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Wireless World

Growing Pains

FROM January 1st this year the Electronic Engineering Association has ceased to be a member of the Radio Industry Council. This is not the result of any hasty decision, but of a level-headed and objective study of the divergence of the predominant aims and interests of these two great bodies which has become increasingly apparent in recent years.

In announcing the change Mr. G. Darnley Smith, chairman of the R.I.C., said,

"Electronics have become of such enormous importance in the last few years, playing an essential part in many major industries and having uses in all of them, that we—meaning all the Associations—have had to recognize that ours is now a two-fold industry. One side is dealing largely with broadcasting techniques and equipment and the other with electronics for all other purposes. To keep pace with the rapid technical, industrial and commercial advances on the capital goods side of the industry, it has been agreed that the E.E.A. should pursue its own policies and objectives. Close co-operation, however, will continue with the E.E.A. on matters affecting the welfare of both sections of the industry, particularly in the technical field, by means of inter-association committees."

A parallel statement by the Electronic Engineering Association in its annual report reads as follows,

"The Association remained a constituent of the Radio Industry Council during the period under review, during which time the four constituents reached the unanimous opinion that the capital goods side of the industry had developed in size and scope to the point at which capital goods and consumer goods could be recognised with advantage to all concerned as two distinct industries, each with its own objectives and policies. As from the 1st January, 1959, therefore, the Association has given up its right to nominate representatives to the Radio Industry Council, thereby permitting the three remaining nominating bodies, the British Radio Equipment Manufacturers' Association, the British Radio Valve Manufacturers' Association and the Radio & Electronic Component Manufacturers' Federation to devote their attention to the affairs of the domestic broadcast entertainment industry, thus enabling the Association to take full responsibility for the capital goods interests of the Industry. It will, of course, continue its close co-operation with the components and valve industries, with the domestic equipment industry, and also, on a technical level, with the other industries associated with it in the Electronic Forum for Industry."

Commenting on this statement, Mr. F. S. Mockford, chairman of the E.E.A., said,

"Two distinct and vast industries have grown up side by side—one, the domestic entertainment industry supplying millions of sound and vision receivers, radio-gramophones and audio equipment to the general public; the other supplying millions of pounds' worth of capital equipment for home and overseas, much of which is telecommunication, radar and navigational aid radio equipment, but a great deal of which is closed-circuit equipment, such as industrial television, computers, machine controls, and so on.

"Each industry has many more problems than in the past, but their common problems are fewer. The performance, characteristics and siting of broadcasting transmitters and their frequency allocations is still a matter of concern to both, but the E.E.A. to-day has as much or more need for association with other industries—for example, telecommunications, office appliances, machine-tools, aircraft, transport, fuel and power.

"The capital equipment makers, of course, will continue to require and are assured of the closest co-operation of the B.V.A. and the R.E.C.M.F., and joint committees are being formed."

If there are any twinges of regret at the disturbance of an order which has remained unchanged for so long they should be dismissed in the certain knowledge that they are but the growing pains of a strong and healthy industry. The processes of association and dissociation are as fundamental to organizations as they are to living organisms, and the radio industry is no exception. First there was the association of six firms to form the British Broadcasting Company, making both the transmitters and the receivers. Then the National Association of Radio Manufacturers, later to be joined by the traders in the N.A.R.M.A.T. Next the Radio Manufacturers' Association was formed and the traders split off into various groups of wholesalers and retailers. Inside the R.M.A. the set makers and component manufacturers formed sections which developed into the Radio Component Manufacturers' Federation and the British Radio Equipment Manufacturers' Association. These autonomous bodies together with the British Radio Valve Manufacturers' Association and the Radio Communication and Electronic Engineering Association (now E.E.A.), formed the Radio Industry Council to represent their interests in negotiations with Government departments, and in fostering the post-war development of broadcasting and electronics.

The pattern of division and growth is apparent throughout. As the scope of industry widens the "domain boundaries" indicating further potential splits will become more readily discernible in the various associations as at present constituted. What must not be lost in the process of growth is the ready-made machinery for rapid consultation, and the stabilizing influence of independent minds devoted to the task of seeing whole woods rather than trees. The R.I.C., under its newly-appointed director Sir Raymund Hart, and the E.E.A. can together provide the solid foundation upon which further specialization of interest will proceed with safety.

Waveguide Transmission

Topics discussed at the Convention on "Long Distance Transmission by Waveguide" held at the Institute of Electrical Engineers in London on 29th and 30th of January.

IN radio transmissions through free space even when the signal is beamed the power losses to the outside are considerable; conversely, interference from the outside is likely. Such losses and consequent possibilities of interference can be eliminated or very much reduced by guiding the signal. One type of guide which is often employed for long-distance transmissions is the coaxial cable, but this is limited by attenuation and phase distortion to use with frequencies below about 25Mc/s. At higher frequencies low enough attenuations of the order of 10dB per mile or less are offered either by using a single-wire conductor supporting a surface wave, or by the H_{01} (TE_{01}) mode in circular waveguide.

Effects of Bends and Irregularities

Although the use of the H_{01} mode in a circular waveguide was suggested as long ago as 1938 by G. C. Southworth, this system has apparently not yet been used commercially. The attenuation decreases with increasing guide diameter and decreasing wavelength, but low enough attenuations can only be obtained using wavelengths as short as about 6mm in the mode giving lowest attenuation (H_{01}) simultaneously with a guide diameter of about 2 in—several times the cut-off value. In these conditions about 100 other modes are capable of being propagated, and, moreover, the H_{01} mode is not dominant in circular waveguide. Thus conversion of the H_{01} to other modes occurs readily at irregularities or bends in the guide and this leads to greatly increased losses. Reconversion is also likely to occur and, since all modes but the E_{11} have a different velocity from the H_{01} mode, such reconversion results in distortion. To minimize the effects of irregularities guide manufacturing tolerances of the order of thousandths of an inch or less are necessary. These tolerances are most severe for deviations of the axis from a straight line, according to a paper given by H. E. Rowe and W. D. Waters.

H_{01} mode conversion effects can also be reduced and the bends which may be required for geographical reasons allowed by increasing the losses for the undesired modes. Bearing in mind the differing field patterns in the various modes (in the H_{01} mode the electric field is circumferential), the losses for the undesired modes can be increased by changing the guide wall surface impedances in different directions, in particular by making the longitudinal impedance much greater than the circumferential by circumferentially corrugating the guide wall. Considerable attention was given at the Convention to the variety of corrugated guide made by helically winding enamelled or otherwise spaced wire and coating the outside of the helix with an absorbing material to a thickness of about one-fourtieth of an inch. With such helical waveguide the attenuation of undesired modes can be multiplied by about 1,000 or more times their value in ordinary circular guide. Unfortunately the requirements for the absorbing layer to give maximum suppression of unwanted modes and at the same time minimum H_{01} mode loss in intentional bends are to some extent contradictory, according to a paper by H. G. Unger. Corrugated waveguide formed from flat rings a few thousandths of an inch thick spaced a few hundredths of an inch apart in air was discussed in a paper by A. W. Gent. Besides inhibiting H_{01} mode conversion, such waveguide offers a reduced H_{01} mode attenuation of about one-tenth of its value in circular guide with a diameter equal to the ring outside diameter. Another method of increasing the losses in undesired modes is to coat the inside wall of an ordinary circular guide with a layer of low-loss dielectric a few thousandths of an inch thick.

H_{01} mode conversion at bends can be reduced by equalizing the path lengths at various points across the guide by filling it with a suitably inhomogeneous low-loss dielectric. Automatic methods of producing the required inhomogeneity as the guide is bent by filling the initially straight guide either with dielectric discs which become appropriately spaced or, alternatively, with dielectric structures containing air cells which become appropriately deformed were described in papers by Professor H. E. M. Barlow and D. G. Rickard and P. Marié respectively.

An ingenious method of reducing mode conversion by making the H_{01} mode effectively dominant by using an anisotropic guide wall to decrease the wavelengths of the other initially longer wavelength modes, either directly or after conversion to other modes, was described in a paper by Professor H. E. M. Barlow. The other modes can be eliminated in this case by operating closer to the H_{01} mode cut-off, but since this considerably increases the H_{01} mode loss, this method will only be usable with short lengths of guide.

Even after mode conversion effects have been minimized, residual distortion will probably impose the use of pulse modulation so that signals can be exactly reconstituted at intervals and distortions cannot accumulate.

H_{01} Mode Launching

Launching the H_{01} mode is less difficult than bend negotiation, although to secure a sufficient bandwidth and to avoid generating unwanted modes the launching section must be longer than usual—up to about 30 wavelengths. However, at the short wavelengths used this length can easily be accommodated. The signal is generally first produced as the dominant H_{01} mode in rectangular waveguide, and this can be transformed over a broad frequency band into the H_{01} mode in circular waveguide by two basic methods. Either the waveguide cross-sectional shape can be gradually changed from rectangular to circular in such a way as to change the field from the rectangular to the circular H_{01} mode, or alternatively the rectangular and circular waveguides can be directly coupled through holes along a common wall. Direct coupling is usually through a common external wall, although a new type of coupler in which the rectangular guide is centrally placed inside the circular was described in a paper by B. Oguchi and K. Yamaguchi. One way of gradually altering the waveguide cross-section is to decrease the width of one narrow waveguide wall and at the same time to increase the width of the other narrow wall until the cross-section becomes a sector of a circle. The electric field in the H_{01} mode in rectanglar guide from one broad wall to the opposite is thus converted into arcs from one boundary radius of the sector to the other. These arcs are gradually converted to the circular electric field lines of the H_{01} mode in circular guide by increasing the arc cross-section angle until a circle is formed. Narrow-band resonant-slot methods of exciting the H_{01} mode can also be used.

Measurements of the large number of unwanted modes and of the low losses in such guides present a number of problems. The obvious way to measure such a small loss is, of course, to increase it by repeatedly reflecting the input signal to and fro in a comparatively short sample length of guide. Unfortunately, since in this method any guide irregularities give rise to periodically repeated effects, large spurious attenuations may be produced, as was pointed out in a paper by A. E. Karbowiak. Another standard way to measure the loss is from the Q of a short length of guide short-circuited at both ends to form a resonator. Since this Q will be of the order of 10^6, relatively small frequency differences must be measured to obtain the width of the resonance. Such differences can be measured using a waveguide many wavelengths long and short-circuited at its far end, as described in a paper by D. G. Keith-Walker. In this case the small wavelength changes in the standing-wave pattern will add up so as to give a large phase change with changing frequency at the waveguide input. Frequency stability problems are avoided by sweeping the source frequency.

Mode Identification and Measurement

Modes are usually identified and measured either directly from the actual electric and magnetic field pattern, or alternatively from their group velocity obtained from the transmission time through a known length of guide. The transmission time can be measured directly using short pulses of about 10mμsec duration. An alternative method of measuring the transmission time which was described in a paper by H. G. Effemey is to beat a sawtooth f.m. signal with the same signal delayed in transmission, when the principal beat frequency produced will be proportional to the transmission time.

Electric and magnetic fields at the guide walls can be measured by coupling them out through a small hole (containing a probe for electric field measurement) into a section of H_{01} mode rectangular guide with a crystal at its end appropriately oriented to detect the various field components. To measure the field at various points the hole is made in a sleeve which slides between and overlaps into two spaced sections of waveguide. The usual longitudinal slot for field measurement would seriously disturb the propagation of many of the modes. Internal fields are more difficult to measure because of the disturbance which would be produced by the connection required to a normal conducting probe. Two methods have been developed which do not need such a link. One of these methods depends on measuring the change in the Q of a cavity as a small piece of metallic, dielectric or ferromagnetic material suspended by a nylon thread is moved about inside the cavity. Another method which was described in a paper by Professor H. E. M. Barlow uses a similarly suspended small dipole rotating about an axis through its centre and perpendicular to its length. Some of the electric field incident on this dipole is scattered, and this scattered signal can be readily identified, since it is modulated at twice the spinning frequency of the dipole. By measuring the phase and amplitude of the scattered signal the electric field at the dipole can be obtained. Very similar results were obtained using somewhat different lengths of dipole, thus showing that no serious perturbation of the field is produced by the dipole.

Single-wire Surface-wave System

Less attention was devoted at the Convention to the alternative single-wire surface-wave system. With such a surface wave the spread of the field beyond the surface of the conductor and consequently interference from outside increases with decreasing frequency, whereas the attenuation increases with increasing frequency. To compromise between these two effects an operating frequency of about 200Mc/s is generally adopted. The roughly 100Mc/s bandwidth of this system is much less than the potential one or more kMc/s bandwidth of the circular waveguide system. Moreover, the potential attenuation using circular waveguide is also somewhat less than that of a surface wave on a single wire. However, the single-wire system has already beeen utilized commercially as a television link over a 14-mile distance in America.

Bends are also a problem in the surface-wave system. However, since only one mode can exist on the surface, mode conversion and consequent distortion cannot occur at bends. Instead radiation takes place which increases the losses and makes interference from outside more likely. However, radiation at bends can easily be minimized by confining the wave more closely to the surface of the conductor (which generally has a diameter of about half an inch) either by corrugating this surface, or alternatively by covering it with a polythene sleeve of roughly one inch outer diameter.

Surface waves can be launched over a broad frequency band on a continuation of the inner conductor of a coaxial line input by enlarging the outer conductor to form a conical horn. Narrow-band launching using a radiating circular hole concentric with the conductor is also possible.

The conductor can ideally be supported by nylon cords from the poles of an existing telephone system. The telephone wires do not have any effect provided they are half a wavelength or more away, and even closer spacing only increases the transmission loss without producing any distortion, according to a paper by G. Goubau. Even severe weather conditions have little effect on such a line.

WORLD OF WIRELESS

Radio Show Organization

THE announcement, discussed in greater detail in this month's leader, that the Radio Industry Council and the Electronic Engineering Association will in future pursue separate objectives and policies has been followed by the news that B.R.E.M.A. will now undertake responsibility for radio and television shows which are primarily of broadcast techniques and equipment. The component and valve manufacturers will continue to support the National Radio Exhibition and to share in its organization.

Record Radio Exports

PROVISIONAL figures for last year's exports of radio and electronic equipment, issued by the Radio Industry Council, show an increase of over £1.5M on the previous year. The provisional total is £45M —nearly four times the 1948 figure.

As can be seen from the table the highest proportionate rise was for valves and cathode-ray tubes. Last year's exports of sound reproducing equipment were more than double the value for 1955.

Exports of components, which had reached a peak value in 1957, were slightly lower in value although maintaining their volume. Their growth over recent years, together with that for valves, reflects the fact that several British manufacturers are assembling receivers in the consumer countries. This, in turn, affects the figures for the direct exports of receivers. Last year's figure does, however, include £1.1M for television receivers which reached a significant level for the first time.

A reduction in the export of capital goods (transmitters, navigational aids, industrial electronics, etc.) is partly due to the continued fall in Defence orders.

	1958	1957
Capital goods	£15.45M	£16.04M*
Sound and television receivers	3.54	3.56
Sound reproducing equipment	11.28	9.86
Components	9.56	10.10*
Valves and tubes	5.30	3.90
	£45.13M	£43.46M

* Includes items not covered in provisional 1958 totals.

National Scientific Libraries

THE proposed National Lending Library for Science and Technology—the nucleus of which already exists in the D.S.I.R. Lending Library Unit at Chester Terrace, Regents Park, London—will be housed at Thorp Arch, near Boston Spa, Yorks. It will take over the responsibility for the lending service now provided by the Science Museum Library, which will then concentrate on serving the enlarged Imperial College of Science and Technology. The second scientific library under discussion is the National Reference Library of Science and Invention, which it is proposed to establish in London as the successor to the Patent Office Library.

New Coast Station

ILFRACOMBE RADIO, the new Post Office Coast Radio Station at Mulacott Cross, North Devon, was opened on January 29th by T. A. Davies, O.B.E., Inspector of Wireless Telegraphy. For the past three years the short-range radio-telephone service for the Bristol Channel area has been operated from a temporary station at Ilfracombe Head Post Office, and this, as well as the short-range radio-telegraph service previously given through Burnham Radio, will be taken over by Ilfracombe Radio.

This year is the jubilee of the Post Office ship-shore radio for on September 29th, 1909, the Post Office took over services which had previously been operated by Marconi's and Lloyds.

There are 12 stations in the Post Office maritime service. The largest is Burnham Radio and it serves ships at sea in any part of the world. The remaining 11 provide communication up to about 300 miles.

"What's in a Name?"—The word "radio" no longer appears in the title of what was, at one time, the Radio Section of the I.E.E. because "it is felt that this word, with its modern connotation of certain limited applications, is now insufficiently comprehensive." Some years ago the word "telecommunication" was added to the title, but this, too, has now been omitted and the word "communications" (to be "interpreted broadly within the context of electrical engineering") has been added. Announcing the new title—Electronics and Communications Section—the Council of the I.E.E. states that the incorporation of the word "electronics" in the title "is intended to emphasize to the profession that the Institution is manifestly the learned society for those properly qualified electrical engineers who regard themselves as 'electronic' engineers."

Noise and Vibration.—The Acoustics Group of the Physical Society is sponsoring two symposia dealing with the problems of noise and vibration. The first is at 2.15 on March 24th in the Physics Department of Imperial College, London, S.W.7, under the title "Recent Studies of Noise Problems." The second is a one-day meeting on April 7th in the Physics Department of Southampton University, entitled "New Techniques in the Analysis of Noise and Vibration"; it will include contributions on both practical and theoretical aspects of the use of correlation techniques, of digital computers for data processing and analysis, and on general applications of statistical communication theory. Further details of this joint meeting with the Institute of Physics may be obtained from D. M. A. Mercer, Physics Department, The University, Southampton.

Nine Million.—During January combined television-sound licences in the U.K. passed the nine-million mark, for at the end of the year the total was 8,899,067. Sound-only licences at December 31st totalled 5,853,549 including 371,391 for car radio. The year's increase in TV/sound licences was 1.13M compared with 1.19M during 1957 and 1.17M during 1956.

C. & G. Radio Society.—L. H. Bedford, C.B.E., chief engineer of the English Electric Company's guided weapons division, has been elected president of the City and Guilds College Radio Society in succession to Dr. J. D. McGee, O.B.E., professor of instrument technology at Imperial College.

Telemetry Symposium.—Since going to press with the "March Meetings" (page 150) we have received amended details from the Brit.I.R.E. of the radio telemetry symposium which is being held on March 25th at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1. The afternoon session (3-5.30) opens with an introductory paper by A. Cowie, of R.A.E., which is followed by three papers describing a 24-channel time-division multiplex f.m./a.m. system. Papers to be read at the evening session (6.30-8.30) cover a six-channel frequency-division multiplex f.m./a.m. system and a pulse position modulation system. Non-members should apply to the Institution, 9, Bedford Square, London, W.C.1, for tickets.

Valve design techniques will be featured at a five-day London exhibition being organized by the English Electric Valve Company. It will be held at Kensington Palace Hotel, De Vere Gardens, W.8, from March 17th to 21st and will be open each day from 10.0 to 7.0 but on the first day admission will be limited to the Press until 3.0.

3¾-in/sec Tape Records.—Since "Free Grid" prepared his copy for this issue in which he mentions one supplier of "3¾" tape records we have been advised by Guildford Sound Recordings, of Birmingham, that Music on Tape Ltd., of Laurence Pountney Hill, London, E.C.4, also produces these tapes.

"**Hi-Fi—A Guide to Good Listening**" is the theme of the exhibition of high quality radio and audio equipment being staged by the Council of Industrial Design at the Design Centre, 28 Haymarket, London, S.W.1. It will continue until March 14th. The Centre is now open until 7.0 on Wednesdays as well as Thursdays.

"**Do-It-Yourself.**"—Gilbert Davey, who in 1957 showed viewers to the B.B.C. Television Children's Hour how to make a one-valve regenerative detector receiver, is starting a series of instruction on building a transistor pocket receiver. It will begin on March 23rd in the Children's Hour programme "Focus."

FROM ABROAD

Kelly Award.—In honour of Dr. Mervin J. Kelly, chairman of the board of Bell Telephone Laboratories, the American I.E.E., in collaboration with the Laboratories, is establishing an annual award "for achievement in the field of telecommunications." It will consist of a bronze medal and $1,000. Dr. Kelly, who retires on March 1st after 41 years with Bell Telephones, was closely associated with Sir Gordon Radley, director-general of the Post Office, in planning the first transatlantic telephone cable.

Microwave Tubes.—An international congress on microwave tubes on the lines of those held in Paris in 1956 and in London last year is being planned by the Verband Deutscher Elektrotechniker for 1960. It will be held in Munich from June 7th to 11th.

New Zealand has adopted the 625-line standard for its experimental television transmissions starting in Auckland. These tests, using channel 3 (55.25Mc/s vision and 60.75Mc/s sound), are being conducted by the New Zealand Broadcasting Service from its medium-wave station building in the capital. According to one manufacturer 17in sets will cost about £100.

West Berlin is to have a new 100-kW transmitter to replace the 20-kW equipment at present used at the Sender Freies Berlin station which radiates on 566kc/s. It is being provided by Telefunken, the cost being met by a grant of 950,000DM from the association of broadcasting organizations (Arbeitsgemeinschaft der Rundfunkanstalten). The transmitter will be switchable to one third of the power on any frequency in the medium-wave band and is anode modulated through a push-pull Class B amplifier. It is planned to come into service in the Autumn.

Personalities

Air Marshal Sir Raymund Hart, K.B.E., who succeeds Vice-Admiral J. W. S. Dorling as director of the Radio Industry Council was, until the end of January, Controller of Engineering and Equipment in the Air Ministry. Sir Raymund, who is 60, qualified as a signals officer in 1928 and was for three years prior to 1939 employed at the radar research establishment at Bawdsey on the development and operation of ground-based radar systems. During this period he was concerned with the training of radar operating and servicing staff for the chain of radar stations and was responsible for developing the radar reporting system. In 1939 he went to the headquarters of Fighter Command, of which he later became Chief Signals Officer. In 1944 he was appointed Chief Air Signals Officer at S.H.A.E.F. Among the posts he has filled since the war are Air Officer Commanding No. 27 Signals Training Group; A.O.C. No. 90 Signals Group, Director-General of Engineering at the Air Ministry and, since October 1956, Controller of Engineering and Equipment. Air Marshal Hart was knighted in 1957.

Sir RAYMUND HART

F. C. LUNNON

F. C. Lunnon, assistant engineer-in-chief of Marconi's W/T Co., has retired after 47 years' service with the company. Mr. Lunnon's early years with the company were spent at the radio stations at Clifden, Ireland and Glace Bay, Nova Scotia, the two stations which provided the first commercial transatlantic wireless circuit. In 1926 he was given charge of the Writtle development establishment and remained there until 1946 when he was appointed development manager. He became assistant engineer-in-chief in 1951.

W. A. S. Butement, O.B.E., who was Assistant Director of Scientific Research in the Ministry of Supply during the latter part of the war and since the war has been chief scientist in the Australian Department of Supply, was promoted Commander of the Order of the British Empire in the New Year Honours. On the recommendation of the Royal Commission on Awards to Inventors he received an award for his "contribution to the development of radar installations" which included the "split" method of d.f., and a fire control system using echoes from shell splashes.

Major General W. A. Scott, C.B., C.B.E., Director of Communications in the Foreign Office, was appointed a Knight Commander of the Order of St. Michael and St. George (K.C.M.G.) in the New Year Honours.

S. F. Follett.—We omitted to announce in our February note (page 58) on the appointment of S. F. Follett as Deputy Director of the Royal Aircraft Establishment that he was appointed Commander of the Order of St. Michael and St. George in the New Year Honours.

Sir John Cockcroft, K.C.B., F.R.S., who has accepted the invitation to become the first Master of Churchill College to be built in Cambridge, recently received the honorary degree of doctor of technical sciences at the Delft technical university. Sir John, who was Chief Superintendent, Air Defence and Research Establishment throughout the war and was for some time director of the Atomic Energy Research Establishment, is now a member of the U.K. Atomic Energy Authority.

T. S. England, B.Sc., Ph.D., F.Inst.P., A.M.I.E.E., has been appointed head of airborne radar at the Royal Radar Establishment, Malvern. Dr. England, who graduated at the University of Durham in 1937 was for two years working on radar in the Ministry of Aircraft Production before going to T.R.E. (now R.R.E.) in 1942. In 1948 he returned to Durham University where, as a result of two years research work in medical physics, he received his Ph.D. degree. He rejoined T.R.E. in 1950 becoming Superintendent, Circuits and Electronics, in 1954 and since 1956 has been Superintendent, Radar Ballistics.

Sir Robert Fraser, O.B.E., B.A., B.Sc., Director-General of the Independent Television Authority, has been awarded the Fellowship of the Television Society.

Dr. C. S. Szegho, who was for seven years head of cathode-ray tube research in Baird Television and since 1942 has been director of research with Rauland Corporation, of Chicago, has been awarded the Fellowship of the Television Society. Dr. Szegho, who was born in Hungary, received his doctorate of engineering in Germany.

E. K. Cole, C.B.E., chairman and managing director of the well-known firm bearing his name, which he founded in 1926, has been elected an Honorary Member of the Brit.I.R.E., "in recognition of his services to the radio and electronics industry and profession."

E. L. E. Pawley, O.B.E., M.Sc., M.I.E.E., head of the B.B.C. Engineering Services Group, has been re-elected chairman of the E.B.U. Technical Committee. He is also chairman of the committee's working party concerned with television and sound broadcasting on v.h.f. and u.h.f. Another B.B.C. representative on the Committee, **M. J. L. Pulling,** C.B.E., M.A., M.I.E.E., is chairman of the working party covering international television relays. Mr. Pulling, who has been with the B.B.C. since 1934, was for some years Superintendent Engineer (Recording) and is now Controller, Television Service Engineering.

Ralph Brewer, who as mentioned briefly last month (page 56), received the National Reliability Award for his paper entitled "Life Tests of Electron Tubes and the Analysis of Failure Causes" read at last year's American National Symposium on Reliability and Quality Control in Electronics, has been in the G.E.C. Research Laboratories since 1937. During the war he worked on early magnetrons for radar and after the war took charge of valve reliability studies. His work has now extended to cover the study of the survival characteristics of transistors and related semiconductor devices. He is 44.

R. W. Stobbs, F.R.I.C., F.I.M., has been appointed general manager of Preformations Limited, the company recently formed by The Plessey Company and the Arnold Engineering Company, of Illinois, for the manufacture of "Magloy" permanent magnets at Swindon. Mr. Stobbs joined Plessey five years ago as principal metallurgist at the Company's Ilford factory.

Professor A. L. Cullen, Ph.D., B.Sc., who occupies the chair of electrical engineering in the University of Sheffield, has been awarded a grant of £3,835 by the Paul Instrument Fund Committee for the construction of a detector in which radiation pressure is used to convert a microwave signal to an audio or intermediate frequency.

Vice-Admiral Sir John Eaton, K.B.E., C.B., R.N. (Retd.) has joined Marconi's as Chief of Administration at the Research and Development Laboratories at Great Baddow, Essex. He will be responsible for all administrative matters to the Chief of Research, Dr. E. Eastwood.

Air Commodore C. A. Bell, formerly Director of Electronics Research and Development (Air) in the Ministry of Supply (see December 1958, page 576) has joined the staff of G.E.C.'s Electronics Division. During the war, as a member of the British Air Commission in Washington, he was responsible for the radio equipment of American aircraft for the R.A.F. and prior to joining the Ministry in 1954 held several R.A.F. appointments in the research and development field.

William T. Frost, who after 10 years with the B.B.C. went to the U.S.A. last year and joined Ampex Corporation's video development unit, has been promoted to staff engineer. He is at present in charge of an advanced development investigation of basic head/tape phenomena in instrumentation wide-band recording.

A. J. Gray, B.Sc., A.M.I.E.E., who has been with Ferranti since 1935, has been appointed general works manager of the company following the retirement of **W. Hunt,** M.B.E.

OBITUARY

Ronald Keen, M.B.E., B.Eng., M.I.E.E., the direction-finding specialist and author of the textbook "Wireless Direction Finding", died at Umtali, Southern Rhodesia, a few months ago. He joined Marconi's in 1912 and during the first World War was with the Admiralty serving for the most part overseas on d.f. installations. He returned to Marconi's after the war and together with Capt. H. J. Round and the late G. M. Wright was closely associated with the design and construction in 1923 of the Land's End d.f. station—the first coastal station specifically designed as a service to shipping. He transferred to the company's Traffic Services, which eventually became part of what is now Cable and Wireless, and from 1924 to 1939 was in charge of the Brentwood receiving station. During the war he was a Major in the Army Special Communications Unit and was responsible for the installation and technical operation of a network of high-frequency d.f. stations throughout the British Isles.

Hans Bredow, who died on January 9th this year, aged 79, joined the Telefunken Company in 1904. He was associated with Graf von Arco in the early development of spark telegraphy. In 1919 he joined the German Post Office and was responsible for the preparations which led to the commencement of broadcasting in Germany in October, 1923. In 1926 he became Commissar for Broadcasting. He was called on as a consultant when German broadcasting was reorganized after the war.

