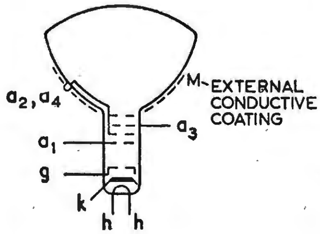
*Including AEI B8H Holder VH68/81 (8 pin)

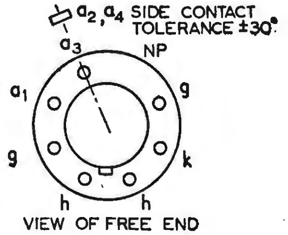
	Symbol	CME1906	CME2306	
Typical Operation				
Grid Modulation (Voltages referred to cathode)				
Second and Fourth Anode Voltage	$V_{a2,a4}$	16	16 to 17	kV
First anode Voltage	V_{a1}	400	400	V
Beam Current		350	350	μA
Third Anode Voltage for Focus (Mean)	$V_{a3(av)}$	200	200	V
Average Peak to Peak Modulating Voltage		35.5	35.5	V
Grid Bias for Cut-off of Raster	V_g	−40 to −77	−40 to −77	V
Maximum Dimensions				
Overall Length		317	374	mm
Face Diagonal		491†	614‡	mm
Face Width		441	544	mm
Face Height		361	443	mm
Neck Diameter		29.4	29.4	mm

†The maximum dimension over the complete panel is 507 mm
‡The maximum dimension over the complete panel is 631 mm

Tube Weight
Nett (Approx) 22.5 37.5 lbs.

Side Contact: CT8 (Cavity) **Base:** B8H





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THORN-AEI RADIO VALVES & TUBES LTD

effect = −1dB and phase angle = 0°. At $\omega = 1$ we still have $|\mu\beta| = 18$dB, but now the angle is, from Fig. 30, 114°, and we find that the $\mu\beta$ effect is −0.5dB, 6°. At $\omega = 1.4$, $|\mu\beta|$ has dropped by 6dB, to 12dB, and the phase angle is 90°, giving −0.25dB, 14°. Proceeding in this way we build up the two overall responses shown dotted as I on Figs. 29 and 30.

This example shows fairly clearly what happens when we put 18dB of feedback on an amplifier which will just be stable with 24dB. Over the main part of the characteristic the gain is almost constant and the phase-shift is greatly reduced. At higher frequencies, however, a nasty hump develops. In place of the steady fall-off of the amplifier characteristic we get a rise of about 4½dB, which is followed by a drop away to join the μ characteristic asymptotically. This hump is produced by positive feedback, for the gain is brought above the basic amplifier gain.

You may consider that this is not too important, but let us suppose that the values change and we get an extra 3dB of gain. The amplifier is still stable but it takes only three minutes to sketch in the vital section of curve II with its peak of over 10dB. The shape here is extremely sensitive to the gain of the system. You will find quite reputable texts which describe these peaks and recommend equalizing them by means of filters. No doubt these filters are readjusted at frequent intervals.

Like all labour-saving devices, the $\mu\beta$ calculator requires that you should practise with it in order to establish the familiarity you need when the problem is not how to use the calculator but how to design the amplifier. The prudent reader will therefore construct for himself the response to be expected with lesser amounts of feedback and will see how the hump declines under these conditions. He can also go back to the typical low-frequency roll-off of last month's article and see how the same treatment can be applied and the same sort of hump developed.

Although it is slightly out of the main line of our discussion the reader may care to notice at this point just how similar to the response of a tuned circuit, an anti-resonant circuit, the fragmentary curve II appears. The Q is not high but it is obviously somewhere in the region between 2 and 10, sufficient to show a quite definite damped oscillation if excited. This is exactly the effect observed when a square-wave input is applied to an amplifier with this sort of response. On top of the square wave we see a decaying sinusoidal transient with a frequency just below, in this case, $\omega = 4$. Just a little more gain and the amplifier will be unstable, with the apparent Q rising to infinity.

The $\mu\beta$ effect calculator is not only used for calculation of the response of feedback amplifiers. If we write $-\mu\beta = A\angle\theta$ we have for the $\mu\beta$ effect, which we can call $M\angle\phi$

$$M\angle\phi = \frac{A\angle\theta}{1 + A\angle\theta} = \frac{1}{1 + \frac{1}{A}\angle{-\theta}}$$

and since M and A are in decibels,

$$-M\angle{-\phi} = 1 - A\angle{-\theta}$$

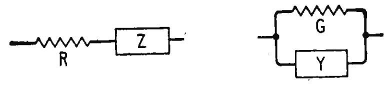


Fig. 31. Networks which frequently arise in equalizer problems.

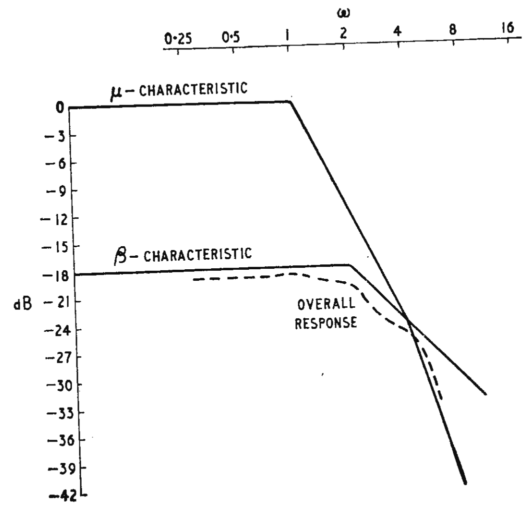


Fig. 32. Amplitude response curves obtained when a capacitor is added across the feedback resistor in the circuit giving the characteristics of Fig. 29.

In equalizer problems we frequently have occasion to work with networks of the forms shown in Fig. 31. The impedance of the first of these is simply R + Z and this can be normalized to the form R(1 + Z/R). The second network has an admittance which in just the same way can be written as G(1 + Y/G) and the reasoning which follows can be applied to this form without it being necessary to repeat it. There is no statement about Z except that it is a general impedance $|Z|\angle\alpha$. If we put $20 \log |Z|/R = -A$ and $\alpha = -\theta$ in the form we have above for $M\angle\phi$ we see that we can immediately read off the normalized term (1 + Z/R) in decibels and degrees. This result is especially useful when we have a sequence of this kind of operation to perform. In the first step Z may be just a pure reactance, which is easily handled by the $[1 + j\Omega]$ template, but if this R + jX combination is taken as Y in the parallel circuit of Fig. 31, and this new network then taken as Z in a further operation, the process will often be most easily treated arithmetically.

Returning to the basic use of the $\mu\beta$ effect calculator let us consider how we should deal in practice with the system analysed in Figs. 29 and 30. The reasoning usually applied runs something like this: the response with feedback shows a rise beginning at about $\omega = 2$. If we knock the gain down here by increasing the feedback we shall flatten out the response. When the feedback path consists of just a single series resistance going back to either a cathode or a feedback defining resistance in a grid circuit we can connect a capacitance across this resistance. This alters both β and $-\mu\beta$, and we must draw out Figs. 32 and 33. The result of a quick computation shows that there is no longer any hump in the response but it lies fairly uniformly below the β characteristic and although it does cross the μ characteristic, indicating

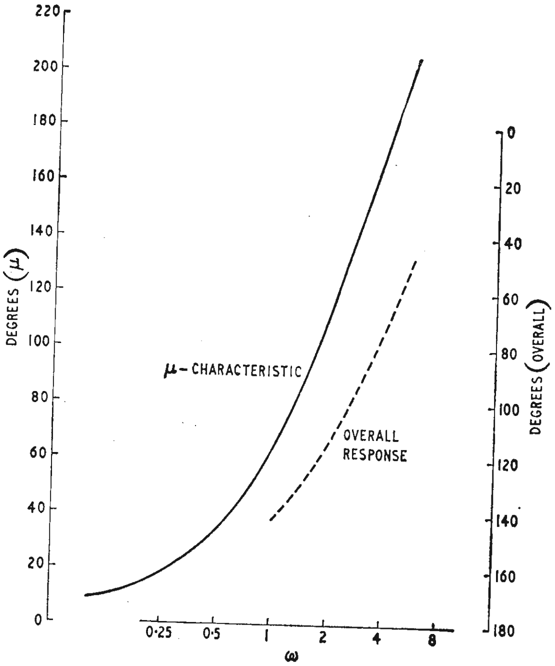


Fig. 33. Phase characteristics corresponding to amplitude responses of Fig. 32.

that the feedback produces an increase in gain at sufficiently high frequencies, the region where it does so is well away from the working band.

This result agrees exactly with what we observe in practice. A small capacitance across the feedback resistance can often be trimmed, while watching the square-wave ringing, to give a very small overshoot. Commercial amplifiers will often show a 10-20% overshoot because they are designed to give the widest possible frequency response: a good paper selling point is always worth having.

It is not an enormous task to do all this calculation with the rounded curves which we get by using the exact template characteristics. There will be a significant change in Fig. 32 if we do so because in the region of $\omega = 2$ we must be below a β curve which has dropped by 3dB. The overall response will thus be much more rounded than the approximate one drawn. It becomes tempting to move the characteristic frequency for the β term out to $\omega = 2.8$ but the choice of the best position will only be made either on the full response curves or even on the amplifier itself. This may seem rather an anti-design design technique but it can be justified here by the fact that the response at the top end is determined by stray capacitances which are not exactly known until the amplifier is constructed. It would be a rather roundabout procedure to build the amplifier, measure the strays, draw the diagrams and try, on paper, several shapes for β, when this final stage is very easily made the subject of an experiment. The preliminary analysis should have already established that the answer can be found so that a direct approach of this kind is fully justified.

At the low-frequency end of the amplifier response we are usually faced with a situation which is of the same theoretical kind but which has very different practical implications. When we come to connect the feedback path we frequently find that the d.c. conditions cannot be ignored. We may, for example, be feeding back from a valve anode to either a cathode or a grid and we do not want either to heat up the feedback resistor or disturb the bias conditions at the front end. Naturally we put in a blocking capacitor. This provides a β response which rises at low frequencies where the capacitor reduces the amount of feedback. It also adds one more low-frequency roll-off characteristic to the total $\mu\beta$ loop. We have rather blithely considered stability in terms only of the forward characteristic on the assumption that the feedback would be flat: what we have done at the top end has made life easier. Now we have an additional circuit which is definitely an unstabilizing circuit and we must include it in our calculations.

This draws attention to another point which can conveniently be made here. When the feedback is restricted in frequency range the effects of the supply system can become very important. In amplifiers designed for music this is most unlikely to arise, but in limited-band voice amplifiers, such as those used in communication and public-address systems, we are not concerned with frequencies below some 200-300 c/s. We must still watch carefully what is happening at 50c/s and 100c/s where we want our feedback to keep supply noise low. We must also watch that the amplifier gain does not run up at the frequencies where motor-boating can be produced by the impedance of the power supply. Where this impedance is determined by electrolytic capacitors we must give ourselves exceptionally good margins to allow for an old lower-limit capacitor on a cold day.