Stanley T. Cope, Marconi's technical librarian died on January 31st aged 52. He joined the company's research department in 1933 and in 1947 transferred to the technical information division where his work lay in the writing and editing of technical handbooks. He became technical librarian seven years ago.

"Wireless World" Index

As stated last month, the index to Volume 64 (1958) is now available price 1s (postage 3d). Our publishers will undertake the binding of readers' issues, the cost being 25s per volume, including binding case, index and return postage. Copies should be sent to Iliffe & Sons, Ltd., Binding Department, c/o 4 Iliffe Yard, London, S.E.17, with a note of the sender's name and address. A separate note, confirming despatch, together with remittance should be sent to the Publishing Department, Dorset House, Stamford Street, London, S.E.1.

European Television Stations

SURVEY OF THE CONTINENT'S NETWORK

DURING the recent abnormal propagation conditions reception of, and interference from, foreign television stations has been frequent, and we have received a number of requests for help in identifying stations. It is thought, therefore, that it would be of more than passing interest to bring together in one survey the operating characteristics of the 500 or more television stations now operating on the Continent.

We have limited this survey to the European Broadcasting Area—it is hoped to cover other parts of the world at a later date. This area is bounded on the South by parallel 30° North (bringing in parts of North Africa) on the East by the meridian 40° East (thus including only Western U.S.S.R.) and on the West by coastlines. Most of the information given has been obtained from the broadcasting organizations in the countries concerned, and this is supplemented by data published from time to time by the European Broadcasting Union.

The map on the following two pages is based on information prepared by the E.B.U. It is impracticable on a map of this size to show *all* the available information regarding radio and cable links; the only differentiation shown, therefore, is between links for the main transmitters and those for satellites which in most cases depend for their input on direct reception of a main transmitter. We also give on the map details of the standards conversion available for Eurovision links. Incidentally, it is worth recording that secondary television circuits to bypass the national networks are now provided extensively on the Continent to facilitate the unilateral, bilateral or multilateral interchange of programmes.

Although basically there are three television systems in use on the Continent there are in fact a number of variants. For instance, the Belgium version of the French 819-line system is accommodated in a 7-Mc/s channel with a vision bandwidth of 5Mc/s compared with 14 and 10.5Mc/s, respectively, in France. Similarly, there are major differences between the 625-line service used in the majority of European countries and those employed in the U.S.S.R. and Belgium. The characteristics of the world's television standards are given in Table 1.

Channels : E.R.P.: Polarization

Details of the channels employed in the European systems are given in Table 2. These channel numbers are used after the name of the station in the particulars of each country in the following pages.

An asterisk has been inserted against the e.r.p. of some transmitters. This indicates that the figure given is the maximum for a directional aerial. Transmitters employing vertical polarization are marked (V), the others being horizontally polarized.

A reproduction of the test card or

(*Continued on page* 111)

TABLE 1: WORLD'S TELEVISION STANDARDS

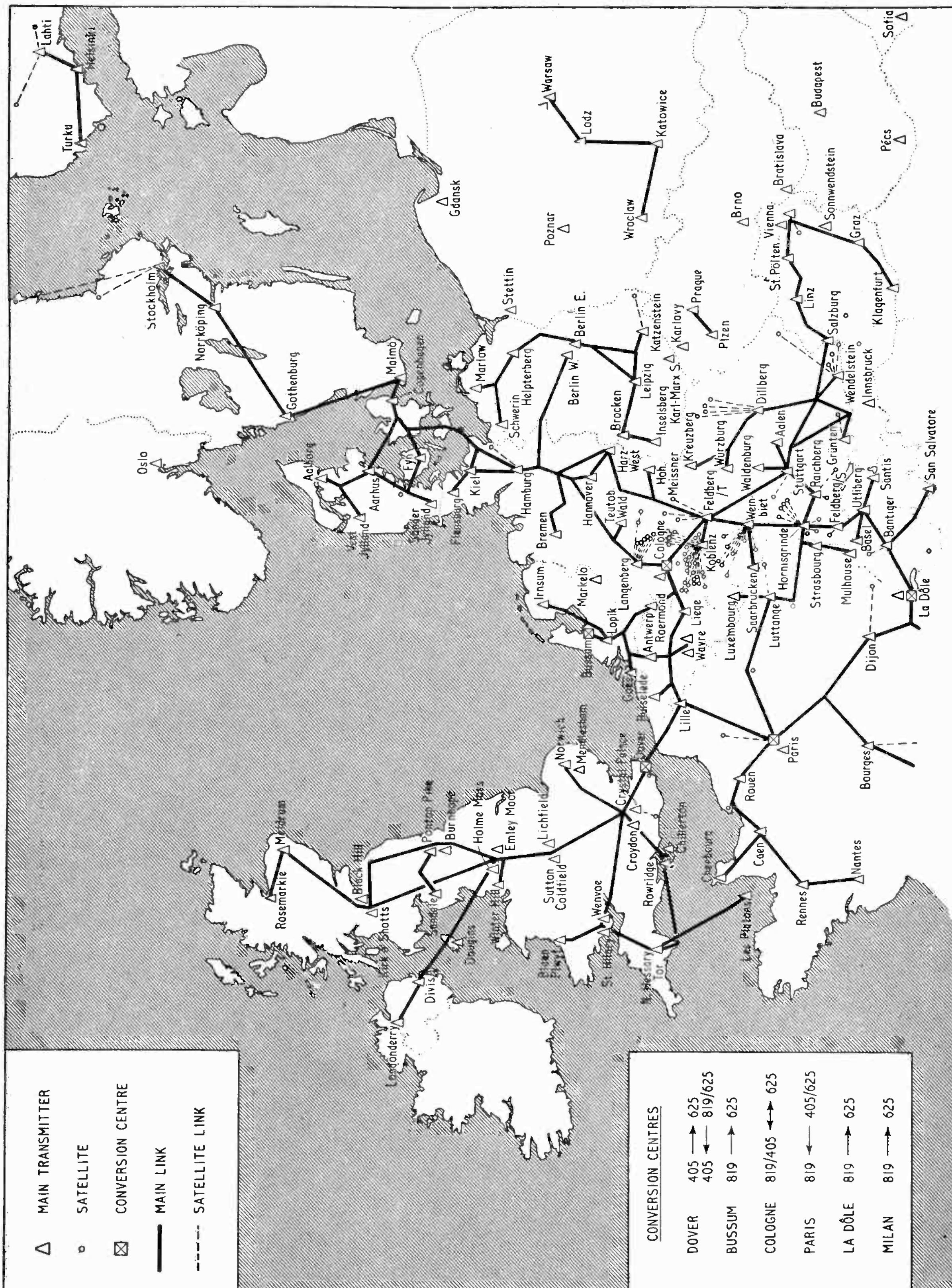
	405	525	625 (C.C.I.R.)	625 (O.I.R.)	819	819 (Belgian)
Vision bandwidth (Mc/s)	3	4	5	6	10.4	5
Channel width (Mc/s)	5	6	7	8	14	7
Sound carrier relative to vision carrier (Mc/s)...	−3.5	+4.5	+5.5	+6.5	−11.15§	+5.5
Sound carrier relative to edge of channel (Mc/s)	+0.25	−0.25	−0.25	−0.25	+0.10§	−0 25
Line frequency (c/s)	10,125	15,750	15,625±0.1%	15,625±0.05%	20,475	20,475±0.1%
Frame frequency (c/s)	50	60	50	50	50	50
Picture frequency (c/s)	25	30	25	25	25	25
Sense of vision modulation	positive	negative	negative*	negative	positive	positive
Blanking level as % of peak carrier	30	75	75*	75	25	25
Minimum level of carrier as % of peak carrier...	0	≤15†	10*	10 min.	≤3	0 − 3
Sound modulation	a.m.	f.m.	f.m.*	f.m.	a.m.	a.m.
Deviation (kc/s)		±25	±50	±50		
Pre-emphasis (μ sec.)		75	50	50		50

† In the Japanese 525-line system the figure is 10-15%.
* In the Belgian 625-line system positive vision modulation is used; the blanking level is 25%; minimum level of carrier is 0—3%; and sound is a.m. with 50 μsec. pre-emphasis.
§ In some of the French channels the vision and sound carriers are reversed—the vision carrier being the lower.

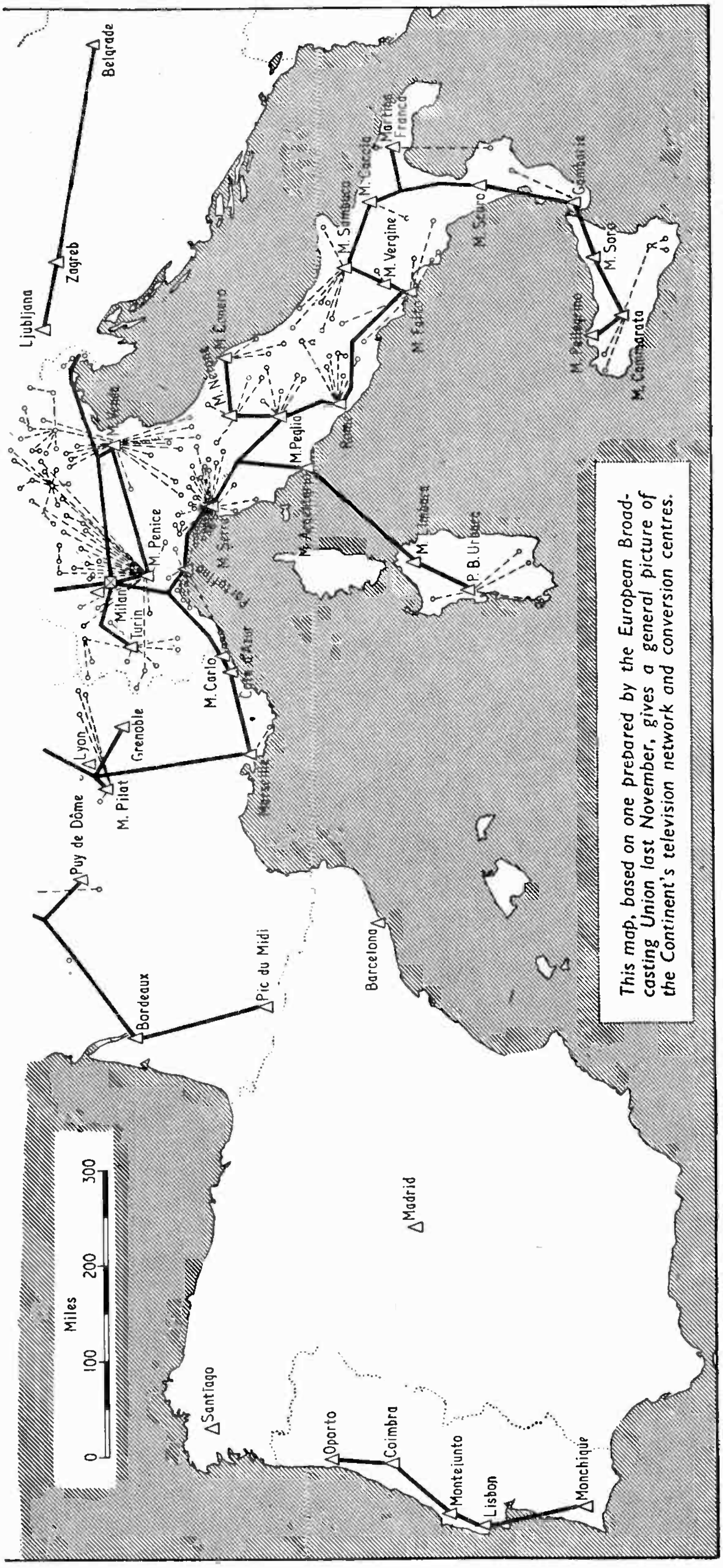
TABLE 2: EUROPEAN TV CHANNELS IN BANDS I & III

U.K. 405 lines (5 Mc/s channels)			C.C.I.R. 625 lines and Belgian 819 lines (7 Mc/s channels)			O.I.R. 625 lines (8 Mc/s channels)			French 819 lines (14 Mc/s channels)		
B1	45.00	41.50	E2	48.25	53.75	O1	49.75	56 25	F2	52.40	41.25
B2	51.75	48.25	E3	55.25	60.75	O2	59.25	65.75	F3	56.15	67.30
B3	56.75	53.25	E4	62.25	67.75	O3†	77.25	83.75	F4	65.55	54.40
B4	61.75	58.25	E5	175.25	180.75	O4†	85.25	91.75	F5	164.00	175.15
B5	66.75	63.25	E6	182.25	187.75	O5†	93.25	99.75	F6	173.40	162.25
B6	179.75	176.25	E7	189.25	194.75	O6	175.25	181.75	F7	177.15	188 30
B7	184.75	181.25	E8	196.25	201.75	O7	183.25	189.75	F8A	185.25	174.10
B8	189.75	186.25	E9	203.25	208.75	O8	191.25	197.75	F8	186.55	175.40
B9	194.75	191.25	E10	210.25	215.75	O9	199.25	205.75	F9	190.30	201.45
B10	199.75	196.25	E11*	217.25	222.75	O10	207.25	213.75	F10	199.70	188.55
B11	204.75	201.25				O11*	215.25	221.75	F11	203.45	214.60
B12	209.75	206.25				O12*	223 25	229 75	F12	212.85	201.70

The vision carrier precedes the sound carrier in this list.
† These channels are outside the limits of Band I (41-68 Mc/s). * These channels are outside the limits of Band III (174-216 Mc/s).



MAIN TRANSMITTER
SATELLITE
CONVERSION CENTRE
MAIN LINK
SATELLITE LINK
CONVERSION CENTRES
DOVER 405 ⟶ 625
405 ⟵ 819/625
BUSSUM 819 ⟶ 625
COLOGNE 819/405 ⟷ 625
PARIS 819 ⟵ 405/625
LA DÔLE 819 ⟶ 625
MILAN 819 ⟶ 625
Lahti
Helsinki
Turku
Stockholm
Norrköping
Gothenburg
Oslo
Malmö
Copenhagen
Aalborg
Aarhus
Vest Jylland
Fyn
Sønder Jylland
Flensburg
Kiel
Hamburg
Bremen
Hannover
Schwerin
Helpterberg
Marlow
Stettin
Gdansk
Poznan
Warsaw
Lodz
Katowice
Wroclaw
Berlin E.
Berlin W.
Brocken
Leipzig
Katzenstein
Karlovy
Prague
Plzen
Brno
Vienna
Bratislava
Budapest
Sonnwendstein
Pécs
Sofia
Graz
Klagenfurt
Linz
St. Pölten
Salzburg
Wendelstein
Innsbruck
Dillberg
Aalen
Würzburg
Kreuzberg
Inselsberg
Karl-Marx S.
Harz-West
Hoh. Meissner
Teutob. Wald
Feldberg /T
Waldenburg
Weinbiet
Stuttgart
Raichberg
Grünten
Feldberg/S
Uetliberg
Säntis
Bantiger
Basel
San Salvatore
La Dôle
Mulhouse
Strasbourg
Hornisgrinde
Saarbrücken
Luxembourg
Luttange
Koblenz
Cologne
Langenberg
Markelo
Irnsum
Lopik
Bussum
Roermond
Antwerp
Liège
Wavre
Brussels
Lille
Paris
Dijon
Bourges
Rouen
Caen
Rennes
Nantes
Les Platons
Cherbourg
Dover
Crystal Palace
Norwich
Mendlesham
Croydon
Chillerton
Rowridge
Wenvoe
St. Hilary
N. Hessary Tor
Sutton Coldfield
Lichfield
Emley Moor
Holme Moss
Burnhope
Pontop Pike
Black Hill
Meldrum
Rosemarkie
Kirk o'Shotts
Divis
Londonderry
Douglas



This map, based on one prepared by the European Broadcasting Union last November, gives a general picture of the Continent's television network and conversion centres.

tuning signal used for the country's television service is also given in most of the summaries.

ALBANIA

There is at present no television service in Albania. The Stockholm Plan of 1952 provided for one station in Band I and three in Band III using the O.I.R. 625-line system.

ALGERIA

Although outside the natural boundaries of Europe, Algeria does come within the European Broadcasting Area and is therefore covered by the provisions of the Stockholm Plan. The television service is provided by the French broadcasting authority, Radiodiffusion-Télévision Française; the standards employed (819 lines) and the test card are, therefore, the same as in France. Under the Stockholm Plan five transmitters are provided for but at present only two, at Algiers (Cap Matifou) and Oran, are in operation. The service is government operated and is financed from licence revenue—2,000 francs sound, and 6,000 francs television. The number of television receivers in use is about 28,000.

	channel	e.r.p.
Algiers	F11	2kW
Oran	8	20

AUSTRIA

Two years ago the Austrian Broadcasting System, Österreichischer Rundfunk, introduced a regular television service. There are now 8 main transmitters in Bands I and III, which are listed below, and 5 satellites. There is also a second station in Vienna which radiates in Band IV.

The television service is financed by a bank credit covered by a guarantee of the Austrian Federal Government. In January this year advertising programmes were introduced to supplement the income. The annual licence fee is 600 schillings (excluding sound

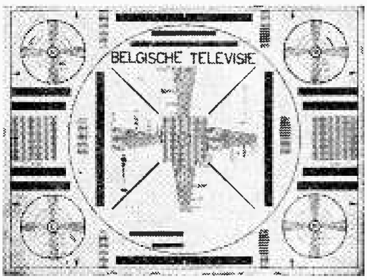
	channel	e.r.p.
Gaisberg (Salzburg) ...	E8	60kW
Jauerling (St. Pölten) ...	†	60
Kahlenberg (Vienna) ...	5	60
Linz, Upper Austria ...	6	3
Patscherkofel (Innsbruck)	4	30
Pyramidenkogel (Klagenfurt)	10	30
Schöckl (Graz)	7	60
Sonnwendstein, Lower Austria	10	1.5

†Vision 49.75 Mc/s, sound 55.25 Mc/s.

radio) which is about £8. The present number of licences is approx. 60,000.

BELGIUM

Because its neighbouring countries operate on different standards (625 and 819 lines), Belgium operates a two-standard television service using a modified version of the Gerber



(C.C.I.R.) 625-line system for its Flemish transmissions and a modified version of the French 819-line system (with a 5-Mc/s video bandwidth) for its French transmissions. All sets in Belgium are designed to receive four standards: both the national services, the C.C.I.R. 625-line standard and the French 819 lines.

The country's television service is operated by the Institut National Belge de Radiodiffusion (I.N.R.) and is financed by the government. Since January, 1958, television set owners have had to pay an annual tax of 840 Belgian francs (£6). The number of television receivers is about 300,000.

	channel	e.r.p.
Antwerp (625)	E2	6* (V)
Liege (819)	3	100
Ruiselede (625) ...	2	100
Wavre (819)	8	100
Wavre (625)	10	100

BULGARIA

So far only experimental television transmissions using a low-power station at Sofia have been made by Radiodiffusion Bulgare, which has adopted the O.I.R. 625-line standard. For these tests channel O3 has been used. Regular transmissions from a new station in the capital are due to begin on May 1st.

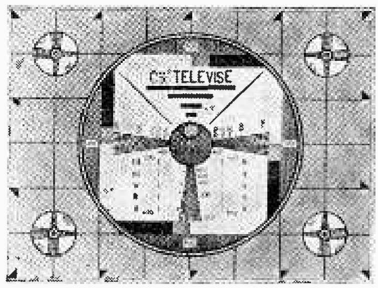
CYPRUS

An experimental television service was introduced on the island by the Cyprus Broadcasting Service just over a year ago. The 625-line transmitter in Nicosia radiates in channel E2 with an e.r.p. of 1.5kW. Television licences, costing £1 per annum, totalled 193 at the end of November.

CZECHOSLOVAKIA

Five stations are now used in the Czechoslovak television chain which operates on the O.I.R. 625-line standard. The service is state financed and viewers pay a fee of 180 crowns

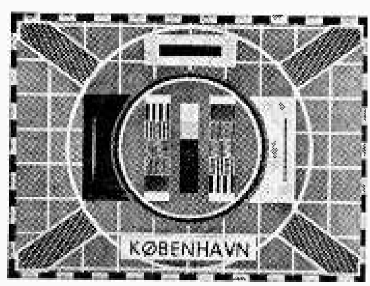
	channel	e.r.p.
Bratislava...	O3	12kW
Brno	9	10
Karlovy Vary	10	0.6
Ostrava	2	12
Prague	2	5



(£9) excluding sound radio. At the end of last June there were about 200,000 television licences in force.

DENMARK

Two high-power transmitters and four medium-power stations employing the 625-line standard are operated by the national broadcasting service, Statsradiofonien, which is financed by the revenue from licence fees. Television set owners pay an annual licence fee of 55 kroner



(about £3). There are about 200,000 television licences in force.

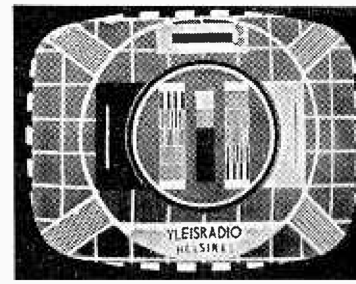
	channel	e.r.p.
Aarhus	E8	10kW
Aalborg	5	10
Copenhagen	4	10
Fyn	3	10
Sönderjylland	7	60
Vestjylland	10	60

EIRE

There is no television service in Eire, but the Minister for Posts and Telegraphs recently appointed a twenty-one-man Television Commission "to consider and make recommendations on the question of establishing a television service." The committee is to base its recommendations on the assumption that the cost of the service will not fall on the Government. The Stockholm Plan provides for 5 stations in Band III for Eire and these are shown as operating on the British 405-line standard.

FINLAND

Three main stations, with two provisional stations, form the television network of the Finnish broadcasting authority—Oy. Yleisradio Ab.—which employs the C.C.I.R. 625-line system. Since January, 1958, viewers have had to pay a licence fee of 6,000Mk (£7), excluding sound radio which is a



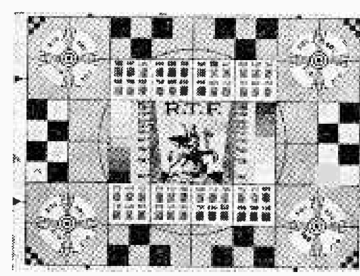
further 1,200Mk. Television licences totalled 7,750 at the end of 1958.

	channel	e.r.p.
Helsinki	E6	10kW
Kotka	5	†
Lahti	9	15
Tampere	8	†
Turku	7	25

†Provisional transmitters.

FRANCE

Regular television transmissions have been radiated in France since 1938 when a 455-line system was used by the Eiffel Tower station. It



radiated in Channel F1 with a 7.6-Mc/s bandwidth. The scanning rate was subsequently changed to 441 lines and the transmissions from Eiffel Tower continued for over five years after the introduction of the present 819-line standard in 1950. Since the cessation of the 441-line transmissions the French Channel 1 (46Mc/s vision, 42Mc/s sound) has not been used.

In order to accommodate the maximum number of stations in the few 14-Mc/s channels available in Bands I and III, the R.T.F. (Radiodiffusion-Télévision Française) has adopted a scheme whereby they accommodate two channels in one. This is done by reversing the position of the vision carrier relative to the sound carrier in alternate channels so that four carriers come within a 14-Mc/s band.

The French television service is financed from licence fees and from government grants. The fee for a home television set is 6,000 francs (£4 10s), but is being increased to 7,500 francs in July. Where a television set is used in public places the fee is four times as much.

The present chain includes the 22 main stations listed below and 15 satellites. Under an agreement recently concluded between the Monacan and French governments, the television station at Monte Carlo will receive the major part of its programmes from the R.T.F.

An unusual feature of the French television service is that in addition to the R.T.F. network a number of satellite stations have been erected by private enterprise to improve local reception. The number of these stations increased so rapidly and so indiscriminately that recently regulations were drawn up prohibiting the erection of such stations except by local authorities. The power of the satellites varies from 0.1W to 5W.

At the end of December there were 988,594 television licences in force.

	channel	e.r.p.
Bordeaux...	F10	25kW*
Bourges	9	200
Caen	2	50
Cherbourg	12	—
Côte d'Azur	6	10 (V)
Dijon	10	30 (V)
Grenoble	10	2
Lille	8A	200
Luttange	6	200*
Lyon	5	0.1
Marseille	8	300*
Mont-Pilat	12	200
Mulhouse...	8	200*
Nancy	7	1.6* (V)
Nantes	4	0.5 (V)
Paris	8A	180
Pic du Midi	5	20
Puy de Dôme	6	160* (V)
Reims	5	0.1 (V)
Rennes	5	0.5
Rouen	10	50*
Strasbourg	5	20*

GERMANY, EAST

Television in the German Democratic Republic is State controlled and is operated by the Deutscher Demokratischer Rundfunk. The 625-line system is employed but the channel numbering differs from either the C.C.I.R. or O.I.R. channels in table 2. The vision and sound carriers (in Mc/s) of the channels at present in use are: 1 (59.25/64.75); 2 (145.25/150.75); 3 (55.25/60.75); 5 (175.25/180.75); 6 (182.25/187.75); 8 (196.25/201.75); 11 (217.25/222.75).

At the end of August there were 257,000 television licences issued in the Republic.

	channel	e.r.p.
Berlin	5	100kW
Brocken	6	—
Katzenstein (Dresden) ...	2	100
Helpterberg	3	—
Inselsberg	5	—
Karl-Marx-Stadt ...	8	—
Leipzig	1	100
Marlow	8	—
Schwerin	11	—

GERMANY, WEST

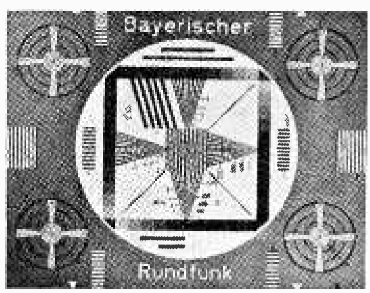
Although the television stations in the German Federal Republic are operated by a number of authorities—each one covering a zone of the immediate post-war period—there is a common television programme known as Deutches Fernsehen, to which each of these organizations contributes. There are 26 main stations and these are listed on page 114 with the initials of the operating authority against each—B.R. (Bayerischer Rundfunk); H.R. (Hessischer Rundfunk); N.D.R. (Norddeutscher Rundfunk); S.D.R. (Süddeutscher Rundfunk); S.F.B. (Sender Freies Berlin); S.W.F. (Südwestfunk); and W.D.R. (Westdeutscher Rundfunk). In addition to the main stations listed there are over 80 satellites in use. A few experimental transmitters operating in Band IV have also been built but these are not listed.

West German television, which employs the C.C.I.R. 625-line system, was, until recently, financed entirely from licence fees, but this is now supplemented by commercial programmes. A combined television-sound licence costs 84DM (£7) a year, of which the postal authorities retain about 27%.

With the incorporation of the Saar in the Federal Republic there has arisen the problem of the commercial sound and television stations in this territory. The French 819-line standard was employed by the commercial television stations, but these are now closed down and the present station at Saarbrücken employs the 625-line standard. Its e.r.p. is being increased to 100kW.

In addition to the national network there are also a few Band IV stations (not listed) being operated for the American Forces. These employ the U.S.A. 525-line standard.

The number of television receivers



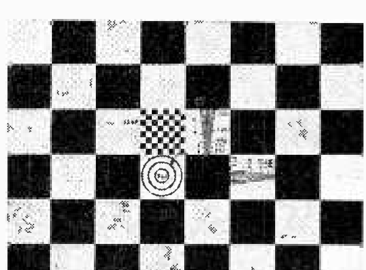
BAYERISCHER RUNDFUNK

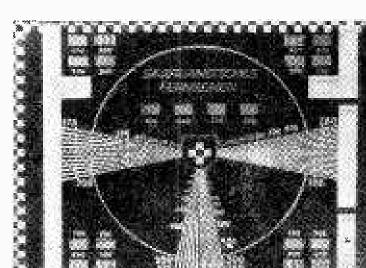
SÜDDEUTSCHER RUNDFUNK

HESSISCHER RUNDFUNK

SÜDWESTFUNK

D.D.R. EAST GERMANY


N.D.R., W.D.R. and S.F.B.


SAARLAND

in the Federal Republic was 1,765,410 at the end of September.

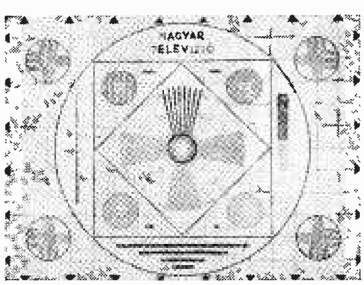
	channel	e.r.p.
Aalen (S.D.R.)	E8	20kW*(V)
Berlin (S.F.B.)	7	50
Biedenkopf (H.R.) ...	2	20* (V)
Bremen-Oldenburg (N.D.R.)	2	100
Cologne (W.D.R.) ...	11	5
Dillberg/Nürnberg (B.R.)	6	100
Feldberg/Schwarzwald (S.W.F.)	8	100
Feldberg/Taunus (H.R.)...	8	100
Flensburg (N.D.R.) ...	4	50*
Grünten (B.R.)	2	100*
Hamburg (N.D.R.) ...	9	100
Hannover (N.D.R.) ...	8	5
Harz-West (N.D.R.) ...	10	100
Hoher Meissner (H.R.) ...	7	100
Hornisgrinde (S.W.F.) ...	9	100*
Kiel (N.D.R.)	5	5
Koblenz (S.W.F.) ...	6	50
Kreuzberg/Rhön (B.R.)...	3	100* (V)
Langenberg (W.D.R.) ...	9	100
Raichberg (S.W.F.) ...	4	40
Saarbrücken	2	10* (V)
Stuttgart-Degerloch (S.D.R.)	11	100
Teutoburger Wald (W.D.R.)	11	100
Weinbiet (S.W.F.) ...	10	50*
Wendelstein (B.R.) ...	10	100*
Würzburg (B.R.) ...	10	1

GREECE

No provision was made in the 1952 Stockholm Plan for television stations in Greece because the Government "had not yet finalized its plans for v.h.f. sound and television broadcasting." The delegation to the conference did, however, state that initially three stations would be erected at Athens, Salonika and Patras. No announcement has been made of the implementation of these plans.

HUNGARY

Following a series of experimental transmissions in channel O2 from a low-power transmitter on the outskirts of Budapest, a new high-power station was brought into service in the capital in January last year and recently a second station, at Pécs, was opened. The television service, which employs the O.I.R. standard, is State financed and the licence fee



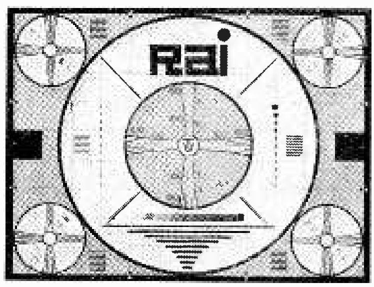
is 600 Forints (£19) a year excluding sound radio. The present number of receivers is approximately 24,000.

	channel	e.r.p.
Budapest	O1	100kW
Pécs	2	5

ITALY

By far the biggest concentration of television stations in Europe is in Italy where, at the beginning of the year, there were 270—approximately one half of the Continent's total. Of this number only 24 are major stations (they are listed below), the remainder being satellites which radiate a main station's programme received by radio. One of these main stations (M. Penice) has as many as 52 satellites. With a total of some 1,100,000 television receivers in the country, there is an average of about 4,000 sets to each transmitter.

Although Italy adopted the 625-line standard when the national service was started by Radiotelevisione Italiana (RAI) in 1954, the channels used vary somewhat from those generally employed on the Continent. Moreover, under a protocol



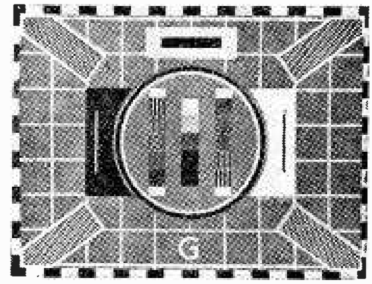
to the Stockholm Plan (1952), Italy is permitted to use an additional channel (81 to 88Mc/s). Italy's television channels are designated by the following letters with which we give in brackets the vision and sound carriers: A (53.75/59.25); B (62.25/67.75); C (82.25/87.75); D (175.25/180.75); E (183.75/189.25); F (192.25/197.75); G (201.25/206.75); H (210.25/215.75).

The television service is financed both from licence fees—14,000 lire (£8) a year for a combined sound and television licence—and from advertising which was introduced when the number of sets in use exceeded 150,000.

	channel	e.r.p.
Gambarie	D	19kW
Martina Franca	D	220
Milan	G	24
M. Argentario	E	2.5
M. Caccia...	A	53
M. Cammarata	A	29
M. Conero	E	24
M. Faito	B	53
M. Lauro	F	100
M. Limbara	H	3
M. Nerone	A	29
M. Peglia	H	34
M. Pellegrino	H	8
M. Penice	B	100
M. Sambuco	H	35
M. Scuro	G	5
M. Serra	D	270
M. Soro	E	5
M. Venda	D	190
M. Vergine	D	1
Portofino	H	127
P. Badde Urbara ...	D	145
Rome	G	36
Turin	C	16

LUXEMBOURG

The 819-line standard, but with a bandwidth of 7Mc/s as in Belgium, was adopted by the Compagnie Luxembourgeoise de Télédiffusion when it added television to its com-



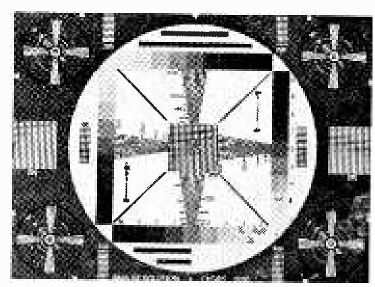
mercial sound broadcasting service in January, 1955. The station, which is built on the top of the Ginsterberg (1,460ft), radiates in channel E7 with a vision e.r.p. of 100kW. Transmissions are horizontally polarized. The service is financed by advertisements so that no licence fee is paid by the 4,000 set owners in the Grand Duchy.

MONACO

Since early 1955 a commercial television station, Tele-Monte-Carlo, has been operated in the principality by the company which owned the commercial stations in the Saar. Early last year the station, which radiates on 819 lines in channel F10 with an e.r.p. of 50kW, was taken over by the Monacan government. It is now leased to R.T.F., the French broadcasting authority, which provides the major part of the programmes.

NETHERLANDS

Sound broadcasting in the Netherlands is conducted by five societies (representing different political and religious parties) whose activities



since 1947 have been co-ordinated through the Nederlandsche Radio Unie. These same societies in 1951 formed a co-ordinating body, which is known as Nederlandse Televisie Stichting, for television. Experimental transmissions were conducted from the end of that year until regular service using 625 lines was started in 1953. Viewers pay annual licence fee of 30 Dutch florins (about £3), excluding radio, and the

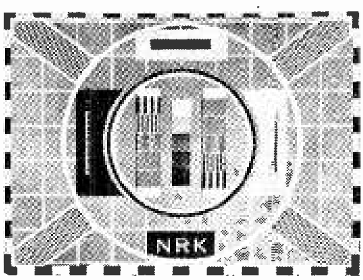
	channel	e.r.p.
Goes	E7	5kW
Irnsum	6	25
Lopik	4	20
Markelo	7	50
Roermond	5	50

service is government subsidized. Television licences totalled 374,738 at the end of November, 1958.

NORWAY

An experimental television service has been radiated from a low-power transmitter in Oslo for the past four years.

The 625-line standard has been employed for these tests conducted by the Norwegian broadcasting organization, Norsk Rikskringkasting. As a result of these tests, the Norwegian government has drawn up plans for a national television network and regular transmissions are scheduled to begin in 1960. As with sound broadcasting the provision of



the technical facilities (transmitters and links) comes under the country's telecommunications administration and the programme technical operations are carried out by Norsk Rikskringkasting. Under the Stockholm Plan there is provision for 10 stations in Band I and 23 in Band III, but this number is considered to be insufficient to cover the country satisfactorily. A revised scheme providing for 28 main stations (18 of which will be high-power) and 19 satellites has, therefore, been drawn up. It is planned to have most of the proposed stations constructed for unattended operation.

POLAND

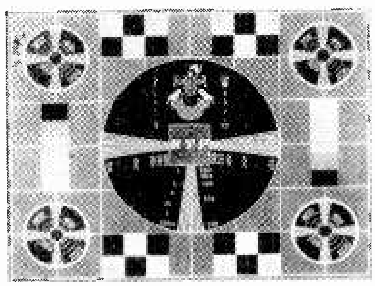
In 1952, after an experimental period with two transmitters operating on different standards (441 and 625 lines), the Polish Ministry of Posts and Telecommunications adopted the O.I.R. 625-line system. The present chain of 8 stations is operated by the Central Radio and Television Administration of the government. A tax of 480 zloty's

(£7) a year is paid on each television receiver. The number of sets in use is now about 80,000.

	channel	e.r.p
Gdansk	O3	—
Katowice	8	26kW
Lódz	6	2.5
Poznan	7	3.5
Stettin	—	—
Warsaw	11	95
Warsaw	2	7
Wroclaw	12	123

PORTUGAL

Three years ago the Portuguese government granted a concession to the Radiotelevisão Portuguesa, S.A.R.L., to organize the country's television service. Its licence permits the transmission of commercial programmes and the company is also



allowed to sell and rent television sets and accessories. R.T.P., as it is known, is now operating five stations, the service areas of which cover a large part of the country. The service employs the 625-line standard. To encourage the purchase of receivers, licences are not being collected for the first two years of this service. The estimated number of receivers in use is 22,000.

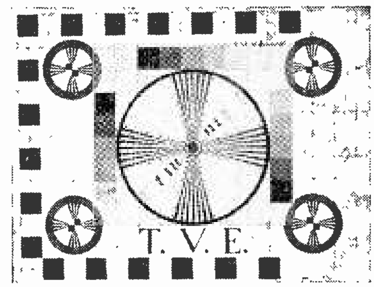
	channel	e.r.p.
Lisbon	E7	100kW
Lousã, Coimbra	3	50
Monchique	5	6.5
Montejunto	3	1
Oporto	9	100

RUMANIA

Under the Stockholm Plan Rumania is to have three stations in Band I and eight in Band III. At present, however, only one transmitter, in Bucharest, is operating. It employs the O.I.R. 625-line standard and radiates in Channel O2 with an e.r.p. of 7.5 kW. The service is government financed.

SPAIN

Since June, 1956, a regular television service on 625 lines has been broadcast from the low-power transmitter installed experimentally at Madrid by the broadcasting department of the Ministry of Information. A second station at Barcelona was recently opened and plans have been made for additional stations at Santiago and Zaragoza and for a new high-power station at Navacerrada to serve the capital. There are approximately 10,000 television receivers in use. The annual lic[illegible]

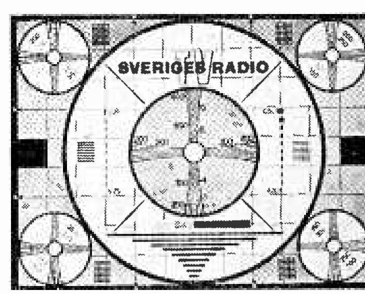


pesetas (£2 10s) for sets with a 14-in tube and 500 pesetas (£4) for larger sizes.

	channel	e.r.p.
Barcelona	E3	20kW
Madrid	3	2

SWEDEN

Regular television transmissions using the C.C.I.R. 625-line standard have been radiated in Sweden since June, 1956, following a long series of test transmissions. The stations are built and maintained by the Board of Swedish Telecommunications and the programmes provided by the Swedish broadcasting organization, Sveriges Radio AB. The television service is intended to be financed from licence fees, but the government is making grants towards initial development costs. The fee is 100 Swedish crowns (about £7) a year, which is payable quarterly. Incidentally, in areas where "reasonably good reception" is not obtainable set owners pay a registration fee of only 10 Swedish crowns. There are, at

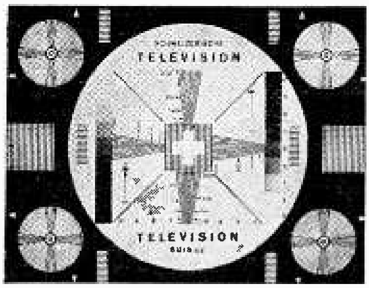


present, about a quarter of a million receivers in use.

	channel	e.r.p.
Gothenburg	E9	15kW
Malmö	10	1
Norrköping	5	15
Stockholm	4	60

SWITZERLAND

Switzerland's tri-lingual television service, which operates on the C.C.I.R. 625-line standard, is radiated by the seven stations listed. The stations are provided by the postal administration and the programmes by the Swiss Broadcasting Corporation. The S.B.C. receives 70% of the proceeds from licence fees and the P.T.T. 30%. The annual fee is 84 Swiss francs, about £7 for home receivers, and 168 francs for public reception. The [illegible] also sub-



sidized by the Swiss Newspaper Publishers Association which is providing 2M francs a year for 10 years on condition that advertisements and sponsored programmes are not broadcast. The number of licences at the end of the year was 50,300. In addition to the seven main transmitters there are five privately owned low-power booster stations.

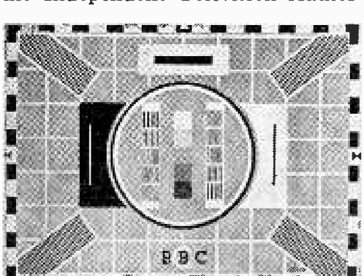
	channel	e.r.p.
Bantiger	E2	30kW
Chrischona, Basel ...	10	10
La Dôle	4	100
Monte Ceneri	5	10
San Salvatore	10	10
Säntis	7	30*
Utliberg	3	20

TURKEY

Provision is made in the Stockholm Plan for Turkey to have 43 television stations—11 in Band I and 32 in Band III. Tests using 625 lines have been conducted for some time but there is no immediate prospect of a service being introduced. An experimental station in the Technical University, Istanbul, has been radiating in channel E4.

UNITED KINGDOM

Being the only country to employ the 405-line system, it is often said that the U.K. is odd-man-out in television, but it must not be forgotten that it was the first country in the world to have a regular television service—in 1936. There is strong feeling in many quarters of industry and research that a change should be made to 625 lines, but, be that as it may, we are here concerned with the present television service which, after the wartime shut-down, was restarted on the same standards in 1946. The service was provided by the B.B.C. until 1955 when, under the provisions of the Television Act, the Independent Television Authority started an alternative service. Whereas the B.B.C.'s income is derived from receiving licence fees, the I.T.A.'s comes indirectly from advertising. For the sake of our overseas readers it should be made clear that the I.T.A.'s programmes are not sponsored by advertisers. They are provided by the programme contractor licensed to operate a station, the advertisements being inserted in "natural breaks" in the programmes.



When used by the I.T.A. this test card carries these initials.

The present combined television-sound licence fee is £3, plus £1 excise duty which is retained by the Treasury. The B.B.C. receives 87.5% of the revenue from all receiving licence fees after the Post Office has deducted an amount for its services in collecting fees and investigating complaints of electrical interference. The remaining 12.5% passes to the Treasury.

There were 8.9M television licences in force at the end of December.

	channel	e.r.p.
Black Hill (I.T.A.) ...	10	475kW*(V)
Blaen Plwyf (B.B.C.) ...	3	1
Burnhope (I.T.A.) ...	8	100*
Chillerton Down (I.T.A.)	11	100*(V)
Croydon (I.T.A.) ...	9	120(V)
Crystal Palace (B.B.C.)	1	200(V)
Divis (B.B.C.)	1	12
Douglas (B.B.C.) ...	5	2.5*(V)
Dover (B.B.C.)	2	4*(V)
Emley Moor (I.T.A.) ...	10	200*(V)
Folkestone (B.B.C.) ...	4	0.1
Holme Moss (B.B.C.) ...	2	100(V)
Kirk o'Shotts (B.B.C.) ...	3	100(V)
Lichfield (I.T.A.) ...	8	200(V)
Les Platons (B.B.C.) ...	4	1
Londonderry (B.B.C.) ...	2	1
Meldrum (B.B.C.) ...	4	17*
N. Hessary Tor (B.B.C.)	2	15*(V)
Norwich (B.B.C.) ...	3	10*
Orkneys (B.B.C.)† ...	5	17(V)
Pontop Pike (B.B.C.) ...	5	12
Rosemarkie (B.B.C.) ...	2	1
Rowridge (B.B.C.) ...	3	32*(V)
St. Hilary (I.T.A.) ...	10	200(V)
Sandale (B.B.C.) ...	4	16
Sutton Coldfield (B.B.C.)	4	100(V)
Wenvoe (B.B.C.) ...	5	100(V)
Wick (B.B.C.)†	1	4*(V)
Winter Hill (I.T.A.) ...	9	100(V)

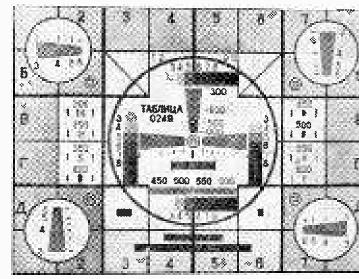
†Temporary stations at present in use.

U.S.S.R.

As mentioned in the introduction, only that part of the U.S.S.R. within the European Broadcasting Area is dealt with in this survey. Regular transmissions using 343 lines and 240 lines were started respectively from Moscow and Leningrad in 1938. A few years later the Moscow transmitter was modified for a scanning rate of 441 lines, and this standard was used until the introduction in 1948 of its present 625-line standard approved by the O.I.R. (International Broadcasting Organization), representing the Eastern European broadcasting authorities.

The major problem in providing a television service for so vast a country is the provision of links between stations. One method recently employed for a relay from Moscow to Leningrad—about 400 miles—was to use two aircraft as relay stations with an intermediate ground station between them.

We have been unable to obtain from the Soviet authorities a list of stations with the frequencies and powers employed. However, from announcements made from time to time we have been able to prepare a list of some towns west of meridian 40°E in which stations are said to be operating. This list, which has been supplemented by information kindly supplied by the Society for Cultural Relations with the U.S.S.R., is given below. Where known the



channel number is given in brackets:—

Dniepropetrovsk; Gomel; Kharkov (O1); Kherson; Kiev (O3); Kishinev; Leningrad (O2); Lugansk; Lwow; Minsk; Moscow (O1); Moscow (O2); Novgorod; Odessa (O1); Petrosavodsk; Riga (O2); Stalino; Stalinogorsk; Tallinn (O2); Vilna (O5); Yaroslavl.

In addition to these main television centres there are also a number of relay or satellite stations. It was recently reported that 30 new stations were brought into operation last year; the northernmost on the Taimyr Peninsular, well within the Arctic Circle. There are about 2.5M television sets in use in the Union. The "subscription fee" for a television set is 10 roubles a month (about £10 a year).

VATICAN CITY

Although residents in the Vatican City are able to receive transmissions from the Italian television service, provision was made in the Stockholm Plan for the Papal authorities to have their own television station. Two frequencies—one in each band—were allocated, but so far no decision has been made on the erection of a station.

YUGOSLAVIA

Two stations were operating independently for a year until last November when a third station, in the capital, was built and all three are now linked and provide a service for 38% of Yugoslavia's population. The C.C.I.R. 625-line standard has been adopted for the service. About 6,000 receivers are now in use.

	channel	e.r.p.
Belgrade	E6	10kW
Ljubljana	10	4.5
Zagreb	9	4

Time Past — BEAM AND BROADCAST

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

This is the second of a series of articles by the first Chief Engineer of the B.B.C. and is concerned with the progress of the revolution caused by the invention of the valve, a progress during which he was intimately concerned with the beginnings of broadcasting. In the first article the author gave an account of how the nineteenth-century scientists established the foundations upon which pioneering inventors built their systems. In a third article he will round off with some predictions about the future.

IN the early autumn of 1915 I stood on the tarmac of Brooklands Aerodrome next to the late C. E. Prince and heard him say into a microphone "Hullo, Ferdy!* If you are hearing me now it will be the first time that speech has been transmitted from ground to an aeroplane in flight. If you are hearing me, please dip." The lumbering "Rumpty," doing its forty-odd knots, fifteen hundred feet above us, gave an obedient lurch; Ferdy had received the speech, strength R_9. The incident gave me a particular thrill; it was the first time I had seen the Thermionic Valve in action.

Of the inventions of the twentieth century that of the valve seems to me to be the most important in the sense that it has had a greater effect upon the form of human life than any other. The valve, generator, detector and amplifier of high-frequency currents, made broadcasting practicable and broadcasting, be it of sound or vision, is of mighty consequence. I say this because I believe that broadcasting is the most powerful means of publication so far devised to influence the mind, taste and manners of mankind. I appreciate the counter-claim for the jet engine and the rocket; these assemblies could indeed be more influential in their capacity to destroy mankind, but I decline to match potential horrors against potential delights. Further, I recognize the importance of drugs—softening pain, subduing infections, restoring sanity—but I still maintain the claims of broadcasting as having a paramount influence upon communal psychology.

Still trying to match credit with those pioneers who deserve it can we find, among several, any one of them who could be allowed to say, in the face of fact, "I gave the world the thermionic valve"? With deep respect for the person who said it I maintain that neither he nor any one single person did so. The invention of the valve, like that of wireless itself, was too big to be borne of a single individual. But names are possible—in the time order, but not necessarily the order of importance of their contributions. I cite Edison, Fleming, de Forest, Langmuir and—a process not a person—the "getter."

Edison was unquestionably the first to arrange a plate near a filament and to explain unilateral conduction across the space between them (1883); Fleming, informed about the Edison effect and having at his disposal, on the shelf of a London University laboratory, "Apparatus for Demonstrating the Edison Effect" probably used it, as a relatively stable rectifier which could be used to give a reasonably accurate measure of the value of high-frequency currents—hence, as a natural evolution, the Fleming diode (1904). Lee de Forest was certainly the one who first placed the third or grid electrode between filament and plate (1907), but the action of this grid was not very well explained or, perhaps because of the softness of the valve, was then inexplicable.

I have no precise evidence to support me but I believe that Langmuir first analysed the behaviour of the hard valve which the "getter" eventually got. In other words it was Langmuir who related g_m, μ, and r_a, and showed the valve to be a voltage-operated device in which these three parameters played a co-ordinated role.

The foregoing, set out in such simple outline, may, by the degree of its generalizations, be unfair to those mentioned and neglectful of those not. If this be so then it is because of the difficulty of compressing into a few paragraphs what is a somewhat confusing and often unedifying story of protagonists upholding flimsy claims in terms of the polemic of vested interests rather than cool and factual analysis. Soft valves, soft thinking? But, with the tolerance of history, no hard words. Whatever may be the truth, the hard valve did appear out of a confused mist and proceeded, from 1914 onwards, to revolutionize the art and practice of electrical communication in all its forms.

It is surely fascinating to look back with wise-after-the-event eyes and watch the inventors of the past teetering on the edge of the obvious. A case in point concerns the use of the valve as a generator of oscillations; in other words the concept that, by positive feedback, the valve could be made to look like a negative resistance and thus overcome the losses in the resonant circuit it sets into oscillation. Lee de Forest described the triode in 1907 but does not claim regeneration until 1912. And simultaneously others, as we see from a famous legal action, had seen the same potentialities long after the appearance of the valve itself.

Thus "IN THE COURT OF APPEALS OF THE DISTRICT OF COLUMBIA . . . . Before Smyth, Chief Justice: Robb and Van Orsdel, Associate Justices . . . . This interference comes here on appeal by the parties Langmuir, de Forest and Meissner, from the decision of the Commis-

* J. M. Furnival a pioneer of aircraft wireless, and now Consultant to Marconi Instruments Ltd.

sioners of Patents awarding priority to Armstrong, also appeals by de Forest against Meissner and Langmuir jointly, and against Langmuir individually, for the invention set forth in the following counts"—and then ten or more thousand words in which other famous names came to the fore, notably Franklin and Round (England). A good deal of the evidence concerned "a beautiful clear tone" which de Forest claims to have produced from his Audion; it seems to have sounded as a syren voice in the ears of the legal pundits who gave judgment in de Forest's favour. Howard Armstrong, that prolific inventor, was much upset by a decision which was inclined to stress a somewhat loose description possessing a few months' priority against one which was far more concise if a little later in time.

While still thinking about these time-lags it is also strange to realize that we had to wait several years before we were given the immeasurable benefit of negative feedback, almost as important an invention in its influence upon the valve's ubiquity as the positive kind of feedback.

So much for genesis.

In spite of my presence at the Brooklands demonstration in 1915 I spent the greater part of the war in Egypt, Salonika and France looking after spark transmitters and crystal receivers. It was not until late in 1917 that I was appointed to do what was rather grandiloquently described as "Research," first for the Army at Woolwich and then for the Flying Corps at Biggin Hill. Here I came into intimate contact with the valve, its moods, potentialities, successes and failures.

Soon after the armistice I escaped out of a uniform (a "war to end all wars" had just been victoriously concluded, what point in remaining in military service?) and joined the Marconi Company. In a short time I became Head of the Experimental Section of the Designs Department, the laboratories being housed in an army hut in a field near the village of Writtle which is in turn near Chelmsford, where the Marconi factory was and is located. A claim to fame, before ever broadcasting came to increase it, lies with the fact that I played a considerable part designing both the first aircraft wireless telephone equipment, used extensively by Imperial Airways, also the Croydon ground station. Who remembers "Croydon calling" and its speech heard against a background hum as loud as any produced in his receiver by the most amateur of amateurs? The hum was purposive; it made tuning-in by the pilot all the easier.

Two important events accompanied my service at Writtle, first the setting up at Chelmsford of a powerful long-wave telephony transmitter and secondly the regular broadcasting service from "2 Emma Toc, Writtle." I will not labour detail, the facts are well known and have been set out elsewhere; I would prefer rather to generalize than to indulge anecdotage. Suffice it to say that the initiative due to H. J. Round and W. T. Ditcham, in setting up the powerful long-wave telephony station at Chelmsford *circa* 1919 stimulated the wireless amateurs to petition for a regular broadcasting service, and that permission for this to be set up, on the limited scale of half an hour a week, resulted in the Writtle station and the Writtle programmes, a service which anticipated that started by the B.B.C., in November, 1922, by some eighteen months.

A diminishing number of wireless amateurs and others attracted to the hobby of building "wireless sets" will remember the programmes from Writtle as being frivolous, I would prefer the description "gay." Perhaps the more remarkable aspect of the Writtle transmissions was the staff that fostered them. This comprised in the order they joined me after I became Chief Engineer of the B.B.C., the late H. L. Kirke, C.B.E., sometime Head of the Research, and subsequently Assistant Chief Engineer; B. N. MacLarty now Engineer-in-Chief of the Marconi Company, the Hon. R. T. B. Wynn, C.B.E., now Chief-Engineer of the B.B.C., and Sir Noel Ashbridge who was for so long the Corporation's Chief Engineer and subsequently Director of Technical Services.

An accompanying group photograph recalls a collaboration which I dare to describe as unique.

In my first article I described how, when still a schoolboy, my subsequent career in wireless was largely determined by the tactile excitements of brass and ebonite: it was a similarly sensual experience which caused me to swerve from occupations concerned with the less romantic aspects of radio to one devoted to the service of broadcasting.

It must have been in the early autumn of 1922, before the formal creation of the B.B.C. in November of that year, when Station 2LO broadcast opera from Covent Garden. Up to the time when I was converted to a belief in broadcasting, the wireless telephone as such had to me done little more than intrigue my technical intellect, its applications were seemingly prosaic, while our Writtle broadcasts seemed to be no more than the aphrodisiac of a hobby ("keep your boys at home"). But the moment of revelation, the moment when I heard the opening bars of the opera, and was in two senses transported, then the potentialities of broadcasting were seen so vividly and so completely that thereafter all attempts to realize them have been to me tinged with disappointment.

The experience must be seen as mystical, as such I have unashamedly tried to describe it; its residue caused me, in prosaic contrast, to frame what I termed the B.B.C.'s technical policy; I still believe in it and I still believe it has not been fully implemented.

In sum it is my belief that "The Programme's the Thing" and that the mechanism which reveals it must be subservient to the art which creates it. To conclude from this that the policy so described does no more than demand realism in reproduction begs the question so long as the term realism is not defined. You do not have realism, as it sometimes is defined, when, for example, a single source of reproduction canalizes a widely diffused source of programme. A two-dimensional representation of a three dimensional subject, such as is seen in a painting cannot be said to demonstrate realism in one interpretation of the term. But the artist who knows his job knows how to make a virtue of necessity and uses the very limitations of a medium to make his art more realistic—in other words, to make the impact of his art upon the sensibilities of an audience more pronounced than realism, prosaically defined, could ever do.

Having said that the Programme is all important it might next be said, stressing the plural, that the Programmes are more so.

A hobby-horse cannot be ridden to death, since,

A notable group, the members of which conducted the first regular broadcasting service, from station 2MT, Writtle, some eighteen months before the B.B.C. was formed. Left to right, standing, B. N. MacLarty, the late H. L. Kirke, R. T. B. Wynn, H. J. Russell; seated, F. Bubb, N. Ashbridge, P. P. Eckersley, E. H. Trump and Miss B. Beeson.

lacking a rider, it is already dead. I shall now attempt, in a brief spell, to resuscitate my old nag. To do so demands an explanation why I believe that this stressing of the plural of Programme is so important. I was, I am and I believe I always will be convinced that the technical method by which broadcast programmes are distributed pays greater respect to the art it serves as, within reason, the number of different programmes it offers, simultaneously, for the individual's choice is the greater. This conviction determined me, after I had left the B.B.C. (1929), to do all I could to proselytize and develop rediffusion, i.e., schemes whereby programmes are distributed through wire networks rather than by radio. Need I stress the limitation of radio in being very spare of channels in the frequency bands available, while relatively the wire suffers no such restriction?

During the late twenties and early thirties the Post Office, the B.B.C. and the Radio Trade more or less openly opposed the development of rediffusion; in spite of so formidable a combination it grew, and when given a chance, goes on growing. This fact reaffirms an unshakable conviction that a majority want a reasonably wide choice between different kinds of clearly produced programmes.