The functioning of the $\mu\beta$ calculator as a tool has been described here: for this it is not really necessary to understand it. There are, however, some other applications which are of great value in feedback amplifier design which are most easily followed when the calculator is related to the Nyquist diagram, a form which we have not found it convenient to use. We shall, therefore, return later to the calculator. By then it is to be hoped that many readers will be proficient in its use.

CLUB NEWS

National Field Day.—This amateur event of the month will be held on June 2nd and 3rd. Nearly 120 clubs and groups are to participate in the field day for which operation is permitted in the 1.8, 3.5, 7, 14, 21 and 28 Mc/s bands.

V.H.F. Field Day.—The R.S.G.B.'s first v.h.f. national field day will be held on July 7th and 8th. Operation is this year limited to the 144-146 Mc/s band, but in future years it is proposed to permit the use of all amateur v.h.f. and u.h.f. bands. Both a.m. and f.m. 'phone and also c.w. is permissible.

Barnsley.—The subject of the lecture at the June 8th meeting of the Barnsley and District Amateur Radio Club is "Relays in a Station," which will be given by D. W. Heath. The meeting will be held at 7.45 at the King George Hotel, Peel Street.

Birmingham.—Radio controlled models will be discussed by A. T. Spencer, of the Wulfruna Model Boat Club, at the June 1st meeting of the Slade Radio Society. On the 15th, P. J. Guy, of the B.B.C., will deal with sound and television magnetic recording and on the 29th there will be a demonstration of sound reproducing equipment. Meetings are held at 7.45 at the Church House, High Street, Erdington.

Bristol.—The fifth annual mobile rally organized by the Bristol Group of the R.S.G.B. will be held at Longleat, near Warminster, Wilts, on June 17th. The two control stations will be G3CHW/A on 1880 kc/s and G3GYQ/A in the 2-metre band.

LETTERS TO THE EDITOR

The Editor does not necessarily endorse opinions expressed by his correspondents

Transistor Circuit Conventions

I HAVE followed with considerable interest the correspondence started by Mr. P. Baxandall's article "Collector Upwards or Positive Upwards" in your January issue. To me his case seemed so well put as to make a supporting letter superfluous; I suspect many others felt as I did. Perhaps this is why more than half of the subsequent letters have dissented from the convention he describes. On symbols I have already had my say[1], but I would like to comment on those letters which dissent from the "positive up" polarity convention. These letters are far from all advocating the same convention, in fact in analysing them I have found it useful to devise the following shorthand to identify the various proposals.

Collectors up .. .. c $\uparrow$

Positive up (and negative below earth line): $\frac{+}{-}$

Positive and negative both above earth line: $\underline{+\ -}$

Positive and negative both below earth line: $\overline{+\ -}$

Certain proposals appear to involve positive and negative supply lines above and below the earth line: .. .. $\frac{+\ -}{-\ +}$

Those letters in which a preference is stated (or can reasonably be inferred) can then be tabulated as follows:—

TABLE

	Circuit Polarity Convention	*Waveforms*
(a) Baxandall	$\frac{+}{-}$	$\frac{+}{-}$
(b) Roddam	c $\uparrow$	
(c) "Cathode Ray"	$\frac{+}{-}$	$\frac{+}{-}$*
(d) Bedford	$\underline{+\ -}$	
(e) Bush	c $\uparrow$ $\overline{+\ -}$	
(f) Sturley, Amos	c $\uparrow$ $\frac{+\ -}{-\ +}$	$\frac{+}{-}$
(g) Cain	c $\uparrow$ ("polarity irrelevant")	
(h) Butler	$\frac{+}{-}$ (for new circuits)	$\frac{+}{-}$*
	$\underline{+\ -}$ and c $\uparrow$ $\frac{+\ -}{-\ +}$ in examples given	
(i) Knowles, Braithwaite	c $\uparrow$ $\underline{+\ -}$	$\frac{+\ -}{-\ +}$
(j) Bateson	$\frac{+}{-}$	$\frac{+}{-}$*
(k) Martin	$\frac{+}{-}$	$\frac{+}{-}$*
(l) Pope	$\frac{+}{-}$	$\frac{+}{-}$*

The main objection directed against the $\frac{+}{-}$ convention is that p-n-p transistor circuits are "upside-down" in relation to their n-p-n and valve equivalents (though in (d) it is suggested that too facile a correlation between transistor circuits and their valve equivalents may be a disadvantage). Admittedly an initial effort is required in recognizing a familiar circuit configuration in inverted form, but once this has been done there are no further difficulties associated with the $\frac{+}{-}$ convention, since the polarities and directions of current flow are the same in all transistor and valve circuits.

Let us now consider the difficulties of the c $\uparrow$ convention which the correspondence has revealed. The circuit given in (f) to demonstrate the authors' ideas shows a p-n-p transistor with c $\uparrow$ and the power lines arranged $\frac{-}{+}$. To make an identical c $\uparrow$ circuit with an n-p-n transistor would involve reversing the power line polarities. The same applies to Figs. 2 and 3 of (h). Thus if circuits using both transistor types appear in the same diagram, we are faced either with a $\frac{+\ -}{-\ +}$ arrangement of power supplies or with crossing-over the power connections to the transistors of one type (see Fig. 7 of (a)), which is at least confusing, and probably impracticable in a complex circuit.

This leads to the conclusion that if the c $\uparrow$ convention is to be followed it is better combined with a $\underline{+\ -}$ or $\overline{+\ -}$ polarity convention. We are then faced with the following difficulties:—

1. The choice of a particular voltage line for earth is usually arbitrary, as several contributors point out. It follows that a change of the earth line should not appreciably affect the circuit layout. With the $\underline{+\ -}$ or $\overline{+\ -}$ $\left(\text{or } \frac{+\ -}{-\ +}\right)$ conventions considerable reorganization might follow such a change, and might impede the recognition of familiar circuits, which most contributors regard as important.

2. The $\underline{+\ -}$ or $\overline{+\ -}$ circuit configurations convey no polarity information in the circuit layout. Whether this is regarded as a simplification or as a suppression of vital information depends on the circuit and the point of view. Low-level linear circuits, when they are working correctly, have least need of polarity information, but if, for example, they are giving trouble due to a shift in bias conditions or being overloaded by large signals, a maintenance man needs polarity information to understand what is happening. I submit that one needs polarity information to recognize the intended functioning of a circuit containing even one diode, and that for more complex non-linear circuits (including any digital computing circuits more detailed than a

* These writers have not explicitly indicated their preferred waveform polarities, but I have considered it unlikely that anyone who advocates the $\frac{+}{-}$ conventions for circuits would fail to do the same for waveforms

(1) *Wireless World*, Vol. 63, No. 7, pp. 333–334, July 1957, "Transistor Circuit Symbols."

logical diagram), and for direct-current coupled circuits, polarity information is as vital as any other aspect of the circuit layout.

3. There may be difficulty in correlating the circuit layout with waveform diagrams. The authors of (f) apparently find no difficulty in correlating a $\frac{+}{-}$ waveform with a $\frac{-}{+}$ circuit. On the other hand the authors of (i) feel this difficulty so strongly that they invert the waveforms to accord with the local polarity convention associated with each c ↑ transistor, so that some waveforms are $\frac{-}{+}$ and others are $\frac{+}{-}$. It should be noted that of the five contributions advocating the c ↑ convention, three do not face this problem at all.

With the $\frac{+}{-}$ convention none of these three classes of difficulty arise.

Judging from the correspondence to date it would appear that if any exponent of c ↑ had written a detailed article like Baxandall's, considering and proposing particular solutions to the objections mentioned above, he would have been likely to find himself in a small minority in the ensuing correspondence. In fact it seems unlikely that any other proposal would have received the amount of support accorded to the $\frac{+}{-}$ convention.

If we feel there are real advantages in this convention we should not be deterred too much from following it by the thought that foreign practice may be different. Foreign circuit designers are by no means unanimous, and those who follow the c ↑ convention do not appear yet to have found a satisfactory solution to the problem of mixed p-n-p and n-p-n transistor circuits.

So let us avoid the difficulties of the c ↑ convention and invite our foreign friends to share with us the advantages of the $\frac{+}{-}$ convention.

In conclusion I should add that the views expressed here are purely personal ones and not necessarily those of any B.S.I. Committee with which I am associated.

Harwell. E. H. COOKE-YARBOROUGH

The "Indusistor"—A Proposed Inductive Transistor

In a recent[1] paper H. G. Dill describes an inductive transistor. It is a usual transistor connected to give (for a.c. conditions) virtually the circuit of Fig. 1. From the analysis presented in the above-mentioned paper[1] an important conclusion is drawn: that r_{bb}' must be sufficiently high in order that the device shall have an inductive behaviour. For this an additional base resistance is necessary (Fig. 2), but unfortunately this cannot be too high because C_{bc} is shunting it.

It is proposed here to compensate C_{bc} by using a distributed RC network as is shown in Fig. 3. From an analysis presented elsewhere[2] it is evident that between the points A and B′ the network presents an inductive component. For instance, Y_0 from the equivalent scheme of Fig. 4(b) is purely inductive[2] for $\omega = 10(RC)^{-1}$, where R is the total resistance and C the total capacitance of the network. It may be shown that for $\omega < (RC)^{-1}$, Y_0 is constituted by a resistance R in parallel with a negative capacitance. This negative capacitance may really compensate C_{bc}.

The scheme of Fig. 3 may present another major advantage. It may be converted into a unified device, as is shown in Fig. 5. One obtains a device—called for convenience, "indusistor"—with two terminals.

The question is now, how great may be the quality factor Q of the inductance presented by the indusistor.