This proposition might well have been denied when, in the early days, the passion for home-building radio receivers was at its height. Many of my readers must remember those delightful times when they would hear one of the cognoscenti boasting his home-built set and how he "received Zloik (station in Czechoslovakia, old man) on my Superwoppodyne; 'phones were lying on the kitchen table and I heard the station quite clearly, while I was upstairs changing my shirt." Well, "it was swell while it lasted"; it was that rarity a hobby that produced a full-scale manifestation. In contrast you built a model steam engine and the consummation was a smell of meths. and a jerky puffing concealed in a pale mist—how different from Zloik "clear as a bell and no fading, old man."

The hobby died, the public bought the superhet, the programme was the thing and this gave rediffusion its opportunity.

I cannot refrain from taking this opportunity to air a grievance. Briefly it is that when there actually was a means to prevent the extension of rediffusion the vested interests made full use of it. My friend and colleague Rupert Carpenter and I devised a system whereby four to six programmes could be sent through the electric mains to householders who, by the movement of a switch, could select any one of them. There happens to be an Act of Parliament, dated 1882, which forbids the electricity authorities to use their wires "for the purpose of sending a telegram." After a demonstration of the practicability of our method it seemed to certain vested interests and their Parliamentary sympathizers that this act was hardly less important than Habeas Corpus. And so, in the "land of opportunity" (see Press) we were forbidden to prove how right our opponents were when they said, as they did, that our scheme would not work and that if it did it would introduce a "dangerous new principle."

The issue requires little elaboration, the proposals we made about it, also about the wider implications of wire-broadcasting received either contemptuous dismissal by Government committees and commissions of enquiry or combative assertions about technical method; funds were even raised to oppose the passage of a bill through Parliament revoking the ancient statute; today, with the impact of television the issue about the method itself is dead but not, I trust, the implications of the story.

I shall not say much here about the more important phases in the development of sound broadcasting, its rejuvenation by v.h.f., the introduction of the "Third" (the most notable and admirable of the B.B.C.'s innovations), automatic monitoring, the overseas service and its intricacies of switching programmes, so admirably conceived and executed and, above all, television. I excuse this unbalance by remarking that it is all recorded elsewhere whereas in like degree heterodox opinion, which becomes me better, has not. I could not, however, even begin to excuse the dismissal of television and so, since it belongs more to Time Future than to Time Past I will have a good deal to say about in in my next and last article.

While I maintain that the most remarkable outcome of the invention of the valve is the broadcasting service, obviously parallel developments are nearly as important.

It was said in my first article that, broadly speaking, the first decade of the development of wireless proved it, as a means to link stations separated by world distances, a comparative failure. It was of course the valve that raised the status of wireless as a world communicator so that it became, under the aegis of private enterprise, a competitor with the under-sea intercontinental cable. In order that private enterprise should not become indecently enterprising the Establishment decided to synthesize thesis and antithesis and so brought the Public Utility "Cables and Wireless" into being.

The invention that brought about the merger was the Marconi beam system whereby it was proved that radio was capable of penetrating to distances of the order of π times the radius of the globe; a globe assumedly well wrapped in an ionized blanket. It was his ability to see the wood, without confusion of trees, that, just after the conclusion of the first war, made Marconi say, "Now that we have the valve why don't we try short waves again?" The sentence implies an appreciation of the signal-to-noise ratio; the higher the frequency of the signal the less the noise. On the other hand the shorter the wave the greater the overland attenuation. Before the aerial currents could be amplified, short-wave ranges were limited to very short distances; once the more feeble but less interrupted signals could be amplified the overall gain was, to say the most, fantastic.

I have never been able to find out whether and if so in what degree Marconi was driven to follow his hunch, so neatly stated, by the mass observation of amateurs; it is surely fitting to remember that these keen experimenters, driven away from the medium-wave gamut, did prove, by their skill and patience, that, on the lowest terms, an investigation of the commercial potentialities of short waves was well worth making. We may also note that the less imaginative authorities were still tied to lower frequency and higher power and still higher aerials.

In commending the beam system we should pay tribute to the genius of C. S. Franklin who designed the transmitters, aerials and receivers, and to T. L. Eckersley whose original work on the physical properties of the ionosphere made it possible to match optimum frequency with world paths and diurnal times.

I am drawn, in these concluding paragraphs to hover on the edge of prophecy; a giddy state and therefore exciting. Boldly stated, it is that point-to-point communication over ocean distances will eventually and as to the greater part be made by cable, while overland communication, as to a considerable part, will be consummated by radio. I stress ocean distances meaning communication where oceans get in the way; there is no need to define the term overland, it means over land. I stress also that it is point-to-point communication that is in question; obviously radio is the only viable method of communication for mobile services.

To expand this thesis we see already how the telephone and telegraph service between, in effect, Europe and North America has been improved by substituting cable for radio. We learn of plans to bridge the Pacific and link the Commonwealth by supplementing this ocean cable by another spanning the Indian Ocean. We know that when the transistor and its associated components become more reliable that great benefits will be conveyed to the ocean cables. We can foresee intercontinental television exchanges (which are almost impossibly expensive when relying upon a radio link) becoming an everyday occurrence when there are sufficient cables to carry them.

As to overland communication by radio there are in operation today many systems, the wave frequencies climbing into and above the four thousand megacycle landmark. Line-of-sight transmission, from hill-top to hill-top, invites shorter and shorter waves and as the systems develop and according to the nature of the terrain we may see them, as we do today in various parts of the world, supplanting the coaxial and multi-quad cables by means of which many hundreds of messages are sent simultaneously through the same link. There seems to be, at first blush, something of a paradox if radio, hitherto used as an ocean bridge, should give up its role in this respect and take on another where, superficially speaking, the physical conductor would seem the obvious link. For overland communication the paradoxical aspects may fade, as does radio, when it is seen that signalling by refracted and reflected waves has a hazardous aspect when compared with a conductor which guides the waves to their destinations.

It may seem as if this adumbration of possible future developments is outside the terms of reference of an article headed Time Past. But no! Time past has seen the wide use of radio for point-to-point communication over land as it has also seen the introduction of the telephone cable bridging the Atlantic; the facts are there; all that has been done, in a time future category, is to postulate the continuation of a tendency already manifest in Time Past.

But "Amarath an Amarath succeeds"; a new form of multi-electrode amplifier—the transistor—is already taking up the work begun by its forbear the thermionic valve.

I end as I began by stressing the importance of the invention of the valve without which the Time Future of telecommunication, which I hope to glance at in my next article, would not, in all probability, be worth writing about.

Television Society's Exhibition

AS in past years, the keynote of the Television Society's Exhibition, which opens at the Royal Hotel, Woburn Place, London, W.C.1, on March 3rd will be television research rather than domestic reception. The three-day exhibition opens at 11.30 on the first day and at noon on the following two days. The respective closing times are 8,0, 8.0 and 7.0. At the time of going to press the following had taken space at the exhibition:—

Avo	Hallam, Sleigh & Cheston
B.B.C.	Livingston Laboratories
B.R.E.M.A.	Mullard
Belling & Lee	C. H. Nokes
Bush	Standard Insulator Co.
British Communications & Electronics	20th Century Electronics
Chapman & Hall	N. E. B. Wolters
Cossor	John Ware
E.M.I. Electronics	Rank Cintel
Ever Ready	*Wireless World* and *Radio & Electronic Engineer*
G.E.C.	

Admission is by ticket obtainable free from the Society at 166 Shaftesbury Avenue, London, W.C.2.

LETTERS TO THE EDITOR

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

Stereophonic Records

HAVING just returned from a brief visit to America, where stereo rules the roost, I read your February Editorial with much interest. (Over there it is almost impossible to sell any new high-grade mono equipment, and the mere sight of a new mono record, however good, scares the pants off record dealers.)

Mr. Haddy, of the Decca Studios, has now convinced me by demonstration that the sound from disc stereo can be as good as the same recording heard direct from 15-in/sec tape, provided the pickup is of adequate quality. The stylus should maintain contact with the groove walls at a playing weight of 3-4 grammes, with no audible needle chatter with the ear three or four feet away. As the Decca pickup fulfils these requirements and is now available through the trade, and other good stereo models are being produced, my previous complaint about inaccessible high-quality units no longer holds.

This leaves us with the great question: How does the best stereo compare with the best single-channel recording? The idea to have direct comparison, put forward in your Editorial, is excellent and should also be applied to pickups. With the co-operation of E.M.I. and Decca we hope to do something on these lines at our Royal Festival Hall Demonstration on the 9th May. If really omni-directional speakers are used I feel sure that a worth-while comparison can be made, even in the R.F.H. The big idea is to play some original passage of music through the same amplifiers and speakers with three different types of input as follows:

(1) Single-channel record with high-quality mono pickup.

(2) Same as No. 1, but with the best available stereo pickup connected for mono output.

(3) Stereo record with same pickup as used for No. 2, but connected for two-channel output.

Even if we prove nothing, it should be good, clean fun.

Idle, Bradford. G. A. BRIGGS,
Wharfedale Wireless Works Ltd.

Stereophonic Sound

I SUGGEST that the mode of sound reproduction, commonly known as "stereo", will only prove technically satisfactory when some manufacturers realize that the "ting" of a cash register is not the only sound that requires reproducing.

Southampton. JULIAN GARDNER

Stereophonic Standards

ONE of the great dangers of a rapid advance in the commercial application of a scientific discovery is that of ill-conceived standards. We are now, for instance, reconsidering our television system, and have recently asked ourselves why we chose odd standards for tape speeds. Now that stereophonic sound is a commercial proposition, we ought surely to start considering very carefully the standards we are going to accept, such as loudspeaker spacing, cross-talk levels and so on. It would be interesting to hear, for example, why 6 feet has been chosen by some as a loudspeaker spacing. One can hardly imagine the most tolerant and adoring wife accepting two reflex cabinets or column radiators placed 6 feet apart in the living room or the lounge. Could we not have 12 feet? Practically every living room in the country must be very close to this dimension in either length or breadth. In this case they could be placed in two of the corners of the room, which should be more compatible with the domestic situation. It would be interesting, therefore, to hear the experts declare whether such an arrangement would be acceptable from a technical standpoint.

Sevenoaks. J. R. OGILVIE

Rigidity of L.S. Diaphragms

MR. BARLOW'S comment in the February issue on my letter intrigued me very much. I was very interested to find he had had similar results to mine—that a rigid (well, somewhat rigid) diaphragm didn't obey the rules. I have been brooding on this problem for some time and one or two thoughts occur to me.

In the matter of extended frequency response, as compared with a paper cone, there are two possible theories, but I wouldn't be prepared to say that either was a good one. Experimental proof is so very difficult. The more credible one seems to me to be this: it is common knowledge that liquids and solids conduct sound more efficiently than gases, and a hard solid is a better conductor than a soft one. One would not use a rolled-up newspaper as a car engine "stethoscope", but a metal rod behaves very well in locating the source of engine noises. I suggest that in a hard synthetic resin diaphragm there is good transmission of high frequencies from the cone apex throughout the main body of the diaphragm which results in a greater area for transferring the sound waves to the air, whereas with the customary felted paper cone this transmission does not occur owing to the (literally) absorbent nature of the material; hence the only part of the cone which does propagate the sound waves is the apex.

The alternative theory is that the hard cone material "rings" and produces spurious extreme treble which is not detected by rough-and-ready frequency response measurements but which might be detected (as was pointed out to me by Mr. Voigt) by applying the output of the measuring microphone to a sensitive oscilloscope. Unfortunately this test will not work with comparatively small inputs to the speaker since it is almost impossible to detect small departures from the sine wave on the 'scope.

This I can say: the old pre-war Hartley-Turner speaker had a phenolic resin cone, and its chief defect was excessive output in the 5 to 6 kc/s. region. When I thought I had finally solved the problem of a synthesized resin cone I found it did exactly the same thing. The top sounded wonderful, but it wasn't the real thing, and the effect was only removed when I modified the formulation to reduce the hardness of the resin and give it (to use an ad. man's phrase) "built-in damping."

This leads to a note on the matter of ordinary damp, which puzzles Mr. Barlow. The cones which were developed in the U.S. were designed to be as hard and stiff as possible. This involved using a very hard filler in the resin formulation. The filler *was* hygroscopic but I thought that perfect sealing off by the resin would make the cone waterproof, since the resin used was supposed to have negligible water absorption. Not a bit of it! I left the cones in a damp atmosphere for a month, and they turned limp. On heating them I could see steam coming off, and then the cones were hard again. I do not believe that any synthetic resin in comparatively thin films can reject moisture. The figures quoted by manufacturers are based on the immersion of quite thick pieces of resin and, in the case of polystyrene for example, I feel pretty certain that the figure of 2.8% quoted by Mr. Barlow is almost a "skin effect". If the major part of the resin used in the cone is a skin then the actual absorption would be quite a high percentage.

If so, then Mr. Barlow's thick sandwich is basically a very good idea, for he seals off the resin on both sides, and doubtless could seal the edges too. But the size/weight figures he gives should, I think, be improved if good treble response is to be maintained. He quotes 15 gm for a 7½-in disc; I stuck to a conical shape as being, in my opinion, the strongest shape, and I finally managed to get down to 11 gm for an 8½-in cone. A felted paper cone of the same size and shape comes out at 5-6 gm, and the resin cone had more real top than the paper one. But if I increased the weight I am sure that the "roll-off" would be fairly severe. One sample had a weight of 22 gm and had the same treble response as the paper cone, but, of course, far better bass.

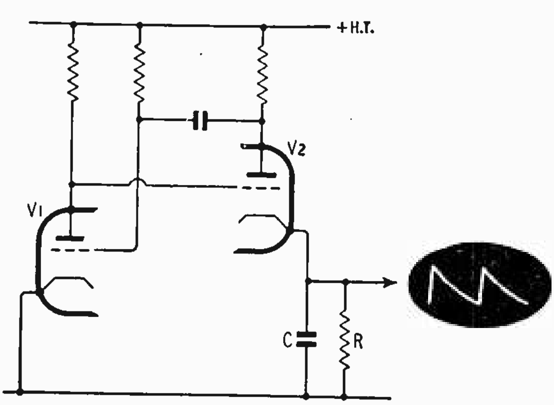
My work, and Mr. Barlow's, clearly indicates that, whilst we may feel pretty certain that felted paper's sole advantage is ease of production, change to another material which denies accepted design dogma involves basic research which is not very easy to carry out. There are so many possible permutations and combinations of materials.

Exton, Southampton. H. A. HARTLEY.

Miller Sweep Circuit

THE Miller sweep circuit described by C. S. Speight in your January issue was first developed some three years ago by J. D. Julian and myself. It may be of interest that the original object was to improve by Miller feedback, the linearity of saw-tooth obtained from the multivibrator with its excellent synchronizing properties.

The multivibrator circuit employed is shown in the accompanying diagram, and is due to H. E. Anthony*.



The timing capacitor C is in the cathode circuit of V2. Because of the low impedance of V2, C will charge rapidly when V2 grid is switched "on" by the multivibrator action. During the period when V2 grid is "off," no current will flow through V2 and C will discharge logarithmically through R. The essential feature of the improved circuit is the substitution for R of a Miller valve.

The circuit is capable of producing more than 200 volts of almost perfectly linear saw-tooth with 350 volts h.t. supply. This can be maintained, with careful design, up to 500 kc/s sweep recurrence. The sweep amplitude can be easily stabilized, permitting accurate time calibration; in addition all the advantages of easy synchronization are retained.

It is not clear why Mr. Speight refers to the circuit as combining the Miller and Puckle circuits, as surely the essential ingredient of Puckle's timebase is the use of a constant-current pentode as a linear charging device. With the Miller-Multivibrator, as I prefer to designate it, it is the run-down which is linear. The constant-current anode characteristic of the pentode is not employed at all.

Bournemouth. L. FREEMAN, Waveforms, Ltd.

The author replies:

A timebase is generally referred to by a name which suggests either a special method of generating a linear sweep (e.g., Miller bootstrap) or a special method of recharging the sweep capacitor (e.g., thyratron, grid-diode). In my view, the Puckle circuit is essentially a recharging device, in which a hard valve trigger circuit replaces the obsolete thyratron circuit.

F. J. M. Farley* describes the Puckle timebase with a resistor in place of the more usual constant-current pentode, and the arrangement then resembles that to which Mr. Freeman refers.

It is worth noting here that the factors influencing the operation of the Puckle circuit are quite different from those of the standard multivibrator and the only real similarity between the two circuits is in the method of applying positive feedback.

In reply to the letter of Mr. J. D. Julian, published in the February issue, I should like to make the following comments.

Apparently, Mr. Julian has overlooked the main difficulty, encountered in combining the Miller and Puckle circuits, which is to ensure that the current drawn by the Miller valve during flyback does not subtract substantially from the recharging current.

The situation is aggravated by the feedback action of the sweep capacitor tending to drive the Miller valve into heavy conduction. Ideally, this valve should be cut off, during flyback, but in practice it is more convenient to limit the anode current to a fraction of the recharge current. In my circuit D1 and R_8 perform this function, and Mr. Julian is incorrect in saying: "D1, it will be appreciated, is not essential to the operation of the circuit and in the interests of economy can well be left out, together with R_8." This statement appears to be based on the assumption that these components serve merely to protect the valve against overload. I would suggest that equivalent components might be inserted into the circuit proposed by Mr. Julian, for, as the circuit stands, it is difficult to see how the sweep capacitor can recharge at all.

I cannot agree that synchronization and triggering efficiency can be improved by applying the pulses concerned to V3 cathode. Synchronization is most effective when it is applied to the initiation of the flyback, rather than to the initiation of the sweep, particularly when the ratio of sweep to flyback periods is as high as that of the circuit described. Another point in favour of the original method of sync. injection was mentioned in the article, and this arises from the action of V2(b) in amplifying the sync. pulses before they become effective.

The statement of Mr. Julian concerning capacitive loading of V2 is irrelevant. The resistor R_1 is introduced to avoid this effect in the free-running circuit, whilst the diode D2 performs a similar function in the triggered version. The diode will cut off, should the rate of rise of voltage at V2(a) anode exceed that at the trigger input, thus isolating this point from stray capacity at the input. When the trigger pulse has a fast rising front, this will be transmitted through D2, contributing directly to the c.r.t. "bright-up" pulse.

Automatic "gate-out" of negative pulses arriving during the run-down is achieved by means of D2, whilst the grid-cathode diode of V2(b) reduces the amplitude of positive pulses to negligible proportions.

The term "initial fast region" was used deliberately

* *Electronics*, Vol. 29, No. 2, p. 186 (Feb. 1956).

* "Elements of Pulse Circuits," by F. J. M. Farley (Methuen).

to suggest the effect of the Miller step on the c.r.t. display. I can see no point in trying to connect this indeterminate arithmetical error with the formal definition of non-linearity. I agree, however, that more should have been said about the Miller step, especially concerning its dependence on sweep speed.

The advantages of the circuit, which I overlooked, unfortunately do not include: "Constant amplitude of run-down, unaffected by sync." As was originally pointed out, the lower limit of sweep depends on the anode voltage of V2(b) during run-down, and this will vary with sync. amplitude.

Mr. Julian states that I overlooked mentioning "the superior triggering or synchronizing ability" of my circuit. It would, therefore, seem that the circuit performs satisfactorily in this respect and no modification is required. This is, in fact, the case.

It would be interesting to compare the commercial circuits referred to by Mr. Julian, with that which I submitted. The fact that these have some properties in common confirms my original opinion, that a timebase can be devised, which is no more complex than the standard Puckle circuit, yet compares with those presently available in commercial equipment.

It was thought that a description of such a circuit might be of interest to readers, but I must apologise to anyone who has been concerned with this type of circuit for not acknowledging the work done in this field.

Southend-on-Sea. C. S. SPEIGHT.

Printed Circuits

IN his reply to my letter (January issue) on printed circuits Mr. W. I. Flack accurately states the case from the manufacturers' point of view, and in so doing confirms my contention that most set makers are very much out of touch with conditions prevailing in the dealers. service department. Regarding his doubt as to a 24-hour service, I can assure him that although I do not regard our service department as being in anyway exceptional, the majority of our repairs are completed within 24 hours. Indeed, on the day that my *Wireless World* arrived and I read Mr. Flack's letter I looked at our job book and found that three TVs reported faulty in the morning had been collected, repaired and returned to the owners by 6 p.m. It will no doubt surprise Mr. Flack and other manufacturers to know that this is the sort of service which the customer expects and which I think he is entitled to receive. On the rare occasions when we have had to return a receiver to the makers for repair we never see it again for at least ten days. I am afraid most manufacturers do not know the meaning of the word "service".

Contrary to popular belief the average dealer's workshop does not consist of several fully qualified and white-coated engineers surrounded with wobbulators and signal generators, busily aligning i.f. strips and making expert repairs to printed circuit panels. If it did, Mr. Flack would be quite right. It would take just as long to repair a "steam wired" set as a printed circuit set. After 30 years' experience I have found that the most efficient dealer service should be run by a few "Old Hands" with the necessary "know-how" and experience to diagnose faults quickly and accurately, (generally aided by nothing more complicated than a valve voltmeter). The faulty set is then passed to a less experienced engineer who executes the necessary repair. Under these conditions the "steam-wired" receiver wins hands down for accessibility and general speed of service.

Is Mr. Flack really serious when he suggests that dealers should stock a complete set of printed circuits for every receiver on the market? At the present rate of progress most units would be obsolete within a year. A good idea from the manufacturers' point of view but as a dealer I will not trust myself to say more on the subject.

I am sure Mr. Flack will agree that when we reach the heart of the matter in this controversy, it doesn't really matter what he, as a manufacturer, or I, as a dealer, prefer. It is the customer that counts, and if he wants his faulty TV back in time to see "Emergency Ward 10" or the Cup Final, there's not much doubt which sort of service he would prefer!

In my original letter I did not question the reliability of the printed circuit, but since Mr. Flack has raised the issue by stating that they are superior in this respect I should like to point out that it is rather early days for such an assumption. I may be wrong but it occurs to me that when some of these printed-circuit receivers have been in use for five or six years, possibly under conditions of extreme condensation, etc., they may not be looking to well. Perhaps we shall then find that—as in the case of push buttons, black screens, plastic c.r.t. masks, etc.,—all new ideas are not necessarily good ideas.

It is unfortunately true that more and more manufacturers are falling for printed circuits but I think that the few who are sticking to their "steam-wired" designs will reap the benefit of bigger sales in the long run. I have found generally that sets that appeal to the service department are good sellers and *vice-versa*, but only time will tell!

London, N.W.6. A. G. TUCKER.

YOUR correspondent, Mr. Flack (February issue), in defence of printed wiring (quite distinct from printed circuits) advances the argument that his technicians employed on production test, like, or even prefer, to work on these panels as against conventionally constructed chassis.

I should like to enquire if Mr. Flack would prefer to fault-find in an unfamiliar conventional chassis where all sleeving is of the same colour, or in one which employed the recognized sensible variety of coloured wiring? Since printed wiring falls into the first category, he would appear to prefer the former.

The second disadvantage is, that since wiring and components are on opposite sides of the printed panel, the eyes are required to move constantly from one side to the other, resulting in both eye and mental fatigue.

Thirdly, looking at the component side, this holds a disjointed array of resistors and capacitors fixed apparently at random and one is unable to see the interconnections. This is not the case with a well-designed conventional assembly.

Fourthly, the experienced and skilled technician is used to looking at valveholders and coils from below, and by seeing all the wiring attached to these components in a well-defined and logical sequence, he makes his measurements without hesitation, just as Mr. Flack would, no doubt, unhesitatingly spell out the word Czechoslovakia. He suggests, however, that it is just as easy, or even easier, to spell the name of that country backwards.

I am well aware that to print and to read in the fashion we, in fact, do is merely an acquired habit. But I hope Mr. Flack will agree with me that it would not be a particularly good idea to print alternate words on the front and back of pages. It would take longer to read and be more strenuous if this method were, in fact, adopted. Although sooner or later one would, of course, get used to it and live with it.

To say, therefore, that printed wiring offers any advantage other than perhaps to reduce the manufacturing costs is grossly misleading. Its general adoption will certainly increase maintenance and repair costs. On balance, therefore, the set owners will not gain, but the engineers' span of life is certain to become shorter.

London, N.W.6. E. KISCH

MR. W. FLACK'S remarks in last month's issue are not altogether complimentary to service engineers in general. He states that the apparent dislike engineers have for printed circuits is because servicing of such equipment calls for a good deal more care and technical skill, whereas with conventional wired circuits, hit-and-miss methods are the order of the day. Anyone who has had experience in servicing printed circuitry is fully aware of the care necessary in handling it, and has, no doubt, discovered that the application of a soldering iron can wreak havoc if not handled very carefully. If this means technical skill as interpreted by Mr. Flack, all good and well. But he goes on to say that there is less room for hit-and-miss methods in servicing printed circuitry than in conventional wiring circuits. I can only assume that this statement applies to "pirates" and the like, who are, unfortunately, to be found in every trade or profession. With a thorough knowledge of basic theory, combined with a logical approach, servicing of both types of circuits should not present undue hazards.

A final point on the cost factor of the printed versus wiring circuits. If the former is supposed to be much cheaper to manufacture, to whom has the saving been passed?

Sevenoaks. A. W. WESLEY-COLLINS

What Makes Currents Flow?

"CATHODE RAY'S" article in the January issue concerning the causes of current flow led me to read the monograph by P. Hammond to which he refers, and I am prompted to make one or two general comments on the subject.

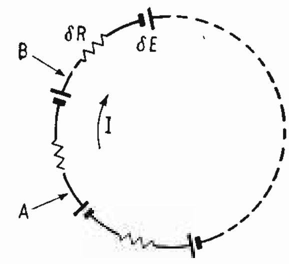
First, let me say that I support Hammond in his view that the current in a simple battery and resistance circuit is caused by charge distributions, whilst agreeing with "Cathode Ray" that the prime cause may be chemical action or even the act of assembling the battery. The term e.m.f. is one which we employ to describe one manifestation of a particularly complex process of electro-chemical action, charge distribution and charge motion, just as we use the term electric field to conceal our ignorance of the true laws of force between charges.

If a straight conductor is positioned between two terminals having a potential difference but without connecting to them, the charges in the conductor must redistribute themselves until the resultant electric field is everywhere zero; but one might hesitate before committing oneself to saying just what form this redistribution will take. For instance, since the applied field is apparently being set up by two equal and opposite concentrations of charge at the terminals, one suitable charge configuration in the conductor should be with similar but opposite concentrations at its very ends. Is this the only suitable configuration or are there others; and if there are which one is correct?

The answers to these questions are by no means obvious, even in this straightforward case of a straight conductor carrying no current, but if current is permitted to flow by connecting the conductor to the terminals and the conductor is no longer assumed straight the problem is complex indeed and I do not pretend to know the correct solution.

"Cathode Ray's" trump card, the closed ring surrounding a varying magnetic flux is, however, fairly easy to explain, at least in terms of the concepts of induced e.m.f. and lumped resistance. The effect of transformer induction, of which this is an example, is basically due, as E. G. Cullwick* points out, to the fact that charges in motion (namely those charges which constitute the current system setting up the magnetic flux) exert forces on stationary charges as a result of this motion. These forces, of whose true nature we are quite ignorant, may be regarded as producing an electric field in the closed ring and this, over a finite length of ring, is equivalent to an e.m.f. tending to drive current through the resistance of the ring.

However, this e.m.f. must not be regarded as concentrated at one point in the circumference of the ring but, like the resistance, as uniformly distributed around it. The figure shows an equivalent circuit containing, say n sections each comprising a small e.m.f. δE in series with a small resistance δR. The current will be $I = n E / n\delta R = \delta E/\delta R$ and the voltage drop from A to B is $I\delta R - \delta E = 0$ and similarly between any two such points of the circumference. If one imagines δE and δR reduced to infinitesimal proportions the reason why no voltage drop can be measured around the ring is at once apparent.



This manner of explanation should satisfy those who prefer to tackle this kind of problem in terms of lumped parameters, but I do not claim that it will bear close inspection from the viewpoint of charge distributions and electric fields. In general it is obviously futile to try to explain fundamental mechanisms in terms of those very concepts which have been adopted purposely to avoid *having* to explain them.

Cranfield. G. H. STEARMAN.

* "The Fundamentals of Electromagnetism", (Cambridge Univ. Press), page 87.

The author replies:

The essential words in Mr. Stearman's letter are presumably "in a simple battery and resistance circuit." For having voted in favour of the view that in such a circuit the current is caused by charge redistribution, he refers to examples of (1) a charge redistribution with no current, and (2) a current with no charge redistribution.

As if this were not enough to underline my doubts about regarding charge redistribution and current as cause and effect, he goes on to emphasize how difficult it is to calculate the charge redistribution in (1) and how easy it is to handle (2)* on the conventional e.m.f. basis.

So he encourages me to go farther than I did in the January issue, by saying that if charge redistribution were to be substituted for e.m.f. as the cause of electric currents it would transform electrical technology into an unteachable mystery.