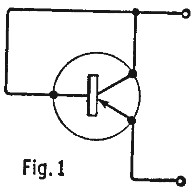


Fig. 1

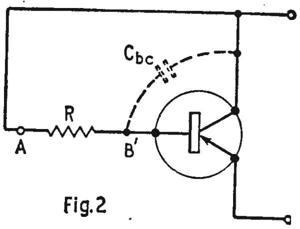


Fig. 2

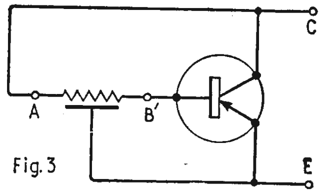


Fig. 3

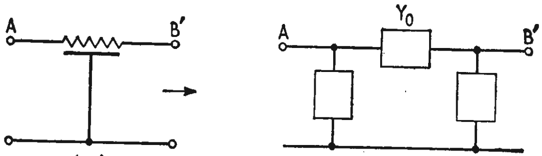


Fig. 4

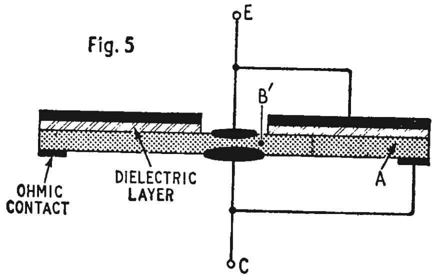


Fig. 5

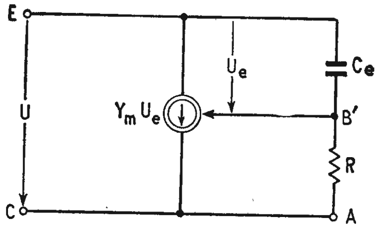


Fig. 6

One favourable effect will be mentioned here. If the transistor is operated at moderately high frequencies (between f_β and f_α) the internal transconductance of the transistor has an expression of the form $Y_m = G\left(1 - i\omega\frac{2.43}{\omega_\alpha}\right) = G(1 - i\omega a)$. Oversimplifying the scheme of Fig. 3 it may be considered that it has an equivalent circuit as indicated in Fig. 6, where C_e is an equivalent capacitance. It may be seen that if $\frac{1}{C_e\omega} << R$ then $U_e = -j\frac{1}{\omega RC_e} = -j\frac{b}{\omega}$. Therefore $Y_m U_e = -j\frac{\omega}{b}Y_m U$ and the current generator may be replaced by the admittance $-j\frac{b}{\omega}Y_m = -abG - j\frac{bG}{\omega}$, from which it is evident that it contains a negative conductance $-abG$ (which cannot appear at low frequencies where $Y_m = G$) and a negative susceptance (therefore an inductance). The total admittance of the device is of the form $Y = \left(\frac{1}{R} - abG\right) - j\frac{bG}{\omega}$ from which it may be seen that the effect of negative resistance may really contribute towards obtaining a reasonable Q. In conclusion it seems that the device of Fig. 5 has some advantages over the similar previous devices. A detailed theoretical analysis is in progress and will be published soon.

M. DRAGANESCU.
Rumania — Department of Electronics, Polytechnic Institute of Bucharest.

H. G. Dill: "Inductive Semiconductor Elements and their Application in Band pass Amplifiers. *Transactions I.R.E.*, MIL-5, July 1961, pp. 239-250.

[2] W. Minner: Theorie und Anwendungsbeispiele eines Schaltelementes mit verteilten Widerstand und verteilten Kapazität. *Arch. Elekt. Ubertragung*, 15 (1961) Nov., pp. 537-544.

Engineers

I AM much afraid that "Free Grid" (April issue) has collected some bias. After enjoying his contributions for all these years, I now find myself for the first time in serious disagreement with him (if, indeed, "serious" is *le mot juste* in this connection) over the matter of engineers.

Surely there were engineers long before the "duly qualified" white collar and spats types who now claim sole rights to the title. And they were professionals to boot! This means that any pirating is being done by the "Chartered," "Associate," "Incorporated" or "what-have-you" brigade in an attempt to increase the snob value of their titles, while most of us contend that the crew of a locomotive or the turner at his lathe qualify as engineers. And if they don't, where, incidentally, are the Royal Engineers to be fitted into the new picture?

I am convinced, too, that the No. 8 Hats responsible for all the complex technical phraseology and multilingual terminology now prevalent are sufficiently erudite to coin a new and distinctive description for themselves which no outsider would envy them, and I suggest that they do so.

In conclusion I also wish to forestall further claims by insisting on my right to refer to such things as "chartered ships," "associated journals," "incorporated components," etc., as and when occasion arises.

London, S.W.15. E. H. JAGO.

Meters and Senses

I AM grateful to Mr. L. H. Hills for his encouraging remarks concerning my article under the above title. His one regret appears to be that I made no mention of how the pitch of a musical sound is affected by removing the fundamental. This was because I had referred to it only two months earlier (January issue, p. 31) in the following words:

"With some instruments, such as the oboe, the harmonics are actually stronger than the fundamental. Fortunately our sense of hearing is so arranged that we automatically identify the fundamental frequency, even when it is entirely absent!"

I am rather surprised to find anyone in the field of musical science who is unsure on this point, for it was (I thought) established by no less an authority than Fletcher* as far back as 1934 that the pitch of a sound rich in harmonics is unaffected by completely removing the fundamental and even the lower harmonics as well. This is a most fortunate phenomenon for the radio industry, and especially that part of it devoted to the production of pocket-sized receivers. For although their failure to reproduce the fundamentals of (say) organ pedal notes detracts considerably from the naturalness and impressiveness of these, at least their musical pitch is recognizable, and the general effect in the reproduction of music is far better than one had any right to expect. It is also fortunate for manufacturers of domestic pianos, the low notes from which have negligible fundamental content.

The explanation given by Fletcher, and as far as I know not seriously questioned, is the production in the ear (because of its non-linearity) of difference frequencies. Those due to consecutive harmonics recreate for the listener the fundamental. For example, in one of Fletcher's experiments he played tones of 800, 900 and 1,000 c/s, which were collectively recognized as a fundamentally 100 c/s note.

I cannot agree with Mr. Hills that it is obvious that removing the fundamental would make the second harmonic become the fundamental, for then the third harmonic would become the one-and-a-half harmonic, and there ain't no such thing. However, although his observations seem contrary to Fletcher's and others', one can never be too sure, and I hope he will investigate the matter further and report results.

While referring to my January article on formants I would like to add that the experiment I described of making recognizable vowel sounds by merely shaping the mouth for those sounds while tapping the teeth with a pencil was shortly afterwards demonstrated much more elegantly on the radio by a speaker who used a Jew's harp as the excitation.

I'm sorry to be unable to help Mr. Briggs with a ready explanation of the selective effect of temperature on the tone of strings and brass. This seems to be a matter for a scientific musician rather than a musical scientist, and I can't claim to be either.

"CATHODE RAY."

* *Jour. Acoust. Soc. Amer.*, 6, 59.

Line Standards for British Television

AS they apply to this one manufacturer, the facts quoted in Mr. Scadeng's letter in the April issue of *Wireless World* are not true. Last year we sold more radio sets on the export market than on the home market. If we managed to sell as many television sets abroad as we sell on the home market, our export figures would be substantially better. If other manufacturers were to do likewise, the figures for TV exports would be many times those at present reached by the industry.

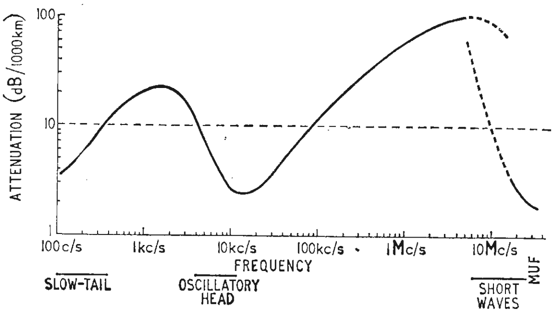
It is very doubtful whether the country would accept a permanent limitation to three television programmes. If there is not to be such a limitation, then we must go to the upper bands, where 625-line standards will be both better and cheaper. In the smaller reception areas u.h.f. pictures tend to be better, not worse.

Next, when we can use a common chassis for both home and export markets, this will provide great economies, in our opinion, and a much more flexible supply. The gadgets that have been a feature of so many German television sets are mainly additions to a basic chassis. For instance, at the last Berlin Radio Show most manufacturers were showing 100 models or more, all on basic home market chassis though with minor variations for different markets or requirements. These on-line variations have to be coped with in any export business and reflect such things as language differences, etc.

Mr. Scadeng talks about great new developments, presumably referring to bandwidth compression. The B.B.C. tests on bandwidth compression have been, to say the least of it, pretty pessimistic. However, if somebody does dream up a system, there is no reason why it could not be applied to 625 lines just as easily as to 405 lines.

Finally, it is suggested that the European countries will be quite content to abandon 625 lines in ten years' time. Since France, Germany, Italy, Belgium, Spain, Norway, and other European countries are all embarking on very substantial expenditure on new 625 networks this year, I do not believe that they will wish to abandon these in such a short period of time. At the E.B.U. Conference, many of the leading experts from different European countries expected the present 625 networks to last for another 25 years.

Cambridge. J. O. STANLEY,
Pye Ltd.



V.L.F. Electromagnetic Waves

READING the timely article (April issue) by Dr. Gould and Mr. Carter on very low frequency electromagnetic waves, I feel that it is useful to call attention to a diagram published some time ago in *Nature*[1] which clearly illustrates how these waves, during propagation over long distances over the surface of the earth, only suffer the same small attenuation commonly assigned to short waves. The diagram shows the day-time attenuation per 1000km for the whole spectrum of ground—ionosphere controlled radio transmission. The data, which was collected off the measurements of a large number of individual atmospherics, is derived by plotting the average field strength as a function of distance. The curves for different frequencies support an inverse square-root law together with the superimposed attenuation factor, which is the ordinate of the curve. Night-time results are also available.

The curve also demonstrates the absorption band in the region of 1-2 kc/s discussed in the article. It is interesting to note that the possibility of anomalous propagation at these frequencies was first pointed out by T. L. Eckersley in 1925[2] and demonstrated by Appleton and Chapman[3]. This region of high attenuation is also one of a rapid change of the phase characteristics of the propagation and in fact accounts for the dispersion of the oscillatory-head and the slow-tail portion of the atmospheric waveform. I should also point out that the data from 30 kc/s to 30 Mc/s was taken from later work by Eckersley[4] where he clearly demonstrates how the propagation characteristics can be calculated both from a wave-guide or mode concept and that of ray tracing.

Romsey, Hampshire. R. C. V. MACARIO

1. Chapman, F. W., and Macario, R. C. V., *Nature*, vol. 177, May 1956.
2. Round, H. J., Eckersley, T. L., Tremellen, K., and Lunnon, F. C., *J.I.E.E.*, vol. 63, 1925.
3. Appleton, E. V., and Chapman, F. W., *Proc. Roy. Soc. A.*, vol. 158, 1937.
4. Eckersley, T. L., *J.I.E.E.*, vol. 71, 1932.

BOOKS RECEIVED

B.B.C. Engineering Monographs.
No. 35: Tables of Horizontal Radiation Patterns of Dipoles Mounted on Cylinders, by P. Knight and R. E. Davies. Pp. 43.

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Each of the Monographs costs 5s. and can be obtained from B.B.C. Publications, 35 Marylebone High Street, London, W.1.

Physics for Electrical Engineers, by W. P. Jolly. A textbook specifically suited to the I.E.E. Engineering Physics syllabus, which will also be useful for Institute of Physics and Higher National Certificate students. The four sections cover the structure of matter, electrical properties of matter, radiation and thermodynamics. There are appendices on light and sound. Pp. 308. English Universities Press Ltd., 102 Newgate Street, London, E.C.1. Price 21s.

Advances in Electron Tube Techniques, edited by David Slater. A collection of papers presented at the Fifth National Conference on Tube Techniques held in the United States in 1960. The papers were concerned with design, development and manufacture of valves. Pp. 235. Pergamon Press Ltd., Headington Hill Hall, Oxford, Price £5.

Tabulation of Data on Microwave Tubes, by C. P. Marsden, W. J. Keery and J. K. Moffitt. National Bureau of Standards Handbook No. 70 gives characteristics of a large number of valves of various types. Pp. 128. Govt. Printing Office, Washington 25, D. C. Price $1.00.

Coupled Mode and Parametic Electronics, by W. H. Louisell. Develops the theory of coupled modes of vibration or propagation and applies it to give a unified theory of devices, such as travelling wave tubes and backward wave valves, in which space-charge waves are coupled to slow-wave structures. The same fundamental approach is then applied to the various parametric devices. Pp. 268. John Wiley & Sons Ltd., Gordon House, Greencoat Place, London, S.W.1. Price 92s.

British Transistor, Diode and Semiconductor Devices Data Annual 1962-63, by G. W. A. Dummer and J. Mackenzie Robertson. A collection of data reproduced, in the main, from manufacturers' information sheets. This 935-page annual avoids the need for a dozen different catalogues on one's shelf. Published by Pergamon Press Ltd., 4 and 5, Fitzroy Square, London, W.1. Price £7 ($25).

POLES AND ZEROS

By "CATHODE RAY"

2.—EXAMINATION OF A SECOND-ORDER SYSTEM

LAST month we made a gentle start with pole-and-zero diagrams. If this was your first encounter with them you may want a recapitulation.

They came into the conversation as a helpful means of representing the performance, frequency-wise of any circuit. We had been discussing the output/input ratios (called transfer functions) of

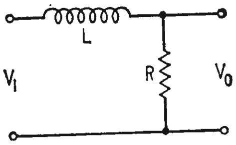

Fig. 1. Example of a first-order system, to refresh the memory.

simple circuit systems such as Fig. 1. Assuming (1) the circuit is linear, (2) the source of the sinusoidal input voltage V_1 is free from resistance, (3) the output voltage V_0 is not required to supply any current, and (4) that transients are ignored, the transfer function is calculated as for a simple potential divider:

$$\frac{V_0}{V_1} = \frac{R}{R + j\omega L}$$

Dividing above and below by R reduces this to one of four standard forms which we found covered all 16 arrangements comprising one resistance and one reactance:

$$\frac{V_0}{V_1} = \frac{1}{1 + j\omega T}$$

where T is the time constant, L/R. In capacitive circuits the time constant is CR, and in their equations the individual Cs and Rs similarly go out leaving only Ts.

V_0/V_1 can be plotted against f $(=\omega/2\pi)$, to give what is well known as the frequency characteristic, by straightforward algebra; easily in this example, but much less easily for circuits with a lot of components. Alternatively a pole-zero diagram can be drawn as an intermediate step. A reason for doing so is that after a little practice one hardly needs to go on to plot the frequency characteristic; one can judge roughly what it will be by looking at the pole-zero diagram, which is very simply derived from the transfer function.

I should perhaps mention at this stage that use of these diagrams is not confined to transfer functions; they apply equally to impedances and admittances (nowadays telescoped together as "immitances").

The way to draw a pole-zero diagram is mark on a complex plane (axes ω and $j\omega$) those values of ω (or f) that make the immitance or transfer function go to zero or infinity. These values are found by equating the numerator and denominator factors to zero. (Any infinite values of ω that do the same thing are off the map and don't count). In our simple example there is clearly an infinity (or "pole") when $\omega = j/T$, because by definition $j^2 = -1$. Then $j\omega$ becomes $-1/T$, which is the same thing as jf being $-1/2\pi T$. This point is marked with an X on the negative "real" axis to the same scale as ω or f as the case may be; Fig. 2.

There is no factor in the numerator containing $j\omega$, so no "zero" to mark, but when there is its sign is a O.

The magnitude and phase angle of V_0/V_1 at any frequency are given respectively by the distances and directions of the poles and zeros from the point on the $j\omega$ (or jf) scale representing that frequency. And so the variation of V_0/V_1 with frequency can be seen. The magnitude is obtained by multiplying together all the distances from zeros and dividing by all the distances from poles. To get the scale right, divide each distance by $1/2\pi T$ (or $1/T$ for a scale of ω), T being the appropriate time constant. The phase angle, ϕ, is obtained by adding all the "zero" angles and subtracting all the pole angles.

Applying the rules to Fig. 2 we have only one distance, to the pole. In this example, $1/2\pi T$ is 1,500, so that is the distance to the pole at zero frequency. Dividing it by $1/2\pi T$ we get 1. Since we are dealing with a pole, we take its reciprocal; again, 1. The angle above the horizontal is zero. All this agrees with what we know about the performance of the circuit at zero frequency, for then

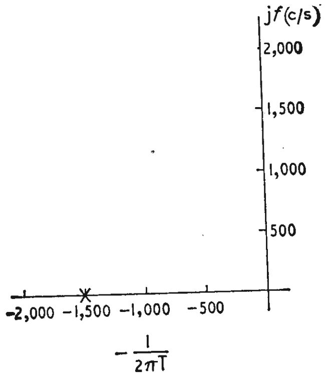

Fig. 2. Pole-zero diagram for the simple Fig. 1 circuit, with scales applicable to all component values making $1/2\pi T$ $(=R/2\pi L) = 1{,}500$.

L is just a connection with no impedance, and $V_0 = V_1$ in both magnitude and phase.

Another point to try on the way up is 1,500 c/s, because that is what we have been calling the turning frequency. Here the distance to the pole is $\sqrt{2}$ times what it was at zero, so the magnitude V_0/V_1 is $1/\sqrt{2}$ or 0.707. The angle is 45° upwards, so our phase angle ϕ must be $-45°$, signifying that V_0 lags one-eighth of a cycle behind V_1. Again, this checks with the results of other methods.

As f approaches infinity, so does the distance from the pole, so V_0/V_1 approaches zero. And ϕ approaches 90°.

Awkward readers (bless them!) will be murmuring

I've fiddled these results, because according to the rules I had a denominator for $|V_0/V_1|$ but no numerator—because no zero on the diagram. But the scale factor $1/2\pi T$ by which the denominator has to be divided acts as the numerator.

In this very simple example it is perfectly easy from the start to visualize the frequency characteristics by mentally watching a ray from the single pole increasing in length and slope as it follows a point moving up the *jf* scale. But when there are several poles and zeros the mental work looks more difficult. However, as we saw last month with an example having one zero and two poles, the difficulties quite quickly recede if one notices certain general principles. For example, poles and zeros cancel out if they coincide; this corresponds to the algebraic cancellation of equal factors above and below the line. But the diagram also brings out pictorially how a pole and zero *tend* to cancel one another when they are close together. Again, phase and magnitude change most rapidly with frequency where there is a pole or zero close to the $j\omega$ axis.

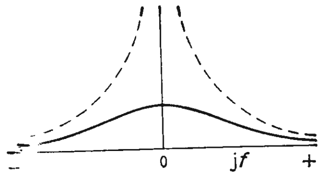

Fig. 3. Frequency characteristic of the Fig. 1 circuit, obtainable from Fig. 2 by imagining an actual pole at X, propping up a rubber sheet, and drawing the contour of the sheet along the jf axis.

Another aid is to imagine a thin rubber sheet spread over the whole diagram. Zeros are represented by tacks holding the sheet down, and poles are actual poles standing up vertically from the surface. Theoretically they ought to be infinitely high; in practice they are as high as possible without endangering the sheet.

Thus Fig. 2 would appear as a sharply peaked mountain rising out of the paper at X. The frequency characteristic appears as the vertical section along the *jf* axis. Fig. 3 shows how this section would look if seen from the right of Fig. 2. The dotted line is a distant view of the infinite peak itself. Mathematicians will recognize its slopes as rectangular hyperbolas. But we are supposed to be concentrating on the full line depicting the section—our magnitude/frequency characteristic. It is, of course, produced by the outlying slope of the mountain. It differs from the sort of curves we have been looking at during the last two months in two respects. One of the differences is due to the left-hand half, which we usually ignore because it applies to negative frequencies. The other difference is that the gradient flattens out at high frequencies instead of tending towards a uniform downward slope. The reason for that, of course, is that our rubber mountain works on a linear height scale, like any other mountain. That is a disadvantage of this kindergarten method.

Both these unfamiliarities bring some compensation if we are observant enough to notice the resemblance between this curve—and the dotted one too—to a resonance peak. The sectional one looks as if its selectivity was rather poor, whereas the dotted one clearly has an infinitely large Q. But, you may think, merely fanciful—negative frequency, and all that. Pity.

But not at all. Negative frequency is a meaningful concept, as I showed earlier, though I doubt whether even Mr. Clay† remembers it, for it was in the October, 1948 issue. It suggests (to anyone who does remember or looks it up) the possibility of removal of the zero-*jf* point up the scale positive-wards; and that is just what can happen with our diagrams. The fact that hitherto all our poles and zeros have occurred on the negative "real" axis just shows we are beginners. We have considered only "first-order" systems. It is high time we went on.

Strictly speaking, our gramophone circuit last month was a second-order system, but because it was of a limited kind we were able to treat it as a combination of first-order systems. To see all the features of record-order functions we must include all three types of element—R, C and L. Fig. 4 is the simplest kind of example of this, with only one of each, all in series:

$$\frac{V_0}{V_1} = F(j\omega) = \frac{R}{\frac{1}{j\omega C} + R + j\omega L} \quad .. \quad .. \quad (1)$$

$$= \frac{j\omega CR}{1 + j\omega CR + j^2\omega^2 LC}$$

We see our familiar capacitive time constant, CR, but what about LC? As we have found substituting time constants for CR and L/R so profitable in the past, let us use a little ingenuity and call CR "T_1", and L/R "T_2". Then LC is just T_1T_2; simple!

$$F(j\omega) = \frac{j\omega T_1}{1 + j\omega T_1 + (j\omega)^2 T_1T_2} \quad .. \quad (2)$$

This is now clearly a function of $j\omega$ with time-constant coefficients, as before. All we need do to bring it into accustomed form for picking out the poles as well as the one obvious zero (at $f = 0$) is to factorize the denominator. But the object of that is to find the value or values of f that make the denominator zero. So, more directly, what we have to do is solve the quadratic equation

$$1 + j\omega T_1 + (j\omega)^2 T_1T_2 = 0$$

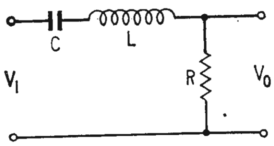

Fig. 4. Simple example of a general second-order system, for analysis.