"CATHODE RAY."

* We are both taking for granted that on this level of electrical engineering we don't venture into atomic physics.

Licence Reminders

IN his letter published in the December issue, Mr. W. R. Gregory complained that he was unable to renew his wireless licence the day before it expired on 31st August because he could not produce a reminder notice.

I should like to assure Mr. Gregory that there is no question of the issue of a renewal licence being conditional on the production of the relative reminder notice and there is no reason why he should not have been allowed to renew his licence a day in advance as he wished. I can only assume that the counter clerk who refused to issue a licence was acting under a misunderstanding and I must apologise on behalf of the Post Office for the inconvenience caused.

London, E.C.1. T. A. O'BRIEN,
Public Relations Officer,
General Post Office.

Transistor Tape Pre-Amplifier

IN Mr. Ridler's article in the December, 1958, issue he chooses the inductance-resistance integrator in preference to the resistance-capacitance integrator as a means of providing the bass-lift for a tape pre-amplifier. He makes this decision on the ground that a high input impedance implies high thermal noise. This is not correct, since the input is shunted by the source which is an inductance and,

(*Continued on page* 125)

in so far as it is pure, no thermal noise exists in it. The argument based on electrostatic pick-up also falls down for the same reason.

This would not matter if the alternative chosen by Mr. Ridler were as good, but this unfortunately is not the case. Even with a perfect integrating amplifier, the resistance included in the source limits the bass correction severely at the frequency at which the Q of the head falls to unity. Taking the ½-henry head in the article and associating it with the probable value of 400 ohms d.c. resistance, the frequency of 3dB loss is 127 c/s and the loss at 50 c/s is over 11 dB. It was this consideration which caused me to reject it as a practical possibility, when considering the problem in 1957. It does not help if the amplifier is inexpensive if the heads have to be of enormously high Q to operate it; the high impedance alternative is more complex, but at least it will work with any head up to an inductance of say one henry, without the risk of leaking electrolytics polarizing the head and, with exact corrections independent of the Q.

The explanation of the failure of Mr. Ridler's curves to show the real loss is that the test tape does not have continuous gliding tone and the number of fixed points is too low to draw conclusions from. The fact that the inevitable rippling in the head's response in the bass region due to the outer gap effect is also not shown must be due to the same cause. The curves for the amplifier and head inductance can be obtained by using, as a signal source, a constant current into a mutual inductance, say one milli henry, and injecting this in series with the head. The added inductance is small compared with the inductance of the head itself and has no effect on the response curve, which should now be flat up to the chosen turnover frequency. In this way it is much easier to see the departure from the strict law, than if a constant voltage input is used.

My second point concerns the bias loop circuit to which Mr. Ridler draws attention in his reference 3. (*E.R.E.*, May, 1957, p. 161) and the essential distinction between that circuit and Mr. Ridler's Fig. 4. In this there is no d.c. resistance included in the first emitter circuit. The omission of this resistance results in an entirely different mode of operation. In this mode the current in the second transistor depends on the base-emitter drop of the first transistor and on the base current of the first transistor, which in turn depends on the alpha gain of the first transistor. As the base-emitter drop of the first transistor is scarcely affected by the battery voltage, there is no term which relates the current in the second transistor to that voltage and the circuit of his Fig. 4 fails when the battery voltage falls since the collector of the second transistor can bottom. In the circuit described in ref. 3 the current in both transistors is practically independent of the base-emitter drops and of the base currents, and is a function of the product of some fixed ratios and the battery voltage. This is due to the swamping of the relatively small collector-emitter voltage of the first transistor, by the drop in the emitter resistance, which may be ten or fifty times as great, and thus will determine the base potential of the second transistor with great precision.

Mr. Ridler is fully justified in claiming the low noise output of his amplifier and it is a pity that such an elegant solution as his Fig. 4 would have been, cannot form the basis of a tape characteristic corrector of the highest class.

London, N.W.2. J. SOMERSET MURRAY

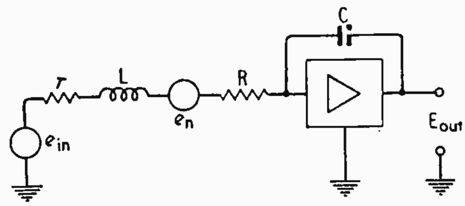
The author replies:

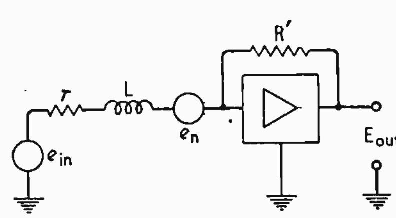
I am afraid that I must still hold to my original contention that the thermal noise in the L-R integrator is lower than in the R-C circuit. The basic equations for the two types are

$$E_{out} = -\frac{1}{RC}\int e_{in}\,dt \qquad \text{(RC)}$$

$$E_{out} = -\frac{L}{R^1}\int e_{in}\,dt \qquad \text{(LR)}$$

and assuming that the circuits are so adjusted that each gives the same gain at a particular frequency, they will have identical signal performances. However, considering the input circuits





the equivalent noise voltage

in the R-C case is $e_n = \sqrt{4kT\Delta f(R + r)}$

and

in the L-R case $e_n = \sqrt{4kT\Delta f r}$

neglecting in each case the input impedance of the amplifier, which will be very low due to feedback. As R must be larger than the reactance of L at the highest frequency, then the ratio of the signal to noise ratios from this cause will be nearly $\sqrt{R/r}$.

There is also a much more serious effect. Unless the first transistor is fed from nearly the optimum source resistance, the semiconductor noise will be far in excess of the thermal noise in the source resistance. With the R-C circuit, the first transistor sees a resistance R in parallel with a capacitor GC, where G is the gain of the amplifier. The resistive component of this will be much greater than optimum at low frequencies, but improve at higher frequencies. In the L-R case the transistor sees the impedance of the head in parallel with a resistance R′G. This is much lower than the optimum at low frequencies and tends to the correct value at high frequencies. Probably both circuits are equally good in this respect. I am presently engaged in a detailed analysis of the problem.

I see that I have committed a grievous error in not giving particulars of the tape head used, as this has led J. S. M. to a false conclusion. The head is one from a Collaro Tape Transcriptor and has a d.c. resistance of 50 ohms; this, of course, gives an equalization loss of − 3dB at 16 c/s. Low-frequency variations in output were observed, but were neglected in the curves as they tended to obscure the main issue in an elementary treatment. I am most grateful to J. S. M. for pointing out the technique of injecting an e.m.f. *via* a mutual inductance, as this does simplify measurements considerably.

With regard to J. S. M.'s second point, I am afraid that I do not have a copy of his paper on hand as our copy here has gone to the binder, but I am sure that what he says is correct. However, the circuit as described has been functioning for fifteen months, and two versions have been tried using transistors of different characteristics but all other components the same. The range of ambient temperature here is extreme; winter minimum is about 50°F and summer maximum about 110° in the house. Another 15° could probably be added for the additional rise inside the apparatus cabinet. The same batteries have been used over this period. The drain is only 1.5mA but due to the heat the voltage has fallen from12V to 8.5V without noticeably affecting the results as judged audibly through a high-quality loudspeaker system. I think that although I have apparently misused J. S. M.'s circuit the results are satisfactory.

Khartoum, Sudan. PHILIP F. RIDLER.

Physical Society's Exhibition

NEW TECHNIQUES IN ELECTRONICS AND MEASUREMENT

A SLIGHT but nevertheless welcome reversion to its old character was noticed in this year's Physical Society's Exhibition. More of the exhibits seemed to be devoted to the results of research and fewer to the "bread-and-butter" sort of developments. Indeed some techniques were openly admitted to be quite impractical and were only shown because of their interest value. Unfortunately this trend was also accompanied by one of the old troubles of the earlier exhibitions—lack of space between the stands for visitors to circulate freely and see things in comfort (either that, or too many tickets were issued). There is a great need for improvement here. In the following pages we have made a selection of items which we think will be of particular interest to our readers.

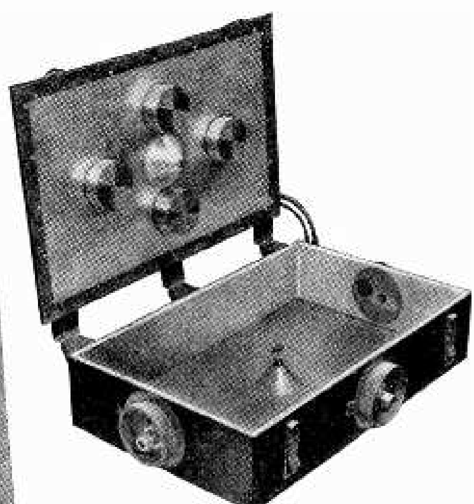
MASERS rely for their operation on the release of energy stored in molecules elevated to a higher-than-normal energy level. In the three-level paramagnetic maser, shown by the Royal Radar Establishment, molecules of a paramagnetic substance placed in a magnetic field are elevated from the first energy state to the third by the absorption of a locally generated "pump" signal (which is higher in frequency than the signal input).

The energized molecules return naturally to the first level in a time known as the relaxation time. The random emission of the corresponding frequency is not wanted and, as the relaxation time falls rapidly with increasing temperature, the maser cavity and crystal must be kept very cool: this is achieved by boiling-off a liquefied gas round the cavity.

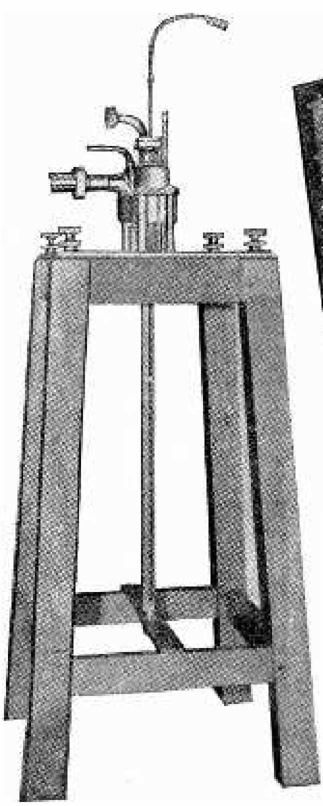
A 3-cm signal is applied to the resonant cavity (which has modes at both signal and pump frequencies) via a coaxial cable. The incoming signal "triggers-off" the relaxation process in proportion to its strength, molecules returning to a lower state and emitting radiation at the signal frequency. The amplified signal is carried back up the coaxial cable and separated from the incoming signal by a directional coupler.

Originally, masers were operated at liquid helium temperatures—in the region of 1.5°K. However, recent work at R.R.E. has established that the rate of decrease of relaxation time with increase of temperature is much smaller for ruby than for some of the other substances used and practical masers operating at about 60°K have been produced. This has the enormous advantage that these temperatures can be reached by boiling-off liquid oxygen which is far more readily available and much cheaper than helium. A large step along the path towards making the solid-state maser a practical device has thus been taken, and already useful gains together with usable bandwidths have been achieved at both 10 and 3 cm.

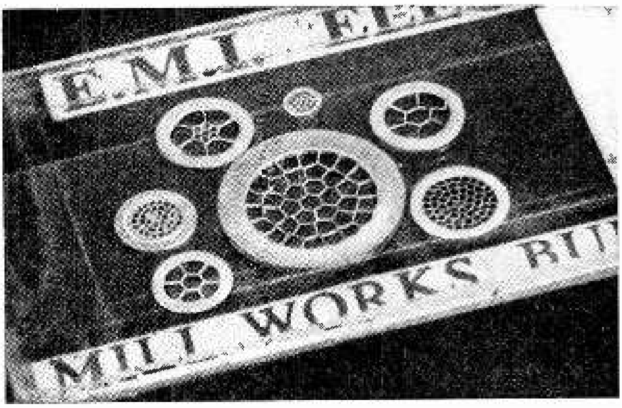
Instead of using a pump signal to elevate the energy state of molecules, the ammonia maser (built by Glass Developments, Ltd, for the Signals Research and Development Establishment, Christchurch) sorts, so to speak, the sheep from the goats by means of an electrostatic field. In this device a "jet" of ammonia gas (about 2 c.c. per day!) enters a vertical "tunnel" formed by eight wires alternately at earth potential and 20kV. This strong non-uniform field affects the molecules having a low energy far more than those in a higher state: these latter pass down the tunnel and into a cavity resonant at the frequency corresponding to the radiation emitted when they drop back to the lower state (about 23.87013 kMc/s). The "goats," or low energy molecules, are deflected



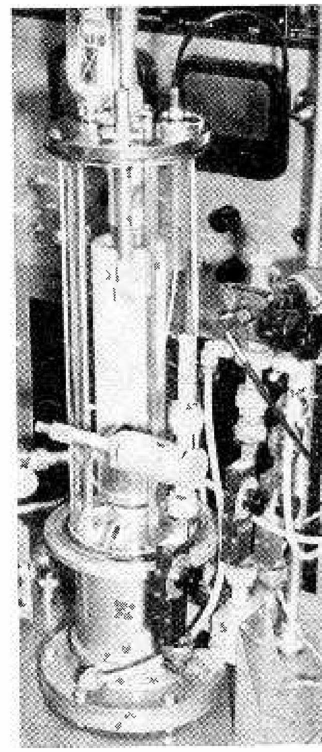
Above: S.E.R.L. parametric amplifier. Silicon diode is in centre of cavity (shown open) on polystyrene insulator. Pump and signal power is introduced via probes seen in side walls of cavity.



Left: Three-level paramagnetic maser assembly for insertion in cryostat. Cavity containing maser crystal is located at bottom of pump waveguide and signal cable (both enter at top): pipes at top are used for cooling. (Royal Radar Establishment).



Klystron grids made by E.M.I. process mounted on microscope slide. Note very small area of grid presented normal to electron beam.



Glass Development's ammonia maser. Resonant cavity is in base, wire "tunnel" forming non-uniform electrostatic field for molecule separation is inside cylinder.

by the electrostatic field and are condensed on a cylinder which is cooled by liquid nitrogen and encloses the wires.

This maser is inherently a narrow-band device and is likely to have greater application as a frequency standard of extremely high purity and stability (possibly 1 part in 10^{10}) than as an amplifier. How narrow this bandwidth is can be judged from the fact that the cavity was machined to within 1/10 "thou" and then its temperature was controlled to about $\pm 2°$C, adjustment of this being used for fine tuning.

Parametric Amplifiers offer, like masers, some very attractive features; but they are likely to be of use at rather lower frequencies, probably in the region where specialized microwave valves take over from the conventional types. It can be shown that if the tuning of a circuit (i.e. one of the parameters L or C) is altered at twice the frequency to which the circuit is tuned (again this is called "pumping") the circuit will exhibit negative resistance provided that the relative phase of signal and pump frequency is correct. This is an onerous requirement so the signal is placed deliberately off-frequency by a small amount: the device will amplify and attenuate alternately as the phase relationship varies, so that the amplified output obtained is modulated at the frequency corresponding to the beat between twice the signal frequency and the pump frequency. Sometimes it is necessary to add a third tuned circuit (known as the "idler") resonant to this; but the Q of the signal frequency circuit may be low enough to include this frequency within its pass-band. This type of amplifier is known as a three-frequency amplifier and it can exhibit a useful bandwidth. As the amplified output depends upon the power supplied by the pump circuit, increasing the pump power increases the gain—eventually oscillation results.

In the three-frequency amplifier shown by the Services Electronics Research Laboratory, Baldock, the parameter varied was "C"—the variable element comprised a small, back-biased, silicon junction diode mounted in the centre of a cavity resonant (in different modes) to pump (1500 Mc/s), idler (972 Mc/s) and signal (528 Mc/s) frequencies. The pump power applied was about 80mW: this realised a gain of 30dB and a bandwidth of 2.5Mc/s, and 25 to 30dB was quoted as being the maximum usable gain at the present stage of development, as stability is difficult to maintain at higher gains.

Microwave Valves. — Broad-band voltage-tuned O-type backward-wave/oscillators—that is oscillators in which the electrons interact with an r.f. wave travelling with a similar velocity but in the opposite direction, and in which a magnetic field is used only for focusing the electron beam—are now available from several manufacturers. Two shown by Standard Telephones and Cables obtain suitable r.f. waves travelling much slower than in free space by using a set of interlinking hairpins as a slow-wave structure rather than the more usual interdigital line. The hairpin line has the higher impedance, and this, as well as the fact that the electron beam can completely interlink its open structure, makes the interaction considerably more efficient.

Klystron Grids have in the past been made from round wires formed into a mesh: this provides a poor hole-to-wire-ratio and reduces efficiency. E.M.I. Electronics, Ltd had on show some klystron grids made by a process which gives an extremely thin section to parts of the grid at right-angles to the electron beam. Aluminium wires are given a thin coating of copper and packed into a copper tube which is then sintered to join all the copper coatings together and to the tube. The whole is "sliced" and the aluminium dissolved out, leaving a grid with very thin "inter-cell" walls.

Microwave Components.—A four-way switch shown by the G.E.C. Research Laboratories used a gaseous discharge plasma initiated by short d.c. pulses to bridge the gaps between the inners of the input and alternative output coaxial lines. R.f. propagation is sustained for several hundred microseconds until the free electron density in the discharge decays below a certain critical value dependent on the transmitted frequency. The rate of decay of the electron density can be varied by changing the gas material and pressure, and its initial value changed by altering the input pulse power. Since the electrons rapidly lose their energy to the positive ions and neutral atoms little noise is produced. This type of switch has been found to be usable from 600 to 4,000Mc/s.

Propagation Test Equipment.—Elliott Brothers (London), Ltd were showing propagation test equipment (which could also be used as a 24-channel telephone or multi-channel data link with a minimum of modification) for the 7.5kMc/s band. This equipment comprises a self-contained transmitter and receiver unit fitted in a cylindrical, weather-proof trunnion-mounted case with the aerial "dish" mounted at one end, the feeder and radiator (Cutler-type twin-slotted cavity) projecting through the end of the cylinder into the middle of the dish. One unusual feature is that the same klystron (1.2W output) is used for transmission and reception, the signals received being separated from the transmission by a wide-band ferrite isolator with a 46dB "reverse" loss. This, of course, necessitates that the incoming signals (from a similar unit) are frequency-displaced by the i.f. (70Mc/s) and automatically ensures that the remote unit is tuned to the transmission from the other. To avoid any chance of adjacent-channel interference a filter (rejection 50dB) consisting of three tunable cavities in the H_{011}, $\gamma/4$ and H_{012} modes is fitted between the balanced mixer and isolator. The whole unit can be tracked in azimuth, elevation and height from a remote point and a full complement of test equipment is built into the waveguide assembly, direct readings of received and transmitted power, etc., being obtained with a display unit fed from the balanced mixer and a thermistor fitted in the waveguide.

Filter Crystals often exhibit undesired modes outside the required response. This makes it difficult to secure satisfactory rejection over a wide band, typical responses for crystal filters having points outside the passband where rejection falls to only about 17dB. Some results of work on this problem at the G.E.C. Research Laboratories were on show, the improved crystals having out-of-band peaks about 25dB down on the main response and of negligibly small amplitude compared with the rest of the out-of-band response. This is achieved by restricting oscillation of the crystal to the main mode by bevelling the edges and using only small-area contacts. Satisfactory results in crystals for frequencies between 1 and 10Mc/s have been produced by this procedure.

Micro-measurement Technique.—The measurement with an accuracy of $\pm 1\%$ of a change of 1.0×10^{-7}cm seems formidable enough without making the operation far more difficult by having to do it at temperatures near absolute zero; but this is the problem presented by the measurement of coefficients of expansion of small samples at liquid helium temperatures. An apparatus for doing this has been developed at the Royal Radar Establishment and was shown on the Ministry of Supply stand.

The sample (about 1cm long) and a reference are placed in a brass "pot", so that both the sample and the reference each produce a capacitance of the order of 10pF to a common electrode mounted on the top plate. A bifilar-wound transformer secondary and these capacitances make up a bridge circuit and the energizing supply (derived from a 100kc/s transistor oscillator) develops about 40V across the bifilar winding. The balance detector (a transistor amplifier feeding headphones or a visual indicator) is connected to the common plate of the capacitors and the bridge is balanced by introducing a further signal, which is adjustable in amplitude and phase, to the centre tap of the transformer. By itself, the sensitivity of the bridge to a small unbalance condition is hardly sufficient—to improve this a high-Q coil tuned to 100kc/s is connected across the output to the null detector. When the temperature has been changed by a small amount, say 1°C, and the bridge has been rebalanced, the relative coefficient of expansion of the reference and sample is obtained.

The sensitivity is such that light pressure applied from a pencil on the top plate of the "pot" causes a large unbalance indication due to distortion of the half-inch-thick pot walls; likewise the expansion caused by breathing momentarily on the pot whilst it is at room temperature gives a clear out-of-balance indication.

Bridges.—A small (1-inch) c.r.t. indicates the phase and amplitude balance in the Cossor LCR bridge Model 1446. The 2-kc/s input signal is fed to the X-plates and the error signal from the Wheatstone bridge to the Y-plates via a high-gain differential amplifier. Balance is thus indicated when the trace is a horizontal straight line. Resistance is measured using d.c. (central spot for balance) so that the resistance of an inductor can be determined.

Impedance comparators containing two resistive arms of a bridge and a high-gain amplifier feeding a detector were shown by Griffin & George and Dawe. In the Dawe Type 304 an internal 1,000-c/s oscillator is provided, and both phases and amplitudes can be compared on a meter. In the compact Griffin & George "Panmetron" the a.c. input is derived from the mains, and a rectangular tuning indicator shows balance at maximum shadow.

Wayne Kerr showed that transformer bridges can be wound with sufficient accuracy to make absolute measurements accurate to within 0.01% and comparisons to within 0.001%. The impedance looking into this type of bridge can be made less than 10^{-5} of the impedance to be measured. As the velocity of light is now known to better than 1 part in 10^6 and linear dimensions can be measured to a similar order of accuracy, a standard capacitance of about 10pF can easily be constructed to an accuracy of 0.01%. Other standards of different sizes can then be obtained using such accurate transformers.

The Griffin-Raleigh Elution Bridge (Griffin and George) is notable for its extreme simplicity of operation. This bridge, used for determination of the end of a washing operation to remove ionically-dissociated solutions, consists of two conductivity cells connected in a Wheatstone bridge circuit and a transistor-amplified balance detector. The influent runs through one cell and the effluent through the other, the bridge being balanced initially in the absence of the material to be washed. This procedure eliminates errors due to temperature, carbon-dioxide absorption and cell differences. When the material is introduced the conductivity of the effluent cell increases, so unbalancing the bridge which returns to balance when the concentration of ionized material in the effluent has fallen to the value that it had when the bridge was first balanced. As one of the conductivity cells is a standard the bridge can be used also for the direct calibration of other cells and for the determination of the resistivity of solutions. It is mains operated and low-voltage a.c. is used to energize the bridge circuit.

Digital Meters.—A sufficient number of these were already on show last year to illustrate most of the common general methods in use (see *Wireless World*, May 1958, p. 222). One simple new system was seen this year however in the Nash and Thompson prototype digital ohmmeter. Here measurements are made using an a.c. bridge whose off-balance

(*Continued on page* 129)

voltage is amplified and used to drive a 2-phase motor. The motor drives a helical potentiometer forming one arm of the bridge. As the bridge passes through balance, 180° phase shift occurs in the off-balance output and the motor reverses and comes to rest. The time taken to travel the full 3 decades of the motor driven counter is approximately 10 seconds, and the input impedance is about 1,000Ω/V.

Analogue-to-Digital Converters.—Mechanical "digitizers" for converting shaft rotations into coded pulse output signals are usually commutator-type devices with wiping contacts or photocells for sensing purposes. G.E.C. have introduced an entirely new system which depends on electromagnetic induction. It is basically a transformer with a single energizing winding and a number of secondary windings corresponding to the number of digits. The rotating part is cup-shaped and contains a magnetic element which provides the coupling between the energizing winding and the various digit windings (which are arranged to conform to some code). A typical energizing voltage is 10V r.m.s. at 20kc/s, giving an output of 1.5V r.m.s.

An entirely electronic analogue/digital converter shown by Mullard samples an input analogue voltage in the range 0-10V and gives a binary output of 10 bits either serially or in parallel. Using transistors throughout, it is based on ten bi-stable circuits which are switched either "on" or "off" according to a comparison process which balances the current produced by the input voltage through a resistor with currents switched by the bi-stable circuits through graded resistors from a 10-volt source. The bi-stable circuits are triggered in sequence at a rate of 12kc/s so the sampling period for a 10-digit output is less than 1 millisecond.

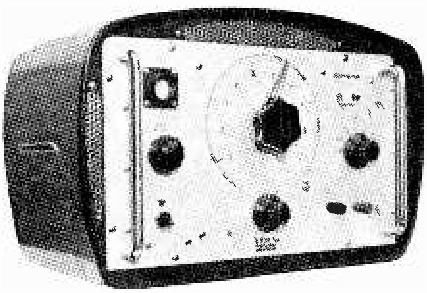
Digital Storage Systems.—The principle of the superconductive storage element, based on a property of metals at very low temperatures, has already been explained in *Wireless World* (July, 1957, p. 326). A particular embodiment of this principle was described in the January, 1958, issue (p. 32), in which circulating currents are magnetically induced in a superconductive sheet by a drive conductor, the direction of circulation signifying whether a "1" or a "0" is stored. The Royal Radar Establishment demonstrated this idea, using three elements made from evaporated films of tin on a mica base with drive and pick-up conductors, the whole being held at a temperature of about 3.7°K in a flask of liquid helium. Pulses of 50mμsec duration were written in, and read out when required, through special transmission lines with Constantan inners to reduce the thermal conductivity.

An unusual type of static storage system capable of giving a serial pulse output was shown by Elliott. It is based on both magnetic recording and magnetostriction principles. Information is stored permanently as a pattern of remanent magnetism along the length of a nickel-iron wire. It is read out by passing a single current pulse through the wire The magnetic field of this pulse interacts with the static magnetic pattern and causes magnetostrictive action, which creates an acoustic wave train corresponding to the stored pattern of information. This train travels along the wire and is converted into a serial pulse output by a pick-up coil, as in normal magnetostriction delay-line stores. The reading-out process does not destroy the stored information, which can be used over and over again.

Ericsson demonstrated the principle of the "twistor" magnetic storage system already described in the January, 1958, issue (p. 32) and February, 1959, issue (p. 80). Information was written into a 4×4 matrix store by coincidence of currents through columns of coils (100mA) and currents through the twisted magnetic wires (200mA) A p.r.f. of 500kc/s was used, with transistor writing and reading circuits.

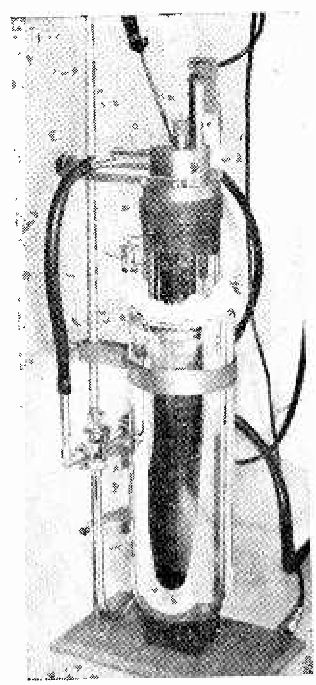
A new kind of square-loop ferrite store, shown by Mullard, is intended for computer speeds up to ten times faster than are possible with the existing types of magnetic matrix stores. It achieves the higher speed of operation by not switching the cores into their full states of saturation. Two ferrite cores are required for each digit stored. They are switched in opposite directions of magnetisation by a wire carrying the input digit pulse and, coincidentally, in the same direction by a read/write drive wire. Thus, one core is magnetized more than the other—which one depending on whether a "1" or a "0" is stored. The output wire threading the two cores combines their outputs in series opposition (corresponding to the input wire) When the read/write drive wire is energized to "read", the differing magnetic flux changes in the two cores induce a combined current pulse in the output wire, and the direction of this depends on whether a "1" or a "0" was stored.

Very Low-Frequency Generators.—A popular circuit, which provides frequencies as low as 1 cycle in 10^4 seconds in the Solartron JO 744 for



Cossor LCR bridge model 1446.

G.E.C. induction digitizer.



Superconductive store in cooling flasks (R.R.E.).

example, uses two integrator stages and overall feedback with 180° phase shift. This can be regarded as providing the sine-wave solution of the differential equation $d^2y/dt^2 = -y$. This method conveniently provides outputs from the two integrators whose phases differ by 90°. In the Solartron oscillator the effective input impedance of the integrators is multiplied by 1,000 times up to 1000MΩ by feeding them from a 1000-to-1 ratio potential divider. This keeps the integrator capacitors to reasonable values, but even so leakage across these capacitors and the integrator amplifiers themselves results in damping being effectively applied in the circuit. A gradual reduction in the output level is however avoided by sampling it at its peak value and using current feedback to keep this peak value constant.

Low frequencies are obtained by a different method in the Servomex Transfer Function Analyser Type TFA46. A plane loop of wire is rotated at the required modulating low frequency ($\omega_m/2\pi$ say) in a magnetic field which is alternating at a much higher carrier frequency ($\omega_c/2\pi$ say). If B_{max} is the maximum flux linking the loop, then at any time t the flux linking it can be expressed as $B_{max} \sin\omega_c t \sin\omega_m t$. The e.m.f. induced by the changing flux linkage is the differential of this quantity, i.e. $B_{max}\,\omega_c \cos\omega_c t \sin\omega_m t + B_{max}\,\omega_m \sin\omega_c t \cos\omega_m t$. The second term causes the amplitude to vary with the modulating frequency. It represents effects due to the flux linkage changing at the modulating frequency, and is as might be expected negligible when the modulating frequency is very much lower than the carrier frequency ($\omega_m << \omega_c$). The loop output is then equal to $B_{max}\,\omega_c \cos\omega_c t \sin\omega_m t$ and the low-frequency modulation term $\sin\omega_m t$ can be obtained by demodulating the carrier frequency. Simple avoidance of the use of a carrier frequency by rotating the loop in a fixed magnetic field at the required low frequency would not be nearly so effective since the output would vary with frequency and also be very low at very low frequencies. Direct modulation of a valve-generated high-frequency signal by means of a motor-driven capacitor is used in the Airmec Type 257 to provide (after demodulation) frequencies from 0.03 to 30c/s. A second set of stator vanes on the capacitor can be manually rotated to provide a second output with a continuously adjustable phase difference from the first. These last two methods have a number of advantages. First, the output frequency can be varied by changing the motor speed without any delay due to long time constants, and its level can also be set quickly and accurately simply by varying the carrier level. Secondly, the purity and level stability of the output are independent of frequency. Finally, the output frequency is readily measured from the motor frequency.

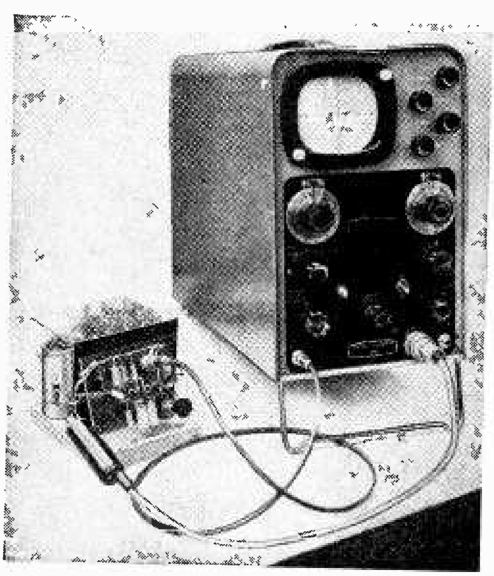
Audio-frequency Oscillators.—A Wien bridge which is balanced by the addition of two extra resistive arms (one of which is an amplitude-stabilizing thermistor) and which is fed from a push-pull transistor amplifier is used in the Dawe Type 421 to avoid the low input impedance and changing output phase-shift difficulties normally associated with transistors. A standard Wien bridge oscillator using valves is an addition to the range of Mullard educational constructional circuits.

A parallel-T network is used to control feedback in the Muirhead D-888-A analyser-oscillator to provide either narrow-band amplification with an equivalent Q of at least 70 or, with additional feedback, oscillation at frequencies beyond the audio region up to 650kc/s.

Ultrasonics.—Two new metal-testing sets were shown covering the range 1 to 10Mc/s, this latter high frequency being preferable for the examination of materials with a tight-knit grain structure, such as austenitic steels. The idea behind this is to use a shorter, higher-powered pulse (consequently the higher frequency so that a reasonable number of cycles form the pulse) to give higher definition, so making clearer the difference between the grain structure "grass" and the echoes due to faults in the material: smaller faults, too, are detectable. The Ultrasonoscope MkII flaw detector provides a non-linear amplifier facility so that this "grass" may be compressed in amplitude.

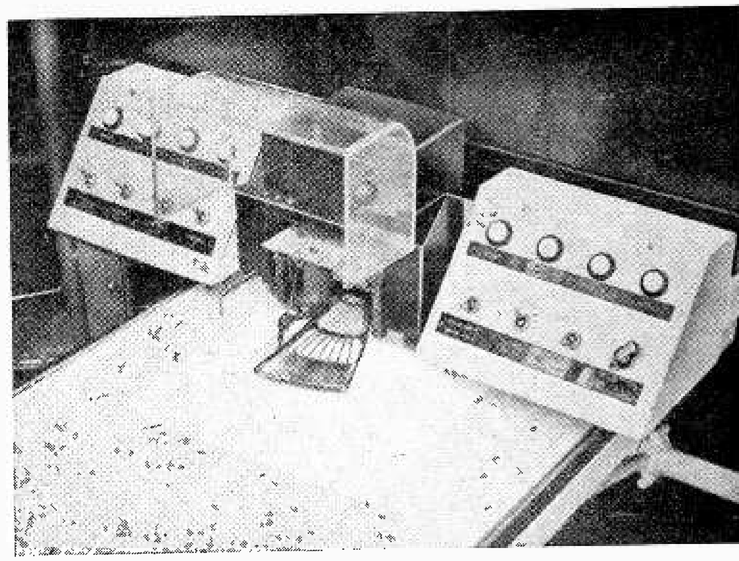
Kelvin Hughes, in their Mk. 5 set, provide two gated amplifiers whose outputs are displayed on much-brightened portions of the timebase. This, it is said, eases the problem of locating "dangerous echoes" in production testing, by setting the gates so that only the points where faults could be the cause of failures in the object being tested are displayed at full brightness.

A rather amusing demonstration of the potentialities of barium titanate transducers was given on the stand of Sir Howard Grubb, Parsons and Co., Ltd. This took the form of a small transducer propagating a 1.6-Mc/s particle vibration in air and a receiver whose output was mixed with the transmitted frequency and fed to an a.f. amplifier and loudspeaker. Relative movement of the transmitter and receiver resulted in a doppler "burp" from the loudspeaker. This work, of course, has a serious application: it forms part of a research programme with a view to improving "sonic" gas analysers by raising the frequency used from 3 or 4kc/s possibly into the megacycle region.



U.K. Atomic Energy transistor sampling oscilloscope displaying a pulse a few millimicroseconds wide. The sampling pulse generator and sampling circuit are housed externally to the oscilloscope in a probe attached to the avalanche input pulse source to avoid using cable to carry very short pulses.

Short-Pulse Generators.—A secondary-emission pentode is used to generate pulses with a rise time of less than 15mμsec in the Wayne Kerr Type P131. The pentode is normally cut-off, but on triggering with a positive input pulse it conducts, and a negative pulse is sent from the anode down a short-circuited delay line, this negative pulse being also fed back to the cathode. This positive feedback to the cathode results in a cumulative process, since owing to the secondary emission the anode current is several times the cathode current. The secondary emission also results in the secondary-emission electrode (dynode) losing electrons, and so its potential rises and provides the leading edge of the output pulse. At a time determined by the line constants the negative pulse from the anode is reflected from the short-circuited end with its phase reversed. When this positive pulse is received back at the anode, the feedback to the cathode cuts off the pentode and the dynode potential immediately falls, terminating the output pulse. Owing to stray capacitances this fall would normally be rather slow. These strays are however discharged by using the positive reflected pulse to switch on a normally cut-off ordinary pentode connected between dynode and cathode. The resulting output pulse fall time is less than 20mμsec.



Printing mechanism and control gear of the Hammersmith Hospital body radiation scanning machine.

Medical Electronics.—A mechanical scanning and recording machine for displaying pictorially the distribution of radioactivity in human organs (introduced deliberately by radioactive isotope techniques) was demonstrated by Hammersmith Hospital Department of Physics. The patient himself is moved on a floating-top couch in a scanning raster under a stationary radiation detector. The output from the detector is fed to a ratemeter and a recording meter which is fixed to the moving couch. According to the rate of count the meter deflection causes printing ribbons of different colours to move under a printing stylus, which makes dots through them on to a fixed sheet of paper. The result is an even array of dots covering an area equal to the area of patient scanned. The regions giving a count rate within certain limits come out in the same colour, rather like height contours on a map.

Bristol University Department of Anæsthetics had an electroencephalographic display system, based on a standard c.r.o., which gave inherent rhythm and phase information like the Grey Walter toposcope but by using a television type of timebase instead of the rotating p.p.i. kind. A 10-second frame timebase is used, with a line-timebase period depending on the frequency component of the brain wave under investigation. The output of the e.e.g. amplifier modulates the brightness of the tube spot, and the display (on a long-persistence screen) appears as vertical bands of light and dark.

Oscilloscopes.—A response from d.c. to 60Mc/s (3dB down) with a calibrated maximum sensitivity of 50mV/cm can be achieved in the new Cossor Model 1076 using the 1078 plug-in Y pre-amplifier. Twenty-four calibrated timebase speeds from 0·02μsec/cm to 5sec/cm are available, and a 200Mc/s (±2%) oscillator provides intensity modulation dots for the measurement of pulse rise-times. A trigger level control is one of the facilities in the 1070 plug-in trigger unit. Other plug-in units, including, for example a differential Y pre-amplifier, are being developed for this oscilloscope.

Infinite persistence storage oscilloscopes for viewing "once in a lifetime" phenomena, using a tube similar to that described in our review of last year's Physical Society Exhibition (May 1958, p. 221), have previously been shown by Cawkell and are now also made by Solartron. Facilities available in the new Solartron QD 910 include a triggered timebase with 49 alternative speeds from 1μsec/cm to 10 sec/cm and two identical Y-amplifiers with responses from d.c. to 1Mc/s (3dB down) and single or differential inputs.

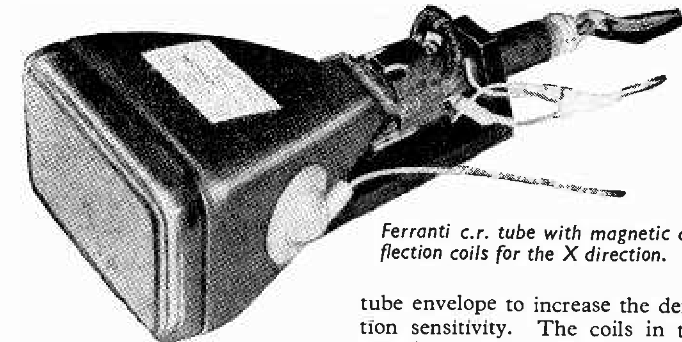
A sampling principle for viewing repetitive waveforms is used to give an effective response from d.c. to 300Mc/s (3dB down), using transistors except only in the final c.r.t. plate driving stages, in an oscilloscope shown by the U.K. Atomic Energy Authority. The maximum sensitivity is 200mV/cm and the equivalent input noise 100mV. The input impedance is as high as 1pF in parallel with 0.25MΩ. Signals with p.r.f.'s from 100c/s to 10kc/s can be observed, and from 40 to 320 samples taken.

The principle consists in using a very short pulse to sample a small portion of each input pulse, the samples being taken at a time delay from the beginning of the input pulse which is increased slightly between successive input pulses. Thus the sampling pulse gradually progresses through the input pulse and builds up a picture of it in the process. The sampled pulse can be amplified throughout the period between input pulses so that only a comparatively poor response is needed for this amplifier. Moreover, if each sampled pulse is referred to the same zero potential, the sampled pulse amplifier need not even respond to d.c. Since the period between input pulses in which the sampled pulse is amplified and fed to the c.r.t. is "most of the time", this period is nearly independent of the input p.r.f., and so the brightness also is unaffected by the input p.r.f.

The equivalent rise time is equal to the width of the sampling pulse. The very narrow sampling pulses thus required to obtain a short rise time are obtained by avalanche operation of a transistor. In such operation the transistor emitter current is initially cut off by making the base positive with respect to the emitter. Its collector is connected to a negative potential of several hundred volts through a high resistance so as to draw a current of several hundred microamperes, the collector taking up a potential of about −50V. If now the base potential is allowed to fall to that of the emitter, cumulative electron multiplication occurs in the transistor and the collector potential very rapidly rises to that of the emitter. By differentiating this rise, a very short pulse of several hundred milliamperes into a few tens of ohms can be obtained. By selecting ordinary 10Mc/s OC44 transistors, pulses as short as 1 to 2mμsec can be obtained in this way. Sampling is carried out in the oscilloscope by feeding the avalanche pulse to the base of a 50Mc/s SB100 (this is the only high-frequency transistor required) and the input pulse to its emitter. The difference between these two pulses then appears on the collector. Most of the noise is produced in this sampling process and in the avalanche sampling pulse itself.

Amplitude Distribution Measurement.—A sampling technique was also used in an instrument shown by Plessey. The input waveform is fed to one plate of a special type of c.r.t. and the sawtooth sampling waveform (which has a much lower frequency) to the opposite plate. A thin wire parallel to these plates replaces the usual screen. For a fixed sampling voltage, only a certain voltage on the input waveform will deflect the beam so as to strike the thin wire. The current thus produced will be proportional to the length of time during which this input voltage occurs. As the sampling voltage gradually changes, the current in the wire thus gives the lengths of time during which the various voltages present in the input occur.

C.R.O. Tubes.—Development in this field is aimed at the twin requirements of higher deflection sensitivity and increased trace brightness (especially with high-speed writing). Unfortunately these two requirements often conflict. The use of post-deflection acceleration to increase the brightness, for example, tends to reduce the deflection sensitivity and distort the trace. If the deflection plates are brought very close together to increase their effect on the beam, the anode aperture has to be made proportionately smaller so that the beam electron density, and hence the brightness, is reduced. An interesting method of tackling these problems was demonstrated on the G.E.C. Research Laboratories stand in the shape of an experimental tube with "field-enhanced luminescence." In this the beam traverses a field-free region between the deflection plates and the fluorescent screen. The electron tracks are therefore not affected after the deflection plates. To obtain the necessary brightness an electrostatic field of about 1500V is applied across the thickness of the screen. This accelerates the electrons through the phosphor and gives a bright trace—but whether it is the primary electrons or secondary electrons produced at the aluminium backing layer of the screen that are being accelerated is not certain. Actually the backing layer is at earth potential and the front of the phosphor has the +1500V applied to it. The final anode of the tube is also at earth potential (giving the field-free region) so the cathode has to be negative with respect to it (actually −2kV).



Ferranti c.r. tube with magnetic deflection coils for the X direction.

Another interesting development connected with deflection sensitivity was the use of magnetic instead of electrostatic deflection. This eliminates the need for high deflection voltages and allows transistors to be used for driving purposes. As an example Ferranti showed a small tube with a 5½-in × 3½-in screen on which magnetic deflection coils were used for X deflection and electrostatic plates for Y deflection. Because there is only one set of plates inside the tube it has been possible to make the anode aperture larger and so increase the spot brightness. Moreover, the tube length is reduced. The coils, of course, are wound to suit the driving circuits and can be resonated to give overscanning by a large amplitude sine wave (so that the visible part of the scan is produced by the comparatively linear section of the wave). G.E.C. Research Laboratories went further than this by making both X and Y deflection magnetic, and building the coils actually *inside* the tube envelope to increase the deflection sensitivity. The coils in their experimental tube (two pairs) are arranged sequentially like electrostatic deflection plates and measure about 3cm × 1cm, with inductances of about 20μH. The deflection sensitivity is 1mA per millimetre in both directions.

Scan Magnification.—A means for increasing the spot movement produced by a c.r.t. magnetic-deflection system without increasing the power input to the coils has been developed by Mullard, Ltd. The basic principle of this involves passing the electron beam through a magnetic diverging lens after deflection; but this is not so simple as it seems, for two reasons. The spot will increase in size and become distorted, due to divergence of the beam itself, and there is difficulty in producing a magnetic lens of the required form. The solution adopted is to use a system of quadrupoles, which are "lenses" having a diverging effect in one direction and a converging effect at 90° to this (x and y deflections, say). One quadrupole is placed between the scanning coils and the c.r.t. screen: this will cause a movement of the beam in the x direction to increase and also mis-shape the spot. In the converging, or y, direction the deflection would be reduced; to obtain an increase in this direction the beam has to enter the lens in such a way that a focus is formed *inside* the lens; then divergence of the emergent beam is effected and the quadrupole magnifies (although to a lesser degree than in the x axis). Thus the beam entering the magnifying quadrupole must have different x and y foci and be shaped in such a way that the ellipticity introduced by the magnification process exerts a correcting rather than a distorting influence. This beam requirement is met by employing two more quadrupoles, with their axes crossed at 90°, as the focusing system. The demonstration on the Mullard stand showed the potentialities of this system very well—the image on the scan-magnified display filled the tube and the conventional display was rather less than half-an-inch across. Some increase in spot size (about 5 times) does occur; but with modern c.r.t.s this should not prove an insurmountable problem; the quadrupoles, too, have the advantage of being of fairly simple construction—small bar magnets and simple pole pieces are used.

Electroluminescence, already well established for illuminated signs and notices, is now being developed for more complex indicators. Thorn, for example, were showing a new type of digital indicator for displaying the numerals 0 to 9 on a single flat plate (which could be viewed from very oblique angles). The numerals are built up by activating various combinations of electrodes on the back of the electroluminescent layer, the front electrode being continuous over the whole surface. A coding matrix, formed by a printed circuit with pellets of non-linear resistance material, selects the right combination of back electrodes to construct a particular numeral when the activating voltage is applied to the appropriate one of ten input wires. About 500V a.c. is required for activation, with a current of 0.5mA.

Also demonstrated by Thorn was a crude but nevertheless interesting attempt at achieving scanning over a series of electroluminescent elements (with perhaps the eventual aim of television picture presentation). A row of electroluminescent and photoconductive elements were linked together electrically and optically so that the light from one electroluminescent element activated a photoconductor connected in series with the next electroluminescent element. The output voltage from the photoconductor causes the second electroluminescent element to light up and illuminate the next photoconductor, and so on, causing a spot of light to travel down the row. The speed of scanning is severely limited at the moment by the slow response of the photoconductors.

Image Intensifiers.—The principle of electroluminescence (see above) was used in an X-ray image intensifier demonstrated by Thorn in association with the Physics Department of King's College Hospital. It consists of an electroluminescent layer and a photoconductive layer separated by an optically opaque but electrically conducting material. An alternating voltage of about 1,000V, 50c/s, is applied across the whole "sandwich". X-ray radiation falling on the photoconductor causes it to conduct in proportion to the intensity. This produces a corresponding pattern of increased voltage across the electroluminescent layer, and light is emitted to form a visual image. The picture is 20-50 times brighter than that obtained from a conventional fluorescent screen.

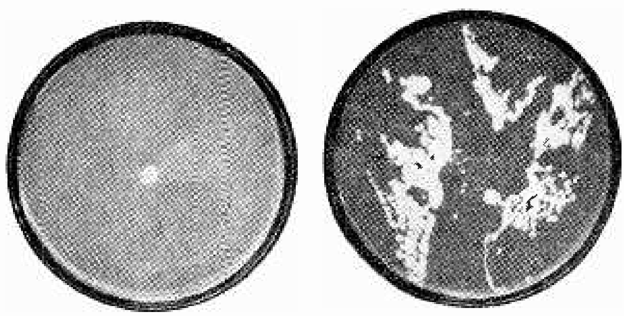
Brightness amplification can also be obtained by using television techniques, and it is then possible to introduce extra facilities like variable contrast to assist in viewing. English Electric Valve Company showed a $4\frac{1}{2}$-inch image orthicon pick-up tube intended for this purpose.

A more direct method of using the television pick-up tube for image intensification—this time for an electron microscope—was shown by Siemens Edison Swan. The fluorescent screen of the microscope is replaced by a photoconductive type of pick-up tube, the two envelopes being sealed together and evacuated as one. The sensitive screen of the pick-up tube is a layer of amorphous selenium, and the resistivity of this is modified in a pattern when bombarded on one side by the high-energy electrons from the microscope beam. The other side of the selenium is scanned with 405 lines by the electron beam of the pick-up tube, and a signal corresponding to the electron-microscope image is obtained from a signal plate as in television technique.

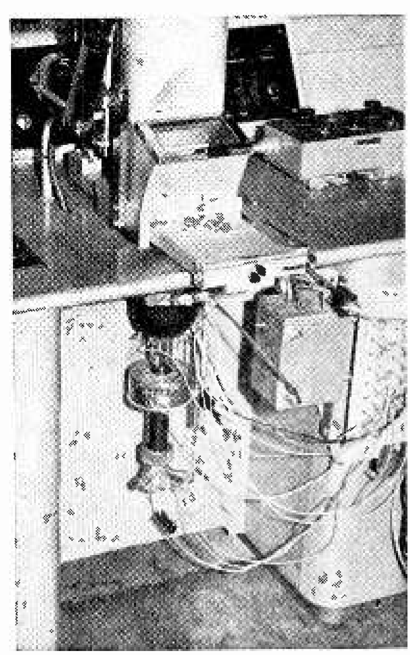
Photoelectric Devices.—One of the latest and most efficient devices for converting light into electrical energy is the silicon junction "solar cell." Ferranti were showing examples which gave open-circuit voltages of 500mV for a light intensity of about 1,000 foot-candles, and currents of 20mA per square inch of active area. They are available in various sizes with rectangular and circular shapes and in multiple form. One demonstration showed the ability of these cells to resolve high-frequency pulses of light (above 1Mc/s).

The photomultiplier tube has hitherto been rather a large and clumsy device because of the space required for its electron multiplier structure. This is becoming increasingly less true nowadays. For example, 20th Century Electronics were showing a single-stage tube measuring only 30mm × 6mm. It has a sensitivity comparable with a gas-filled photocell (about 100μA per lumen) and the speed of response of a vacuum photocell.

Semiconductor Devices.—There was evidence of continuing development in power and high-frequency transistors. Silicon transistors are



Above: *Mullard scan magnification: both 5-in tubes are operated under identical conditions except that one has scan magnification, the other conventional deflection and focusing. Gain is about 12 times.*



Right: Image intensifier tube mounted under the desk top of an electron microscope (Siemens Ediswan Swan).

becoming more common and B.T.H. have now entered the field with several diffused-junction development types. These include an h.f. transistor with an alpha cut-off frequency of 30Mc/s and a power type with a collector dissipation of up to 100 watts. Thorn demonstrated the switching of a 300-watt lamp by their GT422 power transistor from a 45-volt supply. G.E.C. had a new h.f. drift transistor, EW69, with a cut-off frequency of 30Mc/s.

Amongst the more specialized semiconductor devices was a p-n-p-n "sandwich" diode structure with a characteristic suitable for bi-stable switching circuits (see Technical Notebook, October 1957, p. 502, for principle). It has two states of conductivity and is made to switch from one to the other according to the value of the applied voltage. The triggering voltage is 100V and the holding current for the fully conducting state is 50mA at less than 1.5V. Another semiconductor switching device giving two states of conductivity (shown by Plessey) depended on a phenomenon which occurs in germanium at very low temperatures, when the material is virtually an insulator. If a voltage is applied across the germanium the few remaining free current carriers are accelerated until, at a critical field strength, their energy is sufficient to ionize the impurity centres and cause a non-destructive breakdown. The resistance of the germanium then falls from about 10MΩ to 20Ω.

Transistor Tester.—Noise can be measured in the new battery operated Avo Transistor Analyser by comparison with the output from a 1,000c/s stabilized transistor oscillator. By restricting the measurement to noise above 200c/s, spurious hum pick-up is avoided and amplifier interstage coupling made easier. Current gain is measured by comparing the output from the oscillator before and after amplification using a calibrated attenuator and high-gain transistor amplifier.

Barium Titanate Capacitors are difficult and expensive to make in high values—difficult, because barium titanate is very brittle in the form of ceramic sheets, so making it hard to "stack" them without breakage; expensive, because the sintering process is carried out in air, and palladium is the cheapest metal able to withstand the sintering and remain unaffected. In the new Plessey process the barium titanate powder is mixed with a

Avo transistor analyser allowing noise measurement.

plastic binder to form a flexible sheet and the binder is volatilized during the sintering process, leaving the barium titanate dielectric. To overcome the expense associated with palladium they have also developed a process by which a sufficiently high dielectric resistivity may be obtained by sintering in hydrogen, so that nickel can be used for the "plates".

Resistance Wires for use in extremely stable highly accurate resistors are sometimes wound in pairs, the two wires having mutually compensating temperature coefficients and changes of coefficient. Johnson, Matthey have, in their Silver Minalpha wire, carried this technique a stage further by using the compensating alloy as a sheath to Minalpha wire. Minalpha itself (copper-nickel-manganese) has a positive temperature coefficient of about 5 parts in 10^6 per °C up to 26°C: this then turns negative after reaching a maximum. The silver-alloy sheathing (silver-tin-manganese) exhibits almost the reverse of this characteristic, having a small negative coefficient up to 20°C, going positive above this point, so that, by choosing the optimum proportions of Minalpha to sheath, a resistance wire with built-in compensation from 10°C to 100°C is produced.

Printed Circuits.—A recent development in this field was shown by G. V. Planer, Ltd, being a copper circuit on a glass substrate. The copper is deposited by a direct metallizing process, no "glue" of any type being used. Circuits produced by this method are said to be inert, stable and suitable for high-temperature operation. The examples shown included some inductors built up from double-sided "windings," the copper continuing over the edge of the glass to make contact with the coil on the other side and the coils on other sections of the stack.

Magnetic Materials. — Comalloy (Murex Ltd. is a cobalt-aluminium-molybdenum material with an energy product of $1{\cdot}0 \times 10^6$ gauss-oersteds, the remanence being $9{\cdot}7 \times 10^3$ gauss. Although the energy product is not as high as that of some "magnetically-hard" materials, this sintered material possesses the valuable characteristic of being machinable before its final heat treatment is applied. In its pre-treatment state the cutting characteristics resemble those of mild steel, and it is said that little distortion occurs during treatment, so that it is usually necessary only to restore the surface finish.

Melting by bombardment with an electron beam was perhaps the most direct application of electronics shown at this year's exhibition. Two demonstrations were given, one by S.E.R.L. (on the National Research Development Corporation's stand) and the other by Associated Electrical Industries. The S.E.R.L. apparatus was being used for zone refining: this was accomplished by encircling the rod of material to be refined with a heated tungsten filament and beaming the emission with two annular plates above and below, and connected to, the filament. The current is controlled by the variation of the filament temperature and e.h.t. and for zone refining either the cathode assembly or the rod can be moved vertically (surface tension of the molten material keeps the rod whole). The temperatures achieved are sufficient to melt tantalum (m.p. 3000°C) and tungsten. A 3/16-in diameter ruthenium (m.p. 2450°C) rod requires a bombarding current of about 100mA at 3.75kV.

Four electron guns consisting of a retractable tungsten filament in a slot in an air-cooled brass block (again connected to the filament) are used in the A.E.I. equipment: these are mounted above the material (e.g., silicon) to be melted and the beams are focused and deflected on to the material by electromagnets. 5kV is applied to the guns and silicon crystal-pulling can be achieved with an input power of about 1kW (rough comparison: 4kW for r.f. and silica crucible method). The container is, of course, continuously evacuated, a pressure of at least 1.0×10^{-5}mm mercury being necessary. Silicon crystals produced by this process are extremely pure as the molten material is not in contact with any contaminating substance (e.g. silica) and most of the other impurities are volatilized.

RELATIVITY

By "CATHODE RAY"

2. Throwing Weight Around

There was a young lady named Bright
Who travelled much faster than light.
She started one day
In a relative way,
And came back the previous night.

Traditional

THE difficulty about relativity is not so much that it is complicated as that it upsets things we had come to regard as absolutely basic, such as length and time. It is as if we were suddenly asked to accept that two and two make three. Perhaps an arithmetic of that kind would be no more complicated and difficult than the one we know, but it would mean we would have to think hard about every step instead of reeling it off from memory.

As we saw last month, Einstein's Special Theory of Relativity follows naturally from two simple facts, but the results are startling.

The facts are:

(1) The speed of light in empty space, denoted by c, is always the same.

(2) Nothing has been found in the whole universe which can be shown to be fixed* and thereby entitled to a better claim than anywhere else as a reference point for measurement.

We drew a graph of time against length or distance (that is to say, space in one dimension) as reckoned from one viewpoint (ours) and then plotted on it the varying position with time of another viewpoint travelling at a uniform speed relative to us (Fig. 1). We also plotted on the same graph the progress of a beam of light, showing it travelling at the frequently and accurately measured speed of almost 3×10^8 metres/sec. Our problem was to provide the graph with time and distance scales applicable to the other viewpoint, such that according to them too the speed of light would be 3×10^8 metres/sec., as per Fact No. 1.

We were given the other viewpoint's zero-distance line, because it was our line representing their position relative to us. It then became clear that in order to comply with the requirements we had to abandon the usual assumption that what to the observers at the other viewpoint were a second and a metre must necessarily be the same to us.

Having done that, we had an infinite choice of time and distance scales. For instance, we could have made their metre measure up on our scale as two-thirds of a metre, leaving their time scale the same as ours. But that arrangement would have made our metre look like $1\frac{1}{2}$ metres to them, and in the light of Fact No. 2 such a lack of reciprocity would be anomalous. In other words, since there is no essential distinction between the two viewpoints, it would be unaccountable that one of them should find the other's lengths smaller and one should find the other's lengths larger.