Using the usual formula:

$$j\omega = \frac{-T_1 \pm \sqrt{T_1^2 - 4T_1T_2}}{2T_1T_2}$$

$$= -\frac{1}{2T_2} \pm \sqrt{\frac{1}{4T_2^2} - \frac{1}{T_1T_2}} \quad .. \quad .. \quad (3)$$

It is tempting to simplify this to

$$\frac{1}{2T_2}\left(-1 \pm \sqrt{1 - \frac{4T_2}{T_1}}\right) \quad .. \quad .. \quad (4)$$

† See correspondence April, May and September 1960 issues.—ED.

but we shall see that it can be misleading, and it is better to stick to (3).

However we write it, the important thing is the $\pm$, which tells us there are two solutions, one using the plus and the other the minus. That is what is meant when Fig. 4 is called a second-order system. There is of course the possibility that both solutions are the same, when $T_1 = 4T_2$ so that the square-root term goes out. There is also the possibility of $4T_2 > T_1$, resulting in j having to be brought in, making both solutions complex. That is the interesting one.

However, let us start with $4T_2 < T_1$. That means the square root is of a positive quantity, so no j and we can plot the two poles each side of the $1/2T_2$ point as in Fig. 5. (Note that in order to avoid bringing in 2π everywhere we are working in ω, adult fashion, instead of f.) There is also the zero at zero, as indicated by the numerator in eqn. (2). So V_0/V_1 begins with zero at zero frequency, obviously due to C in Fig. 4. It increases in pro-

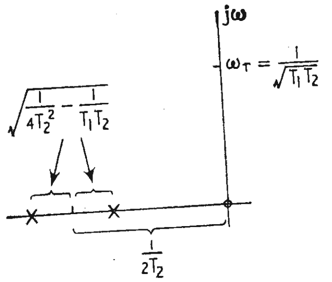

Fig. 5. Pole-zero diagram for the Fig. 4 circuit, for component values that make $4T_2 < T_1$ (i.e., $R_2 > 4L/C$).

portion to ω, but at the same time the distances to the two poles increase, slowly at first but then faster, so at very high frequencies the increase in V_0/V_1 due to C is nearly offset by the nearer pole and more than offset when the effect of the second pole is counted. Clearly, then, there is a maximum somewhere and then a fall-off to zero at infinite frequency. Which is exactly what we would expect, looking at Fig. 4. As regards phase, it begins with $+90°$ due to the zero, but this is first cancelled and then finally reversed by the approach to $-90°$ for each of the poles. We can easily sketch $F(j\omega)$ as in Fig. 6. (Compare Fig. 3). Equation (1) shows the height and position of the peak, which occurs where $j\omega L = -1/j\omega C = j/\omega C$. We all know this well as the series resonance condition, the two reactances cancelling one another out. In terms of time constants, the resonant frequency, which we can call f_r, is $1/2\pi\sqrt{LC} = 1/2\pi\sqrt{T_1T_2}$, and $\omega_r = 1/\sqrt{T_1T_2}$, as marked in Figs. 5 and 6.

If visualizing the pole and zero rays gives us any difficulty, tacking down the centre of our rubber sheet at the origin to represent the zero at once shows us the upper graph of Fig. 6, plus its negative-frequency counterpart.

The question that leaps to the eye is what happens when the poles separate so far that the nearer one coincides with the zero, and what are the corresponding circuit conditions? Looking at the term under the square-root sign in eqn. (4), we might think we could find out by making $T_2 = 0$ (say, $L = 0$) so that the whole term was 1, leaving $-\frac{1}{2T_2} + \frac{1}{2T_2}, = 0$. But in the meantime $1/2T_2$ has become ∞, so this conclusion has become uncertain and in fact wrong. What happens as L is reduced to zero is that the centre point $(-1/2T_2)$ moves off the map leftwards to infinity while the distance between it and the right-hand pole increases to $\infty - 1/T_1$. While any pure mathematicians in the house are opening their mouths to protest against that way of putting it, I'll hurriedly substitute the statement that the right-hand pole moves leftwards to the point $-1/T_1$ and the left-hand pole moves to $-\infty$. This, of course, is just what one would have got by omitting L at the start and arriving direct at the first-order transfer function, $j\omega T_1/(1 + j\omega T_1)$.

So far as the rubber model is concerned, the effect of banishing the farther pole makes little difference, for its influence was small anyway, and the nearer pole may not have shifted very far. But we see, either by looking at the type-1 curves in last month's issue or by putting $T_2 = 0$ in Fig. 6 and so shifting the peak and the zero ϕ rightwards to infinity, that the shape is fundamentally different. And so we learn that this visual aid, though useful at the early kindergarten stage (education being defined as a process of diminishing deception) is not altogether reliable, at least in distant parts, owing to uncertainty of " sea level."

An alternative procedure is to vary T_1, which appears only once in each solution of the equation. This time we increase it to infinity, which eliminates C in Fig. 4 by converting it into a short-circuit. This cuts out the square-root term without affecting the rest, so we get

$$-\frac{1}{2T_2} \pm \frac{1}{2T_2}$$

without any awkward repercussions. The right-hand pole now does reach the origin, disappearing in mutual cancellation with the zero there, and leaving only the left-hand pole, at $-1/T_2$. This checks with what we got with Fig. 1, now identically the same circuit. (Remember Fig. 2 was plotted for jf, so 2π appears.)

Having pretty thoroughly explored the positive range of what lies under the root sign, we come to the second case by making it zero: $4T_2 = T_1$. Our pole formula then reduces to

$$\frac{1}{2T_2} \pm 0$$

and the pole-zero diagram is simply Fig. 7. The fact that the cross represents two coincident poles is shown conventionally by the roman number.

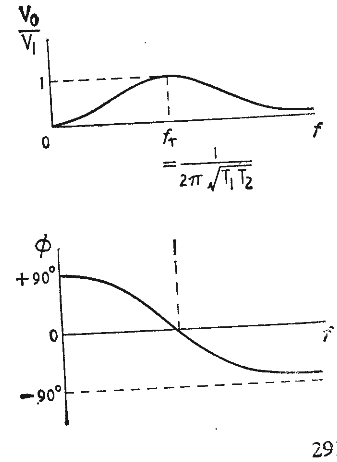

Fig. 6. Magnitude and phase of transfer function for Fig. 4 plotted against frequency. Its shape can be estimated by looking at Fig. 5.

You may question the need for this, seeing that a single pole goes to infinity and one can hardly advance on that. The answer is that each of the poles counts when distances and angles are being reckoned.

In this connection it is interesting to plot the frequency of resonance on Fig. 7. As we have already noted, in general $\omega_r (= 2\pi f_r) = 1/\sqrt{LC}$, or $1/\sqrt{T_1 T_2}$. When, as in this special case, $T_1 = 4T_2$, $\omega_r = 1/2T_2$. So both poles are at an angle of 45° and together they cancel the 90° angle to the zero, as shown at f_r in Fig. 6.

In working out the corresponding magnitude of $F(j\omega)$ one can easily go wrong over the scale factors. (The same applies to Case 1, which we didn't stop to do.) To avoid this we had better write out the whole transfer function for this particular case and frequency. Remember, $j\omega$ in each denominator factor has to be multiplied by *minus* the *reciprocal* of a solution of the equation formed by putting the denominator equal to zero, so that when $j\omega$ is equated with either of those solutions the corresponding factor becomes zero and indicates a pole. In our Case 2 both solutions are $-1/2T_2$, so

$$F(j\omega) = \frac{j\omega T_1}{(1 + j\omega 2T_2)(1 + j\omega 2T_2)}$$

This shows that the distance of the zero ($1/2T_2$ at this frequency) must be multiplied by T_1, whereas the distances of the poles ($\sqrt{2} \times 1/2T_2$ at this frequency) must be multiplied by $2T_2$. Doing this:

$$|F(j\omega)| = \frac{\frac{1}{2T_2} \times T_1}{\left(\frac{\sqrt{2}}{2T_2} \times 2T_2\right)^2} = \frac{T_1}{4T_2} = 1$$

as one would expect, since at resonance the two reactances in Fig. 4 add up to zero.

Now at last we come to the third case, in which $4T_2 > T_1$. The best way of dealing with this is to divide inside the square-root sign by $j^2 (= -1)$ and multiply outside by j. This makes the square root positive and therefore calculable, while making it clear that on the pole-zero diagram the whole term must be represented vertically. Again, the $\pm$ sign shows that equal distances must be set off in both directions; Fig. 8.

Each pole phasor, then, has a "real" part and an "imaginary" one, so as a whole is "complex." This, however, introduces no real complexities in the procedure. But it is worth mentioning that because the imaginary parts of the pole phasors are equal and opposite, these phasors are called the conjugates one of the other. The conventional sign for the conjugate of a quantity is an asterisk; e.g., Z^* is the conjugate of Z. Don't start looking for a footnote.

The transfer function admittedly looks impressive when written out in full:

$$F(j\omega) = \frac{j\omega T_1}{\left(1 + \frac{j\omega}{\frac{1}{2T_2} + \frac{j}{2T_2}\sqrt{\frac{4T_2}{T_1} - 1}}\right)\left(1 + \frac{j\omega}{\frac{1}{2T_2} - \frac{j}{2T_2}\sqrt{\frac{4T_2}{T_1} - 1}}\right)}$$

And even when tidied up a bit you may not like it much better. My only reason for exhibiting it is to show you what you are by-passing by using the pole-zero diagram. For although the scale factors would certainly be rather cumbersome if one were to calculate them from this equation, they are represented by the distances of the poles from the origin, which can be measured.

Again we take as an easily checkable example the condition of resonance. First of all we have to choose a circuit, or at least the relative magnitudes of the imaginary and real parts of the pole co-

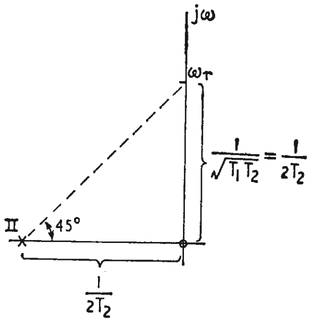

Fig. 7. If $4T_2 = T_1$, the two poles coincide so the place is marked "II."

ordinates. In Fig. 9 I have taken 3 : 1 as a simple ratio. This means that the square-root term, $\sqrt{4T_2/T_1 - 1}$, must be equal to 3, and that gives us the relative magnitudes of T_1 and T_2; $5T_1 = 2T_2$. Next, we use this result in the resonance relationship, $\omega_r = 1/\sqrt{T_1 T_2}$, to find $\omega_r = 1.58/T_2$, or $3.16/2T_2$. Plotting this on the diagram, we find it lies slightly above the upper pole. Applying the rules for finding the value of the transfer function at this frequency, we divide the distance of ω_r to the zero ($3.16/2T_2$) by $1/T_1$, which is $5/2T_2$. So the numerator is 0.632. The two factors in the denominator are found by dividing the distances to the poles (QP and QP*) by OP and OP*. The result is

$$|F(j\omega)| = \frac{0.632}{\frac{1.02}{3.16} \times \frac{6.25}{3.16}} = 1$$

The phase angle is obtained by deducting from the angle from the zero (+ 90°) the angles ϕ_1 and ϕ_2 from the poles—10° and 80° respectively—to give the reassuring answer, zero.

The same obviously correct result is obtainable by substituting ω_r (in terms of T_1 and T_2) for ω in the transfer function. This not only takes much longer but requires more concentration, even in this example which is quite exceptionally simple because of the zero phase angle. For plotting curves of magnitude and angle against frequency, the saving by using the pole-zero method instead would be really substantial.

Do I hear a murmuring from readers anxious to point out that calculating points for the curves can be done at least as quickly, and more intelligibly, by using the old familiar potential-divider expression in R, ωL and $1/\omega C$, without the work of solving a quadratic equation to find the poles, and then having to measure distances and angles? Like George Washington, I will not attempt to conceal from them the truth, which is that they are dead right. Then am I just trying (unsuccessfully, it seems) to blind people with maths? Certainly not. I have carefully chosen an example so simple that

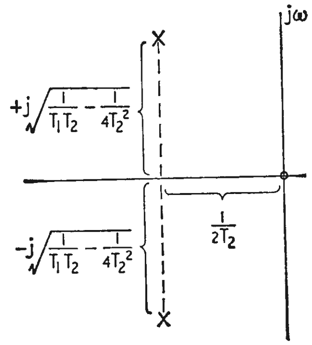

Fig. 8. If $4T_2 > T_1$, the square root terms have to be multiplied by j, so they are set off vertically as shown here.

one knows all along what answers to expect, with the object of building up confidence to tackle those where poles and zeros show a real saving. In any case, as I said, they have the advantage that with practice the general shape is discernible without plotting, simply by looking at the diagram. And the different approach sheds light on the functioning of these circuits.

One thing we notice, looking at Fig. 8, is that the longer the time constant T_2 the closer the poles are to the $j\omega$ axis. The result is a correspondingly rapid change in $F(j\omega)$ with $j\omega$ over the range of $j\omega$ close to a pole. This implies sharpness of resonance. Which is hardly surprising, for T_2, being L/R, is a measure of selectivity, akin to Q.

So if you see poles close to the $j\omega$ scale you can interpret them as sharp resonances, at the frequencies shown by the parts of the scale they are near.

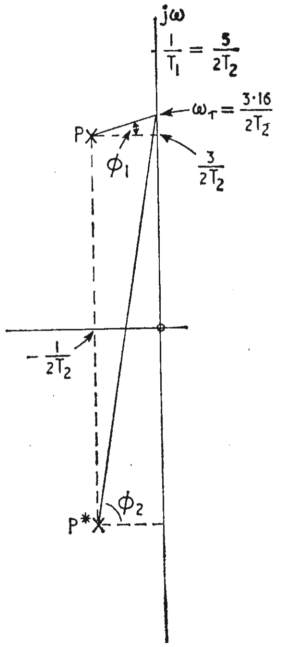

Fig. 9. Numerical example of Fig. 8, $4T_2$ having been made equal to $10T_1$.

If instead of working out this numerical example we had looked longer and harder at Fig. 8 we might have noticed—I might have noticed; you probably did!—that because the abscissa of each pole is $-1/2T_2$ and the ordinate is $\pm j\sqrt{1/T_1T_2-1/4T_2^2}$, the third side of each triangle (direct from O to X) must, according to Pythagoras, be $\sqrt{1/T_1T_2}$. And we have already seen that that is equal to ω_r, the frequency of resonance. So if it is kept constant while T_2 is varied, the poles trace out a circle, as drawn in Fig. 10. To do this, of course, T_1 must be varied too, to offset the effect on ω_r of varying T_2.

This explains why Q in Fig. 9 is a little above P; they both lie on a circle with the $j\omega$ axis as vertical diameter. And, of course, the point where the circle cuts the horizontal axis is where the two poles coalesce in Case 2, Fig. 7.

If you have even a slight acquaintance with the theory of oscillatory circuits, you will almost certainly have caught on to the significance of our three classes

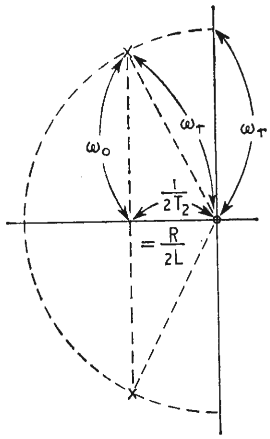

Fig. 10. This corresponds to Figs. 8 and 9, but is purely geometrical, to show magnitudes only. It shows the relationship between the frequency of resonance, ω_r, the frequency of natural oscillation, ω_0, and the quantity $1/2T_2$ or R/2L, which is a measure of the damping.

of this circuit—those in which $4T_2/T_1$ is less than, equal to, or greater than 1. This criterion may look more familiar if it is translated back into L, C and R, when the comparison is between R and $2\sqrt{L/C}$. Textbook theory shows that when, in a circuit comprising L, C and R all in series,

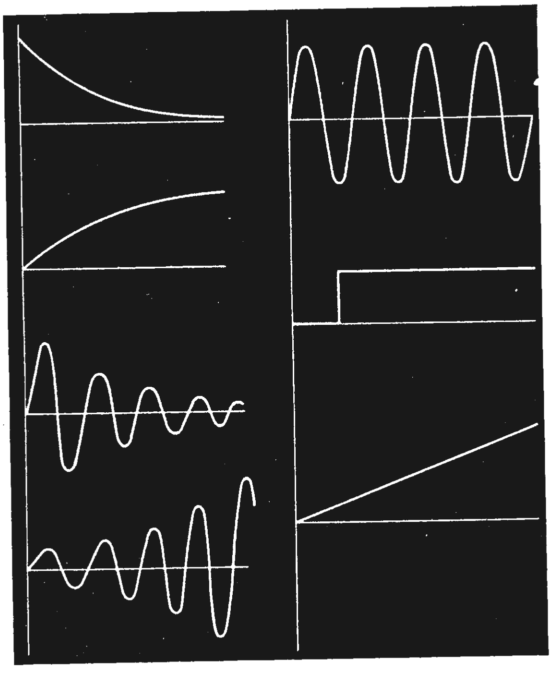

Fig. 11. Some examples of the wide range of exponential forms.

$R < 2\sqrt{L/C}$ (as in our last case) the circuit is oscillatory; any impulse causes a damped train of oscillations at the natural frequency. When $R = 2\sqrt{L/C}$, the circuit is "critically damped"; the response to a disturbance is *just* unidirectional. And when $R > 2\sqrt{L/C}$ it is over-damped. If we are more at home with the Q factor than with time constants we will take the trouble to translate the critical condition $R = 2\sqrt{L/C}$ into terms of Q and find that it means simply $Q = \frac{1}{2}$.

Another piece of information from the textbook is that the natural frequency of oscillation of the circuit we are considering is (in radians per sec $\sqrt{1/LC - R^2/4L^2}$, which is identical with our $\sqrt{1/T_1T_2 - 1/4T^2_2}$. So if we denote this frequency by ω_0 we can very much more tidily specify the ordinates in Fig. 8 as $\pm j\omega_0$. This is shown in Fig. 10, which is structurally the same as Figs. 8 and 9, but as it is only meant to show magnitudes there is no need for j. It illustrates the well-known fact that as the circuit damping, of which R/2L is a measure, is reduced, the frequency of natural oscillation approaches the frequency of resonance, and in low-loss tuned circuits is practically equal to it. At the other extreme, the circuit becomes non-oscillatory or critically damped when the frequency of natural oscillation becomes zero. The frequency of resonance is unaffected so long as T_1T_2 or LC is kept constant.

Analogous effects occur with meter pointers when readings are being taken, or with car bodies over bumpy roads, and many other things. The same mathematical methods can be used for all, so are worth learning.

All the way through we have been studying only the *steady-state* response to *sinusoidal* inputs. Transients and non-sinusoidal waveforms have been excluded. But now that the response of the simple LCR circuit to impulses has been mentioned, it is time to reveal that yet another merit of pole-zero diagrams is that they are valid for transients and for all exponential waveforms. One may tend to think of exponential waveforms as only the familiar die-away and build-up kinds. However, all those shown in Fig. 11 are exponential forms or are simply derived from them, even without taking advantage of Fourier to build up any periodic waveform from sine waves. In fact, most of the forms in common use are included. The only form that never *exactly* occurs in practice is an unvarying sine wave! So the fact that pole-zero diagrams are not limited to it is quite something.

This peak of expectancy is clearly the right moment for adjourning until next month.

News from Industry

Mullard-G.E.C. Semiconductor Activities.—Following news of the decision of the General Electric Company Ltd. and Mullard Ltd. to pool their resources in the field of semiconductors (reported in *W.W.* for March), it is announced that a joint company, Associated Semiconductor Manufacturers Ltd., has been set up and will now combine Mullard and G.E.C. semiconductor development and production and undertake all future manufacture. Two-thirds of the shareholding of A.S.M. will be owned by Mullard and the other third by G.E.C. The sales of all products made by the company will, by agreement with G.E.C., be handled by Mullard's Entertainment Markets Division for types used in sound radio, television and consumer equipment, and through its Industrial Semiconductor Division in the case of industrial types. It is stated that continuity of supplies of existing ranges of both companies' semiconductors is assured.

Murphy Radio Ltd.—A group loss of £266,588 for the year 1961 is reported by Murphy. In 1960 the loss was £76,039. After crediting £47,792 net tax recoverable (£21,235 charged last year) and previous year's adjustments £3,070 (£5,619), there is a loss of £215,726, compared with £91,655. At present the Rank Organisation is negotiating for control of Murphy.

Relay Exchanges Ltd. in its annual report for 1961 records a surplus on trading, before charging depreciation and taxation, of £4,155,346 compared with £3,949,892 for 1960. After allowing some £3M for depreciation and renewal of plant and receivers and sundry other sums including £105,137 for taxation, the net group profit was £951,646. The group includes in addition to many radio and television relay organizations throughout the country the "Rentaset" rental business and Goodmans Industries.