We found we could avoid this anomaly by making the other people's time markings different, when seen from our viewpoint, in the same way as their distances. This, shown in Fig. 2, enabled us to arrive at a formula (part of the celebrated "Lorentz transformation") for converting either's scales of seconds and metres to the other's, the difference being due to each viewpoint travelling steadily relative to the other at a velocity v. The conversion factor is

$$\sqrt{1 - \frac{v^2}{c^2}}$$

and we see that according to it all lengths (in the direction of motion) and time intervals in a system moving towards or away from any observer measure less to him than to an observer travelling with that system. So a chronometer on a rocket hastening to the moon would, so far as perfect measurements on earth could tell, be running slightly slow, though it would be correct to an observer with equally perfect measuring gear in the rocket.

We also soon see, if we try plotting the conversion factor against v, as in Fig. 3, that it doesn't begin to differ appreciably from 1 until v is far greater than can be achieved (relative to earth) by the fastest

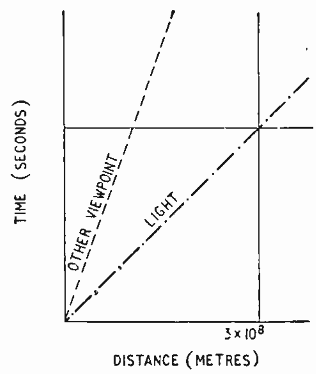


Fig. 1. Simple time/distance graph, showing the progress of a beam of light and of another viewpoint.

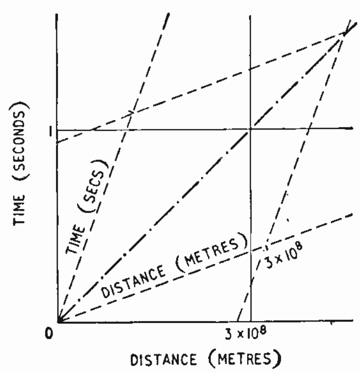


Fig. 2. Development of Fig. 1 to show a pair of time and distance lines (dotted) applicable to the other viewpoint and so arranged as to make the speed of light the same for both viewpoints.

*I omitted to mention last month that following the Michelson-Morley experiment, the null result of which could have been explained by the Lorentz contraction without necessarily abandoning the aether, there was a Kennedy-Thorndike experiment which would have showed the existence of an aether if there had been one—in spite of the Lorentz contraction—and it didn't.

moon rocket, or even by a car on the Preston by-pass. So for most practical purposes relativity doesn't make a ha'porth (or even a microfarthings-worth) of difference. But in modern research certain small particles, such as electrons and mesons, sometimes approach the speed of light quite closely, with remarkable relativistic results. In the limit it would appear that to photons—which are light itself—all distance in empty space is shrunk to nothing, and that what to us are the thousands of million of years light takes to reach us from the far nebulæ is to them no time at all! At least we can say that any speed *greater* than c is unimaginable and presumably impossible, so we need have no fear of being faced with the situation outlined in the verse about Miss Bright.

What then, we may ask, would happen if a particle travelling at nearly the speed of light were to shoot off a sub-particle at high speed in the same direction? If v was the velocity of the particle (relative, say, to us) and u the velocity of the projectile relative to the

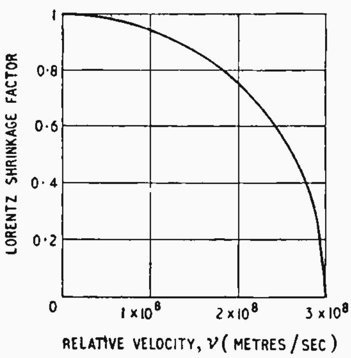


Fig. 3. Distance and time measures on one viewpoint always look less on another travelling at relative velocity v, the contraction factor being as plotted here.

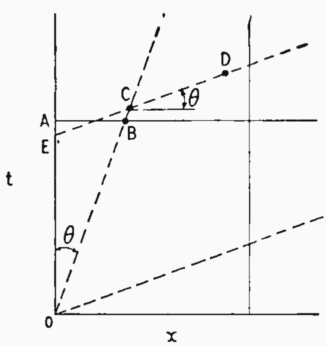


Fig. 4. Diagram for calculating how to combine two velocities which are appreciable in comparison with that of light.

particle, then we would usually reckon that the velocity of the projectile relative to us (w) was $v+u$. So if v was, say $\frac{3}{4}c$, and u was also $\frac{3}{4}c$, then w would be $1\frac{1}{2}c$, which is impossible.

Any such question would reveal that we were still bound by our two-and-two-make-four habits. Fig. 2 is a reminder that we were successful in using the graphical method to arrive at the Lorentz formula by simple geometry, which seems to me much more convincing and easily visualized than the usual textbook method by algebra, so let us try following it up to discover the correct result of combining two velocities in the same direction.

To save effort let us use our previous diagram with its dotted line (OBC in Fig. 4) to represent our tracking of the particle moving at the rate v. Remember, in this diagram the distance 3×10^8 metres is represented by the same length horizontally on the paper as 1 second vertically, so c appears as the diagonal of any square. Therefore

$$\frac{\text{Speed of particle relative to us}}{\text{Speed of light}}=\frac{v}{c}=\frac{AB}{OA}=\frac{x_b}{t_b}=\tan\theta \quad\ldots\ldots\ldots (1)$$

Note that the quantities distance and time are now denoted by x and t respectively; and x_b means the distance from zero, and t_b the time after zero, represented by point B—and so on.

Next we measure off along the particle's time and distance scales—the sloping dotted ones—1 second (represented by anywhere on the upper dotted line) and CD, so that

$$\frac{\text{Speed of projectile relative to particle}}{\text{Speed of light}}=\frac{u}{c}=\frac{CD}{OC}\;\ldots (2)$$

It follows that

$$\frac{\text{Speed of projectile relative to us}}{\text{Speed of light}}=\frac{w}{c}=\frac{x_d}{t_d}$$

$$=\frac{OC\sin\theta + CD\cos\theta}{OC\cos\theta + CD\sin\theta}$$

$$\text{(from (2))} = \frac{OC\sin\theta + OC\frac{u}{c}\cos\theta}{OC\cos\theta + OC\frac{u}{c}\sin\theta}$$

$$=\frac{\sin\theta + \frac{u}{c}\cos\theta}{\cos\theta + \frac{u}{c}\sin\theta}$$

$$=\frac{\cos\theta\tan\theta + \frac{u}{c}\cos\theta}{\cos\theta + \frac{u}{c}\cos\theta\tan\theta}$$

$$=\frac{\tan\theta + \frac{u}{c}}{1 + \frac{u}{c}\tan\theta}$$

$$\text{(from (1))} = \frac{\frac{v}{c} + \frac{u}{c}}{1 + \frac{vu}{c^2}}$$

$$\therefore\; w = \frac{v+u}{1 + \frac{vu}{c^2}}$$

So if (to go back to the example that started this off)

$v = u = \frac{3}{4}c$, we find they add up to

$$w = \frac{1\frac{1}{2}c}{1 + (\frac{3}{4})^2} = 0.96c$$

In fact, even if v and u both go to the limit —c—w is still no more than c. Sounds crazy, of course, but can you find any flaw in the argument?

One can hardly tamper so drastically with all we knew about length, time, and speed, and expect the consequences to go no farther. As the schoolmaster said, you will hear more of this. To go straight to the heart of the matter, consider energy and mass—the basic ingredients of the universe.

When a mass is moving, it has kinetic energy, which we are told at school is equal to $\frac{1}{2}mv^2$. We are also told that energy is conserved; that is, it can't just disappear without trace—it can only change into an equal amount of energy of another kind. Well, even without bringing Einstein into it, that ought to make one think. For we used also to be told that mass is another indestructible quantity. So m in the energy formula was just a constant. But nobody can give an authoritative ruling on how much, in any particular case, v is. Take the earth, for instance. Galileo was threatened with torture if he didn't agree that its v was definitely zero. And certainly, from the point of view of his inquisitors, who were sitting on it, that was true, and its kinetic energy therefore also zero. An astronomer on Mars would observe that its v relative to him was at times very considerable, and he would be glad that the planetary orbits were such that there was no risk of collision, which would demonstrate the earth's kinetic energy in no uncertain fashion. (We would of course take a different view of the catastrophe, blaming the k.e.—and the k.o.!—on Mars.)

So it appears that a body can have a lot of kinetic energy and at the same time none at all, depending on what point one happens to measure its velocity from. Which makes the law of conservation a little less simple than we may have thought. But let that pass.

Consider again the projectile-firing situation, but at such a low speed that Einstein can safely be ignored. Suppose you are cruising along a street in your car and, not liking the face of a man standing in your way, you hurl at it a custard pie of mass m, with a velocity (relative to yourself) v, which, by a curious coincidence, is equal to that of the car relative to the man in the street (Fig. 5). The latter, who happens to be interested in such problems, notes that your action has increased the k.e. that the pie had when it was travelling along with the car ($\frac{1}{2}mv^2$) to $\frac{1}{2}m(2v)^2$; that is to say, you have increased its energy by $1\frac{1}{2}mv^2$. You, on the contrary, are firmly of the opinion that you have imparted a velocity v to a previously stationary and unaggressive pie, thereby increasing its energy by only $\frac{1}{2}mv^2$. So here is another potential cause of friction between you and the man in the street.

I, as an unbiased spectator, am chiefly disturbed by the thought that not only is it impossible to obtain agreement about the *absolute* kinetic energy of a body (which, after all our talk about relativity, was perhaps only to be expected), but that even the k.e. *relative* to what it was before the imparting of a given amount is disputable. *How much energy did you in fact give the pie?* Its impact on the man is four times as devastating as if you had thrown it with equal exertion from a standing car, or three times as much as it had while in the moving car. There is a 3-to-1 discrepancy between different but apparently faultless methods of calculation.

Much to my relief I found on looking into it more closely that although you were correct in supposing that it cost you no more effort to throw your missile from a moving car, and the target was also correct in supposing that the missile from the moving car did four times as much work on his face as one thrown equally hard from a standing car, nevertheless there is no discrepancy. It would spoil the fun to give the solution now; perhaps the Editor might offer a small reward for the best one sent in.

At least we need have no doubts about the correctness of the k.e. formula—$\frac{1}{2}mv^2$. So, m being assumed

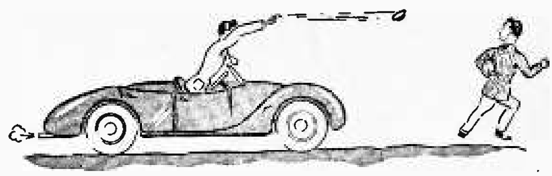


Fig. 5. This incident poses some interesting scientific problems.

constant, doubling the velocity quadruples the energy. At normal car and pie-throwing speeds there need be no uncertainty about what is meant by doubling the velocity (relative to a specified origin). But if our car were travelling towards the man in the street at the speed (relative to him) of $\frac{1}{2}c$, and you were to throw the pie at him with the same speed relative to yourself, we have discovered by a chain of inexorable logic that the man sees the pie coming towards him not at the speed c but $0.8c$. According to classical or school dynamics, your giving the pie the same velocity from yourself as you and it already had relative to the specified origin ought to quadruple its energy, whether the velocity in question was 10 m.p.h. or $\frac{1}{2}c$. But $\frac{1}{2}m\ (0.8v)^2$ is obviously not four times $\frac{1}{2}m(0.5v)^2$—in point of fact it is 2.56 times.

Here is another apparent discrepancy. But even if you didn't know the catch before I started, I have given so many hints that you oughtn't to have much hesitation in suggesting that it lies in wrongly assuming mass to be constant. There is some excuse for this, when we are brought up on the Law of Conservation of Mass—or at least in my day we were—and anyway one has an intuition that the mass of a thing is something pretty definite, that can't be annihilated or created, least of all just by changing its speed of movement. One would as soon expect an electron to vary its charge as it goes along. Nevertheless mass is actually one of the most difficult things to define satisfactorily. Of course it is mixed up in our minds with weight, and although we know that the weight of a thing depends on where it is (being almost nothing in a distant space ship or in a lift falling freely down its shaft) the fact that weight—other things being equal—is exactly proportional to mass is a strange coincidence, which led Einstein to his General Theory of Relativity.

Another Conservation Law

Don't panic! We're not going to embark on that; we had just reached the point of presuming (correctly) that if the relativity law for adding high speeds was not to land us in serious discrepancies about energy we would have to abandon the idea of constant mass. Without going into the mathematical details one can see that what energy is lost by the final velocity of the pie, being only $0.8c$ instead of c, could be made up if its mass were to increase with velocity.

The actual relationship of mass to velocity is most easily calculated on the basis of another conservation law—that of momentum, which is equal to mass times velocity. What you do is describe the momentum conditions of two elastic bodies before and after they have collided, from two points of view moving relative to one another. That brings in the Lorentz transformation. The whole thing is given in simple algebra by R. C. Tolman in his book

" Relativity, Thermodynamics and Cosmology," p. 43. Very conveniently, the law for relativistic increase in mass is that the mass (m) at velocity v is equal to the mass at rest (m_o) divided by our old friend the Lorentz shrinkage factor:

$$m = \frac{m_o}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Because m is divided by this factor instead of being multiplied by it, the graph of mass against velocity is Fig. 3 upside down; at speeds not comparable with c it doesn't differ appreciably from m_o, but ultimately it rises to infinity as the speed reaches c.

Obviously that means that nothing having mass can ever reach, let alone exceed, the speed of light. Photons themselves, which are light (I am still using that word to include all electromagnetic radiation), are the only things that can reach that speed, and they have no rest mass at all—if for no other reason than that they are never at rest! Now zero divided or multiplied by any finite number is still zero, but when the velocity $v = c$ then the Lorentz factor becomes zero, and 0/0 can be anything. In the particular case of a photon it can be shown by other means that it is equal to hf/c^2, hf being the " quantum " of energy of the photon, made up of the frequency of its radiation (f) and Planck's constant (h). The photon's energy hf is therefore equal to its mass multiplied by c^2—a fact we'll return to presently.

We left our pie approaching the face of the man in the street with a velocity $v = 0.8c$. He, poor chap, can take no comfort from the fact that this is less than c, which is what it would have been according to what he had been taught at school, because he (having studied Einstein) knows that so far as he is concerned its energy is just as great as he had feared, owing to its increase in mass. So he wisely takes evasive action by retreating with velocity $0.8c$. Relative to him the pie is now at rest, so its mass is m_o only. (He notes, however, that the street and everything attached to it, flying past him at $0.8c$, have become $66\frac{2}{3}\%$ more massive).

Mass, then, joins length and time as a quantity which has no absolute value, but varies according to the relative speed between it and the observer. These three quantities, you may notice, are the three usually regarded as basic—hence the m.k.s. and c.g.s. systems of units.

That is not to say that the relativistic variation in mass is a sort of hallucination, with no reality. The nuclear physicists, who play about with particles at speeds close to c, are obliged to make very real and practical allowance for relativistic mass in the design of their large and expensive equipment. 300kV, which is not very much nowadays, is enough to accelerate an electron to $0.8c$, which makes quite a substantial difference to its mass.

It is fair to mention that an increase in mass of moving electric charges, such as electrons, had been predicted before the theory of relativity—by J. J. Thomson as far back as 1881, and with the actual relativity formula by Lorentz in 1904—but Einstein showed that this was just part of a general law applying to all masses.

If one calculates the kinetic energy given to a body in accelerating it from rest to velocity v as the work done on it, taking into account this dependence of mass on velocity, one arrives at the result

$$\text{kinetic energy} = E_k = \frac{m_0c^2}{\sqrt{1 - \frac{v^2}{c^2}}} - m_0c^2$$

For comparatively low velocities we can use the approximation

$$E_k = m_oc^2\left(1 + \frac{v^2}{2c^2}\right) - m_oc^2$$
$$= \tfrac{1}{2}m_ov^2$$

in accordance with school dynamics.

And in general, as $m_o/\sqrt{(1 - v^2/c^2)}$ is the variable mass m,

$$E_k = (m - m_o)c^2$$

so the *increase* in mass due to acceleration from rest to velocity v is

$$\frac{E_k}{c^2}$$

In other words, the increase in mass is equal to the increase in energy multipled by the very small constant $1/c^2$.

If the masses of the colliding elastic bodies are calculated for the instant when they are both at rest, their deformed shape signifying the stored potential energy which is just going to fling them apart, they are found to be greater by an amount equal to this potential energy divided by c^2. And if alternatively they are assumed to be perfectly inelastic bodies, like lumps of dough, there is again an increase in mass corresponding to the heat energy generated. *Whatever the form any quantity of energy takes, it can be shown to be accompanied by* $1/c^2$ *times that quantity of mass*, over and above the mass of the same body without that energy.

The 64,000 dollar question—no; literally the 64,000 billion dollar question—that follows from this is: If these infinitesimal increases in mass represent changes in energy, what does the comparatively enormous rest mass m, represent?

Einstein's answer, expressed in the simple celebrated equation $E = mc^2$, is that it represents an enormous amount of energy. And you don't need me to tell you how practically this affects every one of us now. The sudden destruction of quite a moderate fraction of m_o is accompanied by the spectacular release of energy in a nuclear explosion, and its more gradual destruction is at this moment running electrical appliances in homes through the activity of Calder Hall.

So it seems that mass and energy are inseparable; two manifestations of the same thing—the basic stuff of the universe. When an electron gains in mass without anything being added to it except speed, that is not really a breach of the law of conservation of mass; it comes from the energy given to it. Whatever has given it that energy must have lost an equal amount of mass. Millions of tons of the sun's mass are streaming off every second into space as radiant energy. They are not lost, for the photons emitted have exactly that amount of mass, due to their speed, c. Some scientists believe that all the time the radiant energy of the universe is condensing back into matter.

To say anything at all after this picture, in which magnitudes range from the great universe itself working as a whole down to the activity of the minutest particles and waves, which are responsible for that working, would be an anticlimax. So I just stop, leaving plenty for the mind to follow up.

Evaluating Aerial Performance

2. Multi-element and Long-wire Systems: Receiving Aerials: Matching

By L. A. MOXON, B.Sc. A.M.I.E.E.

(*Concluded from page 65 of the February issue*)

As pointed out in the first part of this article aerial gain can be calculated with the aid of tables of mutual impedance. This is, in general, complex, but the reactive component can be got rid of by choosing an element spacing of $\lambda/8$, and the calculations then become quite simple and give the results plotted in Fig. 12 (Ref. 2). Note that maximum gain, 5.3dB, requires a phase shift φ of $0.6\varphi_0$ and the gain curve is equally valid for driven or parasitic beam systems except that in the former case it can be applied up to somewhat wider element spacings. With a parasitic reflector, the maximum gain falls to just over 4dB at $\lambda/4$ spacing, the corresponding figure for a director being only about 2.5dB. A simple method of introducing the phase shift is to arrange that the two elements, together with the connection between them (Fig. 11 (b)) are exactly resonant, and move the feed point slightly off centre. This is equivalent to lengthening one element and shortening the other by the same amount, and inserts equal positive and negative reactances, the values of these being given by the $2\pi bZ_0$ formula of Part 1. The resulting phase shift is given in degrees for $\lambda/8$ spacing by $120\pi bZ_0/R_r$, where R_r is the radiation resistance of the individual dipoles. A number of practical arrangements based on this principle have been described elsewhere[2,9]. It follows from the mode of operation outlined above, that Fig. 12 can be drawn as a universal set of curves for pairs of close-spaced equal-current elements, the use of $\lambda/8$ spacing for the calculations being merely a subterfuge to simplify the algebra. It is further evident that it can be applied to elements of any shape so long as radiation takes place mainly in one plane, and provided that the dimensons remain sufficiently small in comparison with half a wavelength. It therefore holds, more or less, for arrangements such as the popular "cubical quad" aerial system. This usually takes the form of a pair of loops of the kind illustrated in Fig. 13; arrows show the direction of current flow, and also indicate, to scale, the relative magnitudes of the fields which each bit of the loop would produce on its own. It will be seen that radiation from the sides involves currents of opposite sign which tend to cancel each other. The two horizontal portions bear some resemblance to a folded dipole, but relative to this they give a 30% reduction of field strength in the vertical direction. This increases the gain slightly, but only to the extent of about 1dB. This figure was obtained by regarding the loop as a 2-element broadside array with rather close spacing for which handbook data is available, but it is also in reasonable accord with the radiation pattern. It is quite easy to show, with the aid of Fig. 6, that a 14-Mc/s quad will give comparable performance at frequencies up to 21Mc/s in spite of a rather untidy current distribution which has given rise to a belief that the quad is a single-frequency system. A 21-Mc/s quad can also be used at 14Mc/s, the loops being roughly equivalent to shortened dipoles of about 28 ohms radiation resistance.

Fig. 13. Single square loop as used in the "Quad" system. Arrows indicate direction of current flow. The portion efoab = bcde = $\lambda/2$. Figures indicate relative fields produced by each bit of the loop in accordance with Fig. 6(a). Main lobe of radiation in direction at right angles to plane of paper. Alternative mounting is with diagonal vertical with feed point at lowest corner.

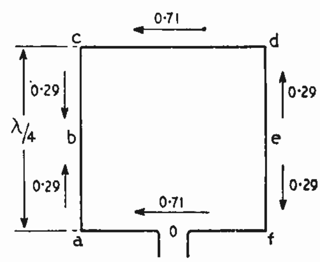
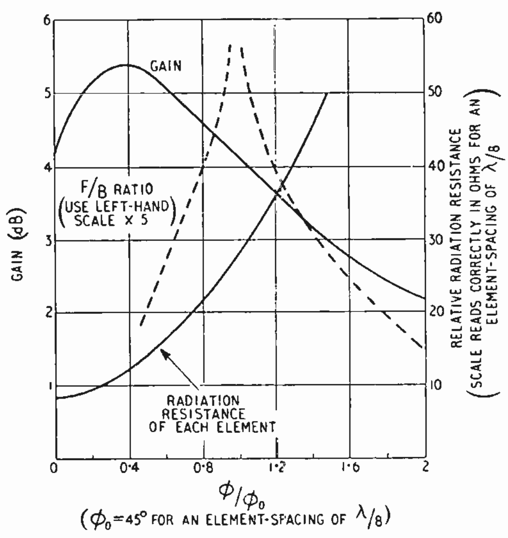


Fig. 12. Variation of gain, radiation resistance and front-to-back ratio with phase angle for pairs of close-spaced, end-fire elements. ϕ_0 is the phase angle corresponding to the spacing. The phase difference between the element currents is $180^0-\phi$.



We now come to the interesting question of what happens with more than two elements. Obviously, the larger the number of elements the more variables we have at our disposal and the larger the number of directions in which the radiation can be made to cancel, to the advantage of those directions in which it does not quite cancel. It is at this point that the process acquires the label of "super-gain" and becomes really fascinating. The gain theoretically obtainable[3] is nearly equal to N^2, which checks quite well with the figure of 5.3dB which was obtained for N=2. Beyond this point the practical difficulties increase rather rapidly, but there is nothing, in principle, to prevent the design of, say, an aerial the size of a matchbox with a gain of a million; for this purpose, however, the matchbox would have to contain 1,000 elements all with zero loss resistance, and the element currents would have to be adjusted to various different values of amplitude and phase with fantastic precision. Having achieved this the bandwidth of the array would be so narrow that it would be impossible to use it for signalling at a useful rate. As another example, one author[4] has designed on paper a 9-element "broadside" version having a gain of 8.5dB based on its directivity, but an efficiency of only 10^{-14} of one per cent at 10Mc/s assuming ½-in diameter, $\lambda/2$-elements. To achieve this the currents have to be adjusted to better than 1 part in 10^{11}!

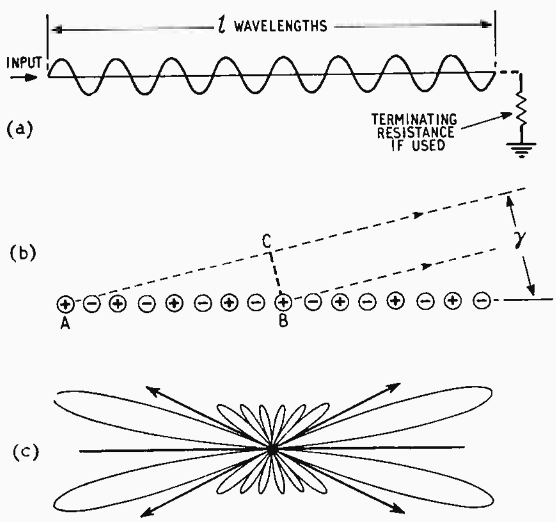


Fig. 14. Current distribution in a long-wire aerial is shown at (a). Standing-wave pattern disappears if aerial is terminated by a suitable load. Average current is then same at all points, ignoring losses. In (b) long wire of (a) is represented by point sources of alternate sign. Radiation in direction AC is zero when AB—AC=$\lambda/2$, which occurs when $\gamma=\sqrt{2/l}$ where l is in wavelengths and γ is in radians. (c) is a typical radiation pattern of a long-wire aerial. Null directions indicated by arrows are those for which $\gamma=\sqrt{2/l}$.

In practice there is some doubt as to how far the process can be carried usefully beyond two elements which, as we have seen, present no problem. A 4-element end-fire super-gain array has been constructed[3], but although fairly wide spacing was used, making the dimensions 0.6λ from back to front, the gain realized was only 8.7dB out of the theoretical 10.2dB, adjustments being critical and the bandwidth only 1Mc/s at 75Mc/s. It seems difficult to reconcile this result with the high gains sometimes quoted for conventional parasitic arrays having three or more elements. Systems of this type are commonly known as Yagi aerials and can give large gains when their length is long in terms of wavelengths. Calculations for an idealized system of this type[5] have predicted a possible power gain of $1.8+5.6l$ where l is the length in wavelengths. The case of 3-element parasitic arrays having equal spacing has been investigated by Walkinshaw[6] who obtained a theoretical gain of just over 7dB, but this entailed the very low figure of about 4 ohms for the radiation resistance, which would present difficulties of impedance matching, and a poor front-to-back ratio. On the other hand reference 3 contains a hint that some improvement might be achieved by the use of unequal spacing.

There is one important class of aerial which, at first sight, appears to require a different kind of treatment. This is the "long-wire aerial," the wires being usually several wavelengths long and arranged in pairs (V-beams) or groups of four (rhombics). Let us first consider the case of a very long wire as in Fig 14(a) with its far end insulated so that a wave travelling down the wire is reflected from the far end and a standing-wave pattern is set up containing numerous current reversals. Such a wire can be regarded as a row of dipoles of alternate sign, as in Fig. 14(b), and for most directions the majority of the dipoles can be paired off with others which give an opposing field so that the effective radiation tends to zero. On the other hand, for directions nearly in line with the wire positive and negative dipoles have their centres nearly half a wavelength apart and thus produce fields which add in phase. The great length of the wire makes up for the low value of $\cos\theta$. Referring to Fig.14(c), note that the main lobes of the radiation pattern are sandwiched between the nulls given by $\gamma=0$ and $\gamma=\sqrt{2/l}$, where l is the length of the wire in wavelengths. The width of these lobes between half-power points is $0.5\sqrt{2/l}$ but a large proportion of the power is radiated in the minor lobes. The power gain is approximately equal to $l/2$.

It is common practice, particularly with rhombics, to terminate the wires in their characteristic impedance, as in Fig.15, in which case there is no reflection and no standing waves, but the finite velocity of the wave travelling down the wire means that at any given instant there are current reversals and, in the direction of travel of the wave down the wire, the field is additive as before. There is, however, no radiation in the opposite direction since, considering any short section of the aerial, the radiation from it is cancelled by that from the corresponding section half a wavelength farther along, which is out of phase having originated half a cycle earlier; this has travelled one wavelength farther, i.e. half a wavelength out and back, and therefore remains out of phase, whereas for the forward direction it has a half-wavelength start

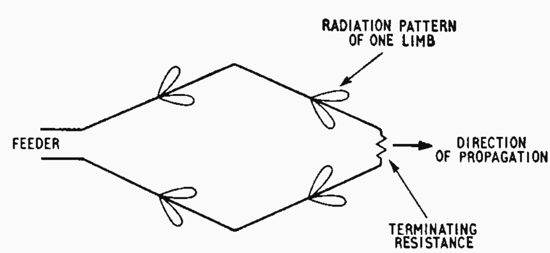


Fig. 15. Terminated rhombic aerial. It consists of four long wires arranged so that lobes in the direction of the arrow reinforce each other.