E.M.I.-Philips Pool Tape Production.—Electric & Musical Industries Ltd. and Philips Electrical Industries Ltd. are to pool their technical resources for the manufacture of magnetic recording tape. Under the agreement a new company is to be formed named Tape Manufacturing Co. Ltd., in which the financial interest will be equally shared by Philips and E.M.I. Tapes will be developed and produced by it but the finished product will be marketed under the separate labels of E.M.I. and Philips in competition with each other. Manufacture will be carried out in a new factory at the E.M.I. works at Hayes, Middx.

Bush Prepare For Colour Television.—A production programme to manufacture colour television receivers, beginning in the autumn, is announced by Bush Radio, a division of the Rank Organization. According to Bush managing director, Dudley Saward, the initial flow from the first production line would be between 6 and 30 sets a week depending on public demand, with prices somewhere between £700 and £800 a receiver.

Jason Electronic Designs Ltd., of 2a Kimberley Gardens, Harringay, London, N.4, who, as noted on p. 116 of the March issue, was in the hands of a receiver and manager, has been sold to Hillvar Ltd., which company has changed its name to Jason Electronic Designs Ltd. It is stated that Jason products are still being manufactured at Kimberley Gardens and that the same service facilities will be continued as before.

Birmingham Sound Reproducers, manufacturers of Monarch record changers and Monardeck tape decks, report that group net profit for the year 1961 reached a record figure of £1,816,547 as against £1,526,576 for 1960. Net profit, after tax of £876,477 (£666,124 in 1960) is up from £860,452 to £940,070.

Erection of 13 high masts complete with aerials for N.A.T.O.'s new v.l.f. transmitting station at Anthorn, near Carlisle, is being undertaken by British Insulated Callender's Cables Ltd. following a £1½M order from Continental Electronics Systems Inc., of Dallas, Texas, for their design and supply. The aerial system involves one central mast and two concentric rings of six masts each. The inner ring will be 1,300 ft from the centre, the radius of the outer ring being 2,100 ft. Height of the masts varies from 745 ft at the centre to 600 ft at the outer ring. Completion of the station will take about two years.

Space research instrumentation is the work of a specialist department recently set up by McMichael Radio with the primary object of making basic pieces of equipment for satellites. Some of the instrumentation in the capsule of Britain's satellite "Ariel" has been supplied by this subsidiary company of the G.E.C.

Collins Italiana S.p.A., owned jointly by Collins Radio Company of Dallas, Texas, and Telettra S.p.A. of Milan, has been formed to market the range of Collins ground and airborne communication equipment in Italy. In the U.K. the complete line of equipment of the parent company is handled by Collins Radio Co. of England Ltd., 242 London Road, Staines, Middx. (Tel.: Staines 54128.)

Grundig Radio-Werke G.m.b.H. are building a new tape recorder works close to the flourishing satellite town of Nürnberg-Dutzendteich. Construction of the office buildings, which will cover an area of 25,000 sq metres, has already commenced and completion will take about one year. When finished some 2,500 workers will be employed in making studio-quality tape recorders for the domestic market and dictating machines for office use.

F. C. Robinson & Partners Ltd., electronic and instrumentation engineers, who have been established since 1948 in Manchester, have now taken premises at Davies House, 181 Arthur Road, Wimbledon, S.W.19 (Tel.: Wimbledon 6386), for a London sales office and showroom. All export business and home sales of instruments and electrical equipment south of an east-to-west line drawn through Birmingham will be handled from the new office. Northern sales will continue to be handled from the company's works at Cheadle, Cheshire.

United States Trade Centre, 58 St. James's Street, London, S.W.1, where ranges of American-made goods are displayed by their makers or by their accredited U.K. importers to trade buyers in Britain, has been fitted out with high-fidelity sound amplifying equipment installed by Associated Electrical Industries Ltd.

A new plant for Fine Tubes Ltd., the producers of precision drawn small diameter thin-wall tubing for use as cathodes, anode and grid cylinders, etc., in all types of electron tubes, is expected to be completed this summer at Estover, near Plymouth, Devon. The company also have premises at King Charles Road, Surbiton, Surrey.

The Vatican has ordered a second Telefunken 100kW short-wave broadcasting transmitter in order to enlarge the Radio Vatican installations.

Head office of Vactric Control Equipment Ltd. is now located at Garth Road, Morden, Surrey (Tel.: Derwent 6644).

Fluxite Ltd., manufacturers of soldering paste and soldering fluid, have moved to new premises at Bridge Road, Merton Abbey, London, S.W.19 (Tel.: Mitcham 9759).

Furzehill Laboratories Ltd., and their subsidiary British Watch Timers Ltd., have moved to new premises in Theobald Street, Boreham Wood, Herts (Tel.: Elstree 4331).

Swedish-made Pearl microphones are now being distributed in the U.K. by Audix B.B. Ltd., Bentfield End, Stansted, Essex, who have been appointed sole agents. The Pearl range includes crystal and moving-coil microphones, also dynamic-cardioid and condenser types for studio and professional use.

Beckman products are to be manufactured and distributed in Japan by a new company, Beckman-Toshiba Ltd., which has been formed in Tokyo and is jointly owned by Beckman Instruments Inc., of Fullerton, California, and the Tokyo Shibaura Electric Company (Toshiba). Beckman make electronic instruments, systems and components and maintain plants and facilities in Canada, Germany, Switzerland and at Glenrothes, Fife, Scotland.

Hawley Products Ltd., manufacturers of loudspeaker cones and fibre mouldings under licence from Hawley Products Co. Inc., of Illinois, U.S.A., and for some years one of the Plessey group of companies, has become a wholly-owned subsidiary of the American company as from May 5. Manufacture is continuing at the company's Cheney Manor, Swindon, factory.

Sylvania-Thorn Expansion.—Plans for a threefold increase in their production of instrument and oscillograph cathode ray tubes are announced by the Sylvania-Thorn Colour Television Laboratories, who have recently acquired additional manufacturing facilities at Thorn Electrical Industries' Enfield premises.

Solid dielectric gang timing capacitors, formerly imported by Impectron Ltd., from the German manufacturers, Ludwig Beck Nachf. oHG, are now to be made in the U.K. and marketed by L. Beck (G.B.) Ltd., 414 Chiswick High Road, London, W.4—a joint venture by the German parent company, Impectron Ltd and the Goldring Mnfg. Co. (G.B.) Ltd.

OVERSEAS TRADE

Norwegian nautical schools at Arendal, Bergen, Kristiansand S., and Oslo have placed orders for complete Marconi communication systems. In addition Marconi Lodestar automatic direction-finding equipment has been ordered for nautical schools at Stavanger, Tromsø, Arendal and Kristiansand S. Lodestone direction-finders are being supplied to schools at Bergen and Porsgrunn.

Orders for 1,000 marine radar equipments in less than nine months are recorded by Decca, who state that this is considerably quicker than any previous 1,000 orders for marine sets yet obtained by the company. The order for the 12,000th Decca radar was one of five recently received from a German source. Throughout the world the total of radar fitted ships is currently estimated at between 22,000 and 23,000, state Decca.

Egypt's Army is to be equipped with Mullard mobile wireless stations under an order worth £165,000 placed with Mullard Equipment Ltd. by the Egyptian Government.

Ankara-Karachi microwave communications link, at present under construction for the Central Treaty Organization, spans 3,060 miles and calls for a 92-station microwave link in the 2,000Mc/s band. Main contractors are RCA International, but the M-O Valve Company was recently awarded a $¼M contract for the supply of travelling wave tubes for the link.

All activities in Canada of English Electric Valve Co. Ltd., hitherto handled by Canadian Marconi Company, have been transferred to a new subsidiary, English Electric Valve Co. (Canada) Ltd., which has been formed in Toronto with the objects of importing, testing, storing and trans-shipping E.E. tubes and also providing an after-sales service.

UNBIASED

By "FREE GRID"

What's in a Name?

ONE wonders why it is so often stated by people who ought to know better that transistors have largely replaced valves, or that one day they *will* do so. I see this foolish statement repeated once again in an otherwise excellent article on a system developed for use in hospitals whereby data about patients' heartbeats, respiration, etc., is fed to a control panel watched over by a nurse. This arrangement is, of course, merely an obvious and logical development of the baby-alarm system first discussed in this journal between 30 and 40 years ago.

The writer of this article, which appeared a few months ago in the *Daily Express*, tells us that "this device has been made possible by transistors, the tiny slivers of metal which have replaced valves." Needless to say, transistors have *not* replaced valves, and never can do so, for the simple reason that they are themselves valves; fully as much so as the older thermionic type. Also I don't think it correct to say transistors have made possible the device described; I feel quite sure the job could have been done by thermionic valves, especially the miniaturized type, although certainly less conveniently.

I am afraid all this trouble comes about because in the heyday of thermionic valves, nobody thought to coin a handy name for them as did the inventors of the modern athermionic type when they coined the word "transistor." The handy trip-off-the-tongue word "transistor" is on a par with the word "radar" which has made many people fail to realize that what we now call "radar" existed long before this name was coined, under the name "radiolocation" and "R.D.F."

Athermionic valves—of which transistors when stripped of their fancy name, are merely a special class—do not date back merely to 1906, or thereabouts, when crystal receivers came on the scene. They date right back to the nineties when the coherer reigned supreme. The coherer fulfils the conditions laid down by the author of the *Daily Express* article when he tells us "the transistor is basically a tiny electronic tap which can control a big flow of electricity."

Surely that is precisely what a coherer is, or was—a tap closed by the tiny oscillations in the aerial circuit, and opened by the decoherer. In the process of this opening and closing, the coherer controlled quite a large supply of local energy large enough at any rate, to waggle the armature of the morse inker.

Antinode Dowsing

I MUST accept with becoming humility, the Editor's implied rebuke—written, I feel sure, more in sorrow than in anger—in his footnote to my complaint in the April issue about the shortcomings of the B.B.C.'s v.h.f./f.m. service.

At the same time I must point out in justice to myself that I was not complaining on my own behalf but merely giving further publicity to the complaints made in a national newspaper by just ordinary listeners without the specialized knowledge of the Editor and myself.

I cannot imagine ordinary dwellers in hollows setting forth by night with their families to look for fat antinodes in the gardens, and after a patient search, finding the fruit they sought in a tree just as Eve did after listening to the ill-meant advice of the serpent.

The ordinary non-technical listener would not, I fear, recognize an antinode when he found one, and even if he did, it would really only reveal to his nakedness—of knowledge and not of body as in the case of Adam and Eve—so that he wouldn't know exactly what to do when he had found what he had sought.

I have great respect for radio dealers—at least for some of them—but I cannot imagine their approving when they found the customer was, like the Editor, using only the simple dipole which is essential to the success of this method. Their remedy would be to get the customer to try to increase signal strength by adding a long line of directors to the horizontal dipole on the roof so that the thing resembled a xylophone, as do some of the TV aerials in East Anglia, upon which I once commented in these columns.

But still, there are plenty of technically wide-awake and conscientious dealers, and no doubt before long we shall find notices in their windows saying they are expert antinode dowsers, and payment for their services will be at so much per μV/m gained.

I have often thought it would be possible for a psychically sensitive person, armed with a dipolar dowsing rod, to feel an oscillating twitch when in the right spot, so imparting movement to the rod as in the case of a water diviner standing near H_2O, or for that matter, near a receiver when the B.B.C. is radiating one of its less entertaining programmes.

The Auto-amplifying Loudspeaker

I WAS interested in the remarks made by the Editor of our sister journal *Electronic Technology* about the Johnsen-Rahbek effect which has once more come to the fore. We in the world of wireless communication know the effect since it used to be employed in a loudspeaker of the same name.

In brief, the loudspeaker consisted of a clockwork-driven revolving cylinder, very similar to that of a phonograph, over which was stretched a metal-backed band of semi-conducting material. One end of the band was firmly anchored to the baseboard and the other attached to the loudspeaker diaphragm. An incoming signal boosted the electrostatic attraction between band and cylinder so that the band was momentarily gripped by the revolving cylinder, thus giving a sharp tug on the diaphragm. In an alternative arrangement the cylinder was semi-conducting and the band entirely metallic.

This type of loudspeaker thus amplified, as well as reproduced the signal, and so was of great interest in the days before valve amplifiers came into their own. The recollection of the Johnsen-Rahbek speaker set me wondering how many other types of self-amplifying loudspeaker had been developed. I can only recall two but I think there were more, and maybe some of the older readers of *Wireless World* can recall others. First the Stentorphone, which was greatly in evidence on all our seaside piers in the summer of 1921, it being sponsored by a national newspaper. The Stentorphone, invented by H. A. Gaydon and made by Creed & Co., used compressed air which was modulated by the incoming signals by means of a vibrating grille valve.

The second one I recall very well as I still possess a specimen of it. It was the Crystavox, made by S. G. Brown Ltd. It consisted of a microphone amplifier built into the base of a small horn-type loudspeaker. The name Crystavox was obviously suggested by the fact that it was intended to be connected direct to our crystal sets, and so give us loudspeaker output without any intervening valve amplifier. This it did very well indeed and it became very popular as in those days valves were expensive to buy and very fragile. Also, of course, being bright emitters, they consumed 0.75 amps apiece, and so soon drained our accumulators dry.

Atomic Anticlimax

THE exhibition staged by the Science Museum under the title of "Atoms at Work" during March was, in my opinion, very well done. It was, of course, not intended for people of the technical calibre of *Wireless World* readers, the youngest of whom will have learned all about the anatomy of atoms at his mother's knee.

The show was clearly intended for the enlightenment of the general public and, as such, I could not help thinking that it credited its intended patrons with more knowledge than they might be expected to possess. It certainly started at the very beginning and took us by easy stages to the Calder Hall nuclear power station, where we were told almost casually, that the heat generated in the reactor was used to raise steam, after which the rest of the power station followed the turbo-alternator pattern of its conventional forbears.

I listened very carefully to the conversation of the passing people, and I couldn't help noticing from their remarks to each other that this simple statement of fact seemed to puzzle them because it was obviously not in accordance with their pre-conceived ideas of what a nuclear power station ought to be.

The trouble is that the ordinary man's acquaintance with "atoms" really began with Hiroshima when he was told of the tremendous energy that was released by the splitting of the atom. He may possibly have heard of the locked-up power of atoms for many years prior to that, but the work of Rutherford and others was never very well publicized.

Unfortunately, after Hiroshima there was too much publicity of the wrong sort. The ordinary man realised that the power of the A bomb came directly from the actual atomic fission without the necessity of any intermediate process such as raising steam, and he expected that electricity would be generated "direct" in the same manner at a nuclear power station. He imagined that the electrons winkled out of the split atom, would be sent along the mains to light and heat his house.

It was quite obvious from the remarks I overheard that the idea of a nuclear power station being exactly the same as an ordinary one, except that a nuclear reactor was used instead of a coal or oil-fired boiler, was very much of an anticlimax.

CONFERENCES AND EXHIBITIONS

Latest information on forthcoming events both in the U.K. and abroad is given below. Further details are obtainable from the addresses in parentheses.

LONDON

July 2–6 Imperial College
The Ionosphere
(Inst. of Phys. & Phys. Soc., 47 Belgrave Square, S.W.1)

Aug. 22–Sept. 1 Earls Court
National Radio & Television Show
(Radio Industry Exhibitions, 59 Russell Square, W.C.1)

Sept. 19–21 Savoy Place
Components for Microwave Circuits
(I.E.E., Savoy Place, W.C.2)

Sept. 25–27 Imperial College
Neutron Beam Research in Solid State Physics
(Inst. of Phys. & Phys. Soc., 47 Belgrave Square, S.W.1)

Oct. 18–19 Savoy Place
Symposium on Electronic Equipment Reliability
(I.E.E., Savoy Place, W.C.2.)

BIRMINGHAM

July 9–12 The University
Sonar Systems Symposium
(Brit.I.R.E., 9 Bedford Square, London, W.C.1)

BOURNEMOUTH

Oct. 2–4 The Pavilion
Battery Symposium
(D. H. Collins, Admiralty Eng'g. Lab., W. Drayton, Middx.)

EXETER

July 16–20 The University
Physics of Semiconductors
(Inst. of Phys. & Phys. Soc., 47 Belgrave Sq., London, S.W.1)

FARNBOROUGH

Sept. 3–9 R.A.E.
Farnborough Air Show
(S.B.A.C., 29 King Street, London, S.W.1)

HARROGATE

Sept. 20–22 Old Swan Hotel
Standardization in Non-destructive Testing
(Institution of Production Engineers, 10 Chesterfield Street, London, W.1)

HARWELL

Sept. 10–12 A.E.R.E.
Low Energy Nuclear Physics Conference
(Inst. of Phys. & Phys. Soc., 47 Belgrave Sq., London, S.W.1)

MANCHESTER

July 5–11 College of Science & Technology
Electronics, Instruments and Components Exhibition
(W. Birtwistle, Inst. of Electronics, 78 Shaw Road, Rochdale, Lancs.)

Aug. 29–Sept. 5 Free Trade Hall
British Association Meeting
(British Association for the Advancement of Science, 3 Sanctuary Bldgs., Great Smith Street, London, S.W.1)

OVERSEAS

June 11–24 Rome
Exhibition & Congress on Electronics, Nuclear Energy, Radio, Television & Cinematography
(R.I.E.N.T., via della Scrofa 14, Rome)

June 12–15 Budapest
Microwave Communications Colloquium
(G. Bognar, Távközlési Kutató Intézet, Gábor Aron u 65, Budapest II)

June 18–19 Chicago
Broadcast & Television Receivers Conference
(I.R.E., 1 East 79 Street, New York 21)

June 25–27 Washington
Military Electronics Conference
(I.R.E., 1 East 79 Street, New York 21)

June 25–30 Copenhagen
Electromagnetic Theory & Antennas
(J. Brown, Electrical Eng'g. Dept., University College, London)

June 27–29 New York
Integrated Automatic Control Systems
(A. J. Hornfeck, Bailey Meter Co., 1050 Ivanhoe Road, Cleveland 10, Ohio)

June 28–29 San Francisco
Radio Frequency Interference
(R. G. Davis, Lockheed Missile & Space Co., P.O. Box 504, Sunnyvale, Cal.)

Aug. 14–16 Boulder
Precision Electromagnetic Measurements Conference
(J. F. Brockman, National Bureau of Standards, Boulder)

Aug. 21–24 Los Angeles
Western Electronics Show
(Wescon, 1435 S. La Cienega Boulevard, Los Angeles, 35)

Aug. 21–28 Copenhagen
Acoustics Congress
(Professor S. Ingerslev, Royal Technical College, Ostervoldgade 10, Copenhagen)

Aug. 27–Sept. 1 Munich
Information Processing & Digital Computers
(International Federation of Information Processing, c/o B.C.S., Finsbury Pavement, London, E.C.2)

Aug. 29–Sept. 1 Stockholm
Speech Communication Seminar
(Dr. G. Fant, Royal Inst. of Technology, Stockholm, 70)

Sept. 3–7 The Hague
Microwave Valves Congress
(Congress Microgolfbuizen, Postbus 62, Eindhoven)

Sept. 3–7 Brussels
Information Theory Symposium
(Dr. F. L. Stumpers, Philips Research Labs., Eindhoven)

Sept. 13–14 Washington
Engineering Writing and Speech Symposium
(J. E. Durkovic, ARINC, 1700 "K" St. N.W., Washington 6, D.C.)

Sept. 19–20 Chicago
Industrial Electronics Symposium
(J. A. Granath, Armour Research Foundation, Chicago, Ill.)

Sept. 28–29 Washington
Broadcast Symposium
(Dr. W. Hughes, Oklahoma University, Stillwater, Okla.)

Oct. 1–3 Utica
Communications Symposium
(G. Baldwin, Paris Road, R.D.2, Clinton, N.Y.)

Oct. 2–4 Miami Beach
Space Electronics and Telemetry Symposium
(Otto A. Hoberg, Marshall Space Flight Center M-ASTR-I, Bldg. 4487-B, Huntsville, Ala.)

Oct. 8–10 Chicago
National Electronics Conference
(Dr. T. W. Butler, Jr., University of Michigan, Ann Arbor)

Oct. 15–18 Detroit
Space Phenomena and Measurements
(Dr. H. E. De Bolt, AVCO Corp., 201 Lowell Street, Wilmington, Mass.)

Oct. 15–20 Basle
British Component and Instrument Exhibition
(Industrial Exhibitions Ltd., 9 Argyle Street, London, W.1)

Oct. 22–24 Baltimore
Aerospace & Navigational Electronics
(W. C. Vergara, Bendix Radio, Towson, Md.)

Oct. 30–31 Anaheim
Spaceborne Computer Engineering Conference
(Dr. R. A. Kudlich, General Motors Corp., 950 North Sepulveda Boulevard, El Segundo, Cal.)

Nov. 4–7 Chicago
Engineering in Biology and Medicine
(D. A. Holaday, P.O. Box 1475, Evanston, Ill.)

Nov. 12–15 Pittsburgh
Conference on Magnetism & Magnetic Materials
(Prof. F. Keffer, University of Pittsburgh, Pa.)

Nov. 16–17 Montreal
Communications Symposium
(A. B. Oxley, Box 802, Station B, Montreal, Quebec)

Nov. 22–27 Milan
Automation and Instrumentation Congress
(Federazione delle Associazioni Scientifiche e Tecniche di Milano, Via del Politecnico, 10, Milan)

Nov. 29–30 New York
Ultrasonics Symposium
(R. N. Thurston, Bell Telephone Labs., Murray Hill, N.J.)