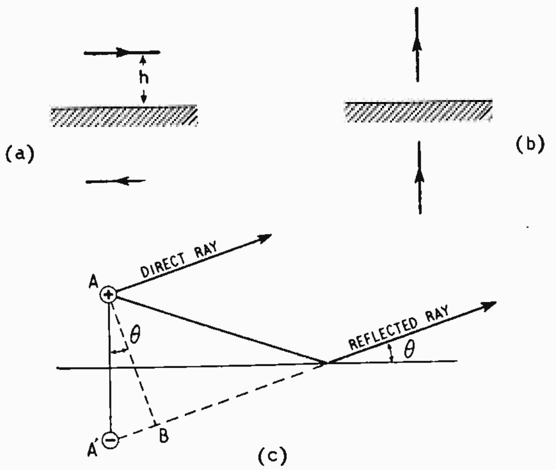


Fig. 16. Illustration of aerial images: (a) due to horizontal dipole and (b) to vertical dipole. (c) represents end view of horizontal dipoles. Note that distance travelled by reflected ray is greater than that of direct ray by distance A′B. Since aerial and image are of opposite sign fields reinforce each other when A′B=λ/2. Perfect "earth" is assumed.

and arrives in the same phase. The energy not radiated backwards is absorbed in the terminating resistance and does not add to the forward-power gain but, conversely, on reception the termination absorbs half the noise power picked up on the aerial and may, therefore, result in a doubling of the signal-to-noise ratio.

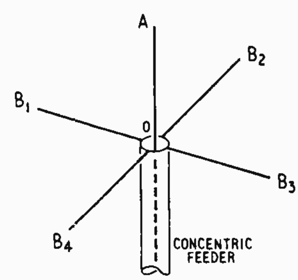
Effect of the Ground.—The ground acts in general as a good reflector of radio waves and therefore, by optical analogy, the aerial must be considered as having an image as shown in Fig.16. This image is to be regarded as a duplicate of the aerial and modifies the radiation pattern so that, referring to Fig.16(c) the radiated field is zero along the ground or when A′B is an integral number of wavelengths, but is equal to twice the free-space field when A′B is an odd number of half wavelengths. For intermediate angles of elevation the field must be worked out from the phase difference corresponding to the number of wavelengths in A′B. Obviously the greater the height the lower the angle of the lowest lobe of radiation. Putting $2h \sin \theta = \lambda/2$, we find that h for an angle of 5° (which is a desirable angle for long-distance propagation at the higher frequencies) is just under three wavelengths. If, however, the ground slopes down at 25° an angle of 30° to the ground will give the required 5° angle of elevation and requires an aerial height of only $\lambda/2$. In practice a height of 20ft only at 14Mc/s with a ground slope of about 20° was found to give near-optimum performance on the long route to Australia, an aerial near the bottom of the slope being just as good as one near the top provided both the aerial and the point of reflection were on the slope. Ground sloping in the desired direction is more or less equivalent to an increase of aerial height, and is a valuable asset for v.h.f. and u.h.f. as well as h.f. communication.

The effect of the ground is much more complicated in the case of vertical polarization. From Fig.16(b) one would expect the radiation to be concentrated at very low angles, but in general this is not the case in practice. The reason is that the representation is only valid for a perfectly conducting earth, fairly high angles of radiation, or comparatively low frequencies. With normal ground it is found that as the angle of radiation is reduced more and more of the reflected wave is absorbed until an angle known from optical analogy as the pseudo-Brewster angle is reached. Below this the reflection coefficient increases again but the image is reversed in sign. This means that for low-angle radiation at the wavelengths used for long-distance communication, assuming level ground, the performance of a vertical aerial is roughly equivalent to that of a horizontal one at the same height.

With a centre-fed vertical aerial the feeder system is liable to present mechanical difficulties since it requires to be brought away from the radiator at right angles. One answer to this problem is the ground-plane aerial, Fig.17. Radiation from the horizontal wires cancels out in all directions, so that the radiatior is effectively half of a dipole. It has been shown that the radiation pattern of short elements is nearly the same as that of a half-wave dipole regardless of the precise shape of the current distribution and the ground-plane aerial is no exception to this. Being half the length, however, it requires twice the current to produce the same field and must therefore be assumed to have a radiation resistance of 18.3 ohms, although the figure usually quoted is slightly higher, about 22 ohms. It is important to realize that the so-called ground plane is merely a device for matching the aerial to an unbalanced feeder; it is not a substitute for the actual ground, and has no reflecting properties.

In certain handbooks a distinction is made between the "free space directivity gain" with which we have been concerned hitherto, and the

Fig. 17. Ground-plane aerial. OA is a λ/4 vertical radiator, OB_1, OB_2 etc. are three or four equally spaced horizontal radials, each λ/4 long.



"practical DX signal gain." This appears to be nowhere fully explained, but seems to arise in part from the practice of comparing vertical stacks of dipoles with single dipoles at the same average height. Because of the relatively complicated geometry, the nulls in the vertical pattern may not occur at exactly the same angle in both cases, and large differences either way may be observed at certain angles of elevation. There is another effect which may account for apparent changes of gain with height, amounting to about ±1.5dB for aerial heights greater than 0.18λ; this is due to the mutual coupling between the aerial and its image, which causes the radiation resistance of a horizontal dipole to vary with height between limits of about 60 and 100 ohms. This causes a variation in current, and therefore of the field at a distance. Beam aerials tend to radiate less energy upwards and downwards which means in general that there is less coupling between the aerial and its image; the "8JK" aerial provides a simple illustration of this because the two image elements must obviously induce nearly equal and opposite currents in each of the real elements, assuming that, as usually is the case, the spacing is small compared with the height. This almost completely removes the variation of radiation resistance with height, the apparent changes in gain being due to the reference dipole. Another possible cause of gain variation, in reception, is non-uniformity in the field surrounding the aerial. This could be due to reflections from neighbouring objects, e.g. telephone wires, and would of course affect the gain equally in the case of tranmission. This effect is one of the causes of error in gain measurements as discussed by Strafford[1]. These effects will usually be small and may work in either direction. There is no justification for the belief that beam aerials may give large gains due to the "lowering of the angle of radiation" *in addition* to their free space gain.

The Effective Receiving Gain of an Aerial.—With modern receivers the range of reception is normally limited by the strength of the background noise, and not by lack of sensitivity. This means that aerial gain is of no value as such, and it is quite common to sacrifice gain in order, for example, to improve the back-to-front ratio.

The problem in reception is to achieve the best possible ratio of wanted signal to noise or interference. For this purpose the proper criterion of aerial performance depends on the nature of the unwanted background and may consist of the power gain, the directivity gain (which is the same as power gain if there are no losses), the depth of nulls in the radiation pattern, or more probably some rather complicated function of the directivity. These cases will be considered in turn, and it will be shown

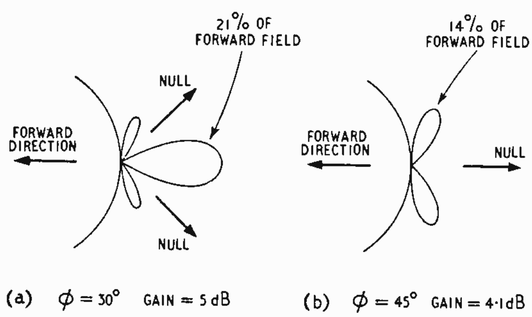


Fig. 18. Effect on back radiation of alternative phasing. Angle over which field is reduced to 10% is greater when gain is higher although nominal back/front ratio is poor.

that, as an index of performance, the nominal back-to-front ratio is more likely to be misleading than otherwise.

At frequencies greater than 100Mc/s or so signals are mainly interfered with by noise generated in the receiver, and the signal-to-noise ratio is then directly proportional to the power gain of the aerial. This situation may be affected in the foreseeable future by the introduction of new low-noise amplifiers such as masers and parametric devices.

A very similar situation exists if the sources of noise are external to the receiver but are uniformly distributed in space. Halving the aerial beam width halves the number of sources which contribute to the noise level but doubles the aerial gain and therefore the strength of those noise sources which are within the beam. The received noise power is therefore independent of beam width, and signal-to-noise ratio is again directly proportional to aerial gain, but this time it is the gain as calculated from the directional pattern, losses in the aerial or feeder system being of no account since they act equally against signals and noise. The losses cannot, however, be allowed to increase indefinitely since, depending on the noisiness of the receiver, a point will eventually be reached where reception is limited by receiver noise or the thermal noise of the aerial loss-resistance[7]. This case is typical of normal reception against a background of galactic or atmospheric noise, although the spatial distribution of such noise is not strictly uniform and this may sometimes have to be taken into account.

The next case to be considered arises when reception is limited by noise or interference from one particular source. Provided the two signals are not in the same direction, the unwanted one can in principle be phased out with at worst some reduction in the level of the wanted one. This can be done either by means of two aerials, with appropriate adjustment of relative phases and amplitudes, or by making use of nulls in the radiation pattern. These nulls occur in the end-on directions and in other directions depending on the phase shift; Fig.12 shows one such null occurring in the 180° direction for a phase shift of ϕ_o, which is the much sought after "infinite front-to-back ratio" condition. Referring now to Fig.18, it is interesting to observe what happens as ϕ is reduced; the nominal front-to-back ratio drops to about 4 to 1 but *two nulls have now appeared instead of one*. The gain is higher, which is useful if the aerial is also to be used for transmission, and moreover, we are free to select whichever null gives least reduction of the wanted signal relative to noise or other interference. One obvious application of this technique would be in television reception for the removal of ghost images caused by one or two indirect signal paths.

If interference is likely to come equally from all direction it might be thought reasonable to treat it as omni-directional noise, and the ratio of average signal to average interference power will of course be equal to the directivity gain. This is not, however, the correct approach if it is required, for example, to separate weak wanted from strong unwanted signals. It is obviously useless to reduce the strength of an unwanted signal merely by a factor of 10 if it is 100 times stronger than the wanted signal! The objective therefore is not to reduce the average level of interference but rather to reduce the number of occasions on which unwanted signals exceed the level of wanted ones. A deep but narrow null in the radiation pattern, unless it can be moved at will, is of very little use for this purpose; on the other hand, reduction of say 10 to 1 or more in field strength over a wide range of angles is of great value and by this criterion the higher gain pattern shown in Fig.18 is slightly better. In one typical case, the reception of amateur signals from Australia via South America in the presence of short-skip interference from Europe, the author has found a parasitic beam to be just as good in practice as a driven arrangement, despite the in-

(*Continued on page* 143)

equality of element currents which causes partial filling in of the nulls. This is, of course, to be expected if angle is more important than depth of rejection.

Interfering signals vary in amplitude between very wide limits; they are almost as likely to exceed a weak wanted signal by 20dB as by 10dB, and may well be as much as 60dB stronger, so that to make a large reduction in the number of occasions on which interference occurs the response of the aerial in unwanted directions must also be reduced by a large amount. Higher gain means that weaker signals can be received and correspondingly greater discrimination is therefore required against strong unwanted signals. These arguments underline the need to reduce the general level of side lobes of high-gain receiving aerials, even if this has a negligible effect on gain.

Feeder Losses.—Consider the case shown in Fig. 19 of a source of power having an internal impedance R_1 connected to a load R_2 through a line having a characteristic impedance Z_0. If $R_1=R_2=Z_0$, and there are no losses in the transmission line, all the power available will be delivered to the load. If now the load is changed to some new value, power is reflected from the load and on its way back, interacts with the wave travelling towards the load to produce a standing wave, i.e., varying amplitudes of current and voltage along the line. If the load remains resistive, the new value being R_2', the ratio of maximum to minimum current along the line is equal to R_2/R_2' or R_2'/R_2, whichever is greater. This ratio or its reciprocal is known as the standing wave ratio or s.w.r. The alteration made to R_2 means that the generator now "sees" a less suitable value of load impedance and delivers less power, the mismatch loss being given as a power ratio[1] by $(1+\sigma)^2/4\sigma$ where σ is the s.w.r. This loss is significant in cases such as TV reception since, in the absence of matching adjustments at the receiver, it reduces the ratio of signal to internally-generated noise. It is not, however, applicable in the case of a transmitter supplying power to an aerial, since the mismatch is usually taken care of automatically by adjusting the aerial coupling to obtain correct loading of the transmitter. When this is done, it follows that if the line has zero resistance all the power leaving the transmitter must reach the aerial because there is nowhere else where it can be dissipated. The distinction frequently made between a "matched" and a "resonant" feeder, is not basic, as sometimes represented, but related in some arbitrary manner to the degree of mismatch coupled with the absence of "matching devices." A typical example of a "resonant" feeder system would be an open-wire line of about 600 ohms impedance feeding a half-wave dipole, the s.w.r. being then given approximately by 600/73, i.e., just over 8 to 1. Sometimes a resonant feeder is used from the aerial to some point such as ground level, at which adjustments can be made, and it is there matched into a non-resonant line which can be as long as necessary; one such case is recalled in which a certain successful aerial system having an s.w.r. of possibly 100 to 1 in the "resonant" portion was publicly criticized, without contradiction, on the grounds of a 3 to 1 s.w.r. in the non-resonant part of it!

Generally speaking the intensive efforts so frequently made to reduce s.w.r. to near unity, in the case of amateur transmitting aerials, bring very little reward in the shape of increased radiation efficiency. High s.w.r. does not in itself introduce losses, although it does accentuate any series resistance losses which may be already present in the line. The reason for this is apparent when we recollect that losses in a resistance are proportional to the square of the current. Series resistance tends to be uniformly distributed along the line, and an s.w.r. of 4 means that the current varies between twice and a half its value for the matched condition; there is thus a 4 to 1 increase of loss in parts of the line, and this is counterbalanced to only a small extent by the reduction of losses to a quarter at the current minima. For standing wave ratios up to

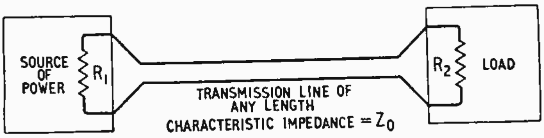


Fig. 19. Source of r.f. power connected to a load via a transmission line.

3 to 1 the extra loss in decibels never exceeds 40% of the matched-line loss, and reaches a maximum value of about 1.2dB when the matched-line loss is large. At 5 to 1 s.w.r. the corresponding figures are 100% and 2.5dB.

Other disadvantages of resonant or mismatched feeders include narrow bandwidth, as previously discussed, and in some cases the possibility of voltage breakdown or excessive heating. The reduced overall bandwidth may be unacceptable in the case of television reception, particularly as it is likely to be associated with picture defects caused by multiple reflections in the line, and in amateur transmission it can be a nuisance owing to the necessity of retuning the transmitter when small changes of frequency are made. A high s.w.r. increases the dielectric and leakage losses in a low-impedance feeder, in much the same way as it increases the series loss since the voltage wave along the feeder varies in a similar manner to the current wave although displaced from it by $\lambda/4$. In the case of an open-wire line, however, standing waves can sometimes be used to reduce losses of this type by placing the insulators at low-voltage points in the system.

The following example of a 700-ohm line in use by the author provides a simple illustration of the calculation of feeder losses. The length is 100 metres and the wire is 20 s.w.g. which is much thinner, and also much cheaper, than the 14 s.w.g. normally recommended. From Fig. 5, the loss per half wavelength at 15Mc/s (20 metres) for one wire is 3.4 ohms. The total loss resistance therefore is equal to this multiplied by 20, i.e., 68 ohms. With the line matched, this loss-resistance can be regarded as more or less in series with the terminating resistance so that 1/11 of the total power into the line is lost. This amounts to just over 1/3 of a decibel, rising to 0.5dB at an s.w.r. of 3. At 28Mc/s the loss rises to 0.5dB, if the line is matched, or 2dB—just noticeable in terms of signal strength reports—if the line is used as a resonant feeder to a half-wave dipole. There is, of course, some loss by radiation from an open-wire feeder, but this is usually very small and would amount in the above example to an additional loss resistance of only 1 or 2 ohms.

Out-of-balance currents can, however, cause a considerable loss by radiation, and can be caused by anything which disturbs the symmetry of an aerial system. When coaxial cable is used for transmitting it is important to ensure that no currents flow on the outer of the cable, in other words voltage should not be induced from the transmitter, or the radiator itself, into the aerial-to-ground path formed by the outer conductor. This is, of course, similar to the requirement, for reception, that currents induced in the outer conductor must not be allowed to flow through the receiver input circuit. To this end the feeder should be brought away from the aerial for a considerable distance at right angles, but in the case of a vertical dipole of tubular construction it can be brought down through the centre of the lower half. An approximation to this last arrangement is obtained with a ground-plane type of construction when the radials are allowed to slope downwards. The lower end of the feeder should be firmly earthed to the case of the transmitter or receiver. As a further precaution the path to earth via the outer conductor can be made non-resonant by adjustment of feeder length.

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BOOKS RECEIVED

The Services Textbook of Radio. Volume 5 Transmission and Propagation by E. V. D. Glazier, Ph.D. (Eng.), B.Sc., A.M.I.E.E. and H. R. L. Lamont, Ph.D., M.A., A.M.I.E.E. Deals with the propagation of electromagnetic energy on transmission lines, in waveguides, and in free space. Practical as well as theoretical aspects are covered and chapters are devoted to waveguide components and couplings and to aerial systems for all useful frequency bands. The text is arranged and marked for reading at elementary, intermediate and advanced levels. Pp. 500; Figs; 425. Price 25s. H.M. Stationery Office, York House, Kingsway, London, W.C.2.

Basic Electricity by Van Valkenburgh, Nooger and Neville, Inc. Treatise in five parts designed originally as a course of training for U.S. Navy technicians with no previous knowledge of electricity. The text is profusely illustrated with simple diagrams in which the approach is often anthropomorphic. The present series has been Anglicized and adapted for British and Commonwealth use by a team of the Royal Electrical and Mechanical Engineers. Pp. 120 (approx.) per volume. Price 12s 6d per part or 55s per complete set. The Technical Press Ltd., 1 Justice Walk, London, S.W.3.

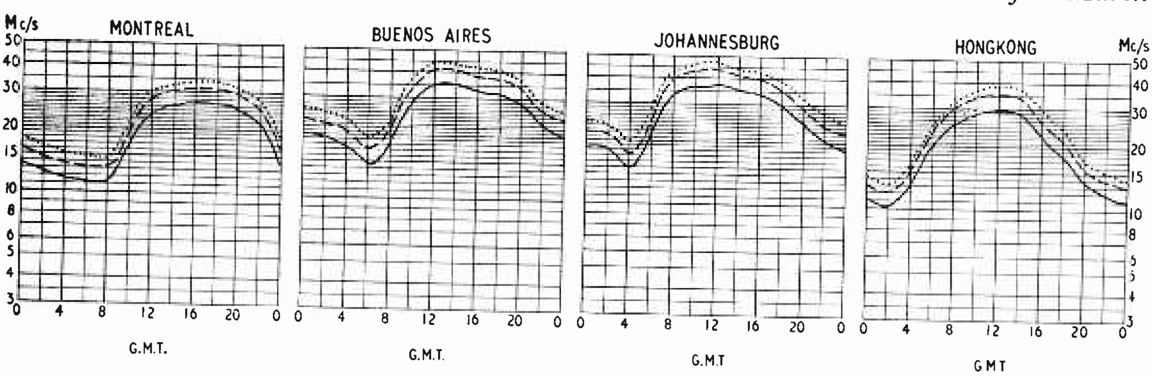
Basic Electricity for Communications by W. H. Timbie and F. J. Ricker. Second edition of a textbook on d.c. and a.c. circuits and conduction in gases and semiconductors. Numerous worked examples show the application of basic laws. Pp. 538; Figs 450. Chapman & Hall, 37 Essex Street, Strand, London, W.C.2.

International Radio Tube Encyclopædia by Bernard B. Babani. Third Edition (1958-59) containing data of 27,500 types including transmitting and microwave types. Pp. 768. Price 63s. Bernards (Publishers) Ltd., The Grampians, Western Gate, London, W.6.

Tube and Semiconductor Selection Guide 1958-59. (Philips' Technical Library). Compiled by Th. J. Kroes. Simplifies selection of preferred types in the Philips range for any given purpose and indicates possible replacements for obsolete types. Pp. 160. Price 9s 6d. Obtainable through the Cleaver-Hume Press, Ltd., 31 Wrights Lane, London, W.8.

SHORT-WAVE CONDITIONS

Prediction for March



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

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

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

— — — PREDICTED AVERAGE MAXIMUM USABLE FREQUENCY

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

The Bifilar-T Circuit

By THOMAS RODDAM

An Important Filter Investigated from First Principles

(Concluded from page 71 of February issue)

WE saw last month that the bifilar-T circuit is not really novel at all, but is, if used properly, an economical way of building a perfectly ordinary filter using a long-known equivalent circuit. The shape of the rejection peak is just what you can get with any other equivalent of the same basic network, provided that resistance cancellation is used to push the attenuation up. Just to see what happens let us take the simplest network which might do the job and turn it into a lattice by means of Bartlett's Bisection Theorem. There it is, in Fig. 15, large as life and twice as natural. If you compare this with Fig. 11 (last month's issue) you see that you have lost the freedom to produce the curve in Fig. 11(a) with C_B less than C_A, because that L_2C_2 must produce a real frequency of infinite attenuation. This is a normal limitation when a ladder is used in place of a lattice. It does not worry us, though, because we do want that peak. The circuit values are all positive, of course, and it is easy to see from what we calculated above that L_2 should be about 1/10th of L_1.

The reason why negative element values are not needed is that I have been quite content to neglect the sense of the output terminals. The bridge shown in Fig. 16 shows that there is not any real justification for associating one input terminal with one output terminal. I do not feel sufficiently interested in this matter of phase reversal to work out the answer. If you happen to care, the shape of the image phase characteristic is in the book and all you have to do is work out the phase shift at one convenient frequency, such as zero, or infinity, or a resonance, and displace the standard curve accordingly.

I must digress for a moment. A couple of paragraphs back I made use of Bartlett's Bisection Theorem, comforting myself with the knowledge that it is in the books for you to look up if you will not trust me. Unfortunately it is only in some of the books, and anyway we do not really need it here. Look back to Fig. 15(a) and imagine, if you will, that a perfect centre-tapped coil, of infinite inductance and unity coupling between the two halves, is added in parallel with L_2C_2. Obviously this cannot alter the conditions at all; since the inductance is infinite it cannot affect the behaviour of the circuit in any way. However, we can now carry out the operation shown in Fig. 14 and transform L_2C_2 into a lattice form, in which, of course, Z_b is infinite. Then using the transformation of Fig. 5 we bring the L_1C_1's into the lattice. The only difference is that this time, since I did not have

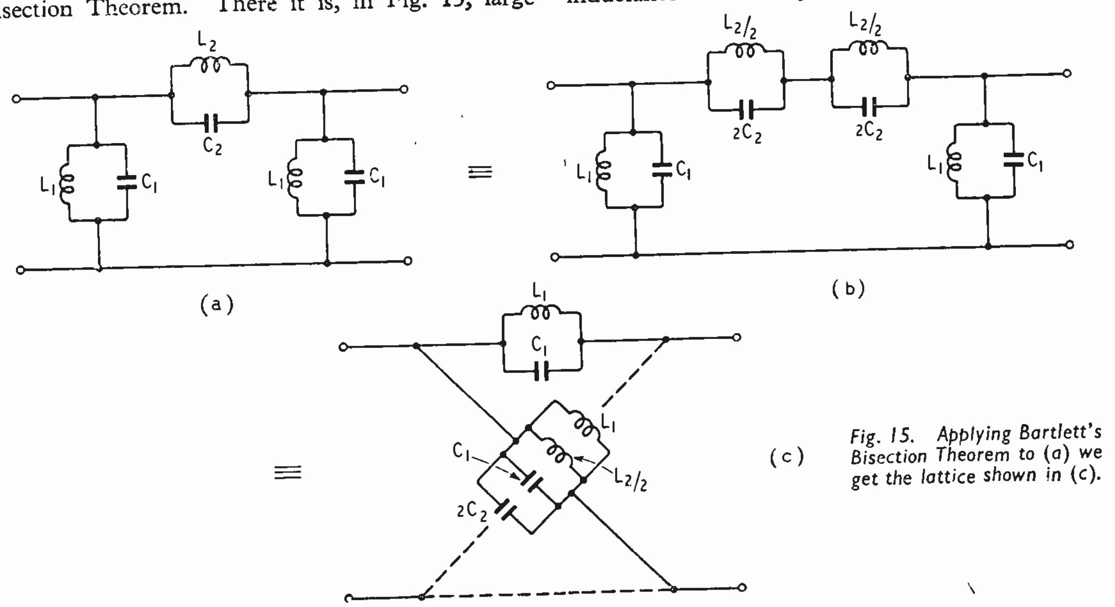


Fig. 15. Applying Bartlett's Bisection Theorem to (a) we get the lattice shown in (c).

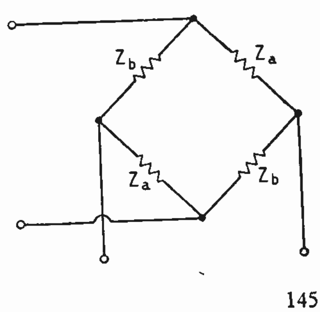


Fig. 16. Drawing the lattice as a bridge emphasizes the essential symmetry of the arms.

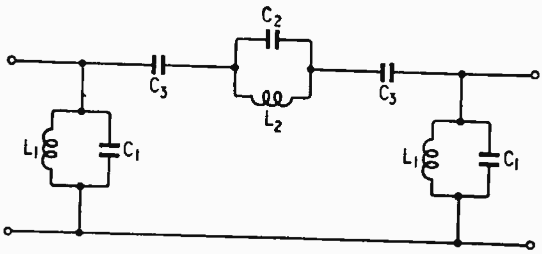


Fig. 17. Adding C_3, here split to preserve the symmetry, to the network of Fig. 15 will give a worth-while improvement.

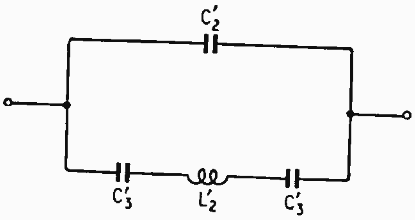


Fig. 18. This configuration is an equivalent for the series arm in Fig. 17.

to try to remember Bartlett's Theorem, the output terminals are crossed over.

The digression in the last paragraph was intended to show how these simple equivalences can be used to establish circuit conditions very easily. I do not think it is really necessary for me to show, by exactly the same reasoning as that used in the last paragraph, that a resistance R connected from the centre-point of L_2 can be called $Z_b/2$ in Fig. 14 and thus introduced as 2R across each of the lattice arms made up of L_1 and C_1 only. This resistance is used to balance the loss in L_2. You can do this calculation by a T-T transformation, but although I actually did this in these columns a good many years ago, the lattice treatment is much simpler and much more elegant.

From the discussion above it seems fairly clear that the bifilar-T, to do the job claimed for it, needs these end circuits and that it is, in fact, nothing more or less than a rather complicated way of making a simple full section of an unsymmetrical band-pass filter. I do not imagine the phase reversal is important, but an extra winding on the inductance at either end would do this equally well and it would be possible to save one element. If the phase reversal is not needed the element saved is a double-wound coil, which, although not expensive, must still cost something.

It is thus rather a problem to find the advantage of the bifilar-T network. I would expect the values to be more convenient in the π-network, because the inductance ratio is halved. Tuning in the π-network is more direct, with the top arm actually tuned to the notch frequency. The near edge of the pass-band is then fixed by the inductance ratio, but the tuning of the end circuits does not affect the notch. With the bifilar-T all the elements seem to control the position of the notch. The actual shape of the characteristic is the same for both circuits if they are designed to the same rules. Even the limitations on resistance cancellation seem to be the same. I must confess that I did not expect to reach this conclusion when I began to examine the bifilar-T, but I am now convinced that it is just a dreary old filter circuit dressed up in a new package. The chief feature of the new package is, indeed, the complete lack of design data.

The effect of leakage inductance in the bifilar coil, especially if one were to choose to work with less tight coupling, and of an appropriate capacitance in the top arm to provide both d.c. blocking and an additional impedance element, might be considered. After sketching out the appropriate variants on Fig. 11 I decided that the results were not of sufficient interest to discuss in any detail. The chief reason for this is that these extra elements appear in both arms of the lattice and thus lead us to rather restricted structures. It is for the reader to follow this up if he will, but I fear he will find that his principal satisfaction came in travelling hopefully.

Two topics seem to follow naturally on from the discussion of the bifilar-T and its equivalent ladder network. The first is the question of slightly more elaborate notch systems, elaborate in the sense of having more complex reactance diagrams. The obvious step is to add a single capacitance element in the series arm of the filter. To get the symmetry needed for ideal resistance cancellation, if we really want this, the capacitance must be split, and in drawing Fig. 17, and its footnote Fig. 18, I have assumed that we shall want this symmetry. I am not showing the equivalent lattice network diagrams as a figure because here again we have one of the standard filters of network theory. This structure, indeed, provides what is called a confluent band-pass characteristic, which means that in general it has two pass bands but that in practice you always arrange them side by side, flowing together. Although it is not a symmetrical filter, it is more symmetrical than the one we have been discussing up to now. Whether the top arm of Fig. 17 is used or whether you use Fig. 18 is something you have to calculate for each application. Sometimes it is convenient to take the coil shunt capacitance directly into the network, as in Fig. 17: sometimes Fig. 18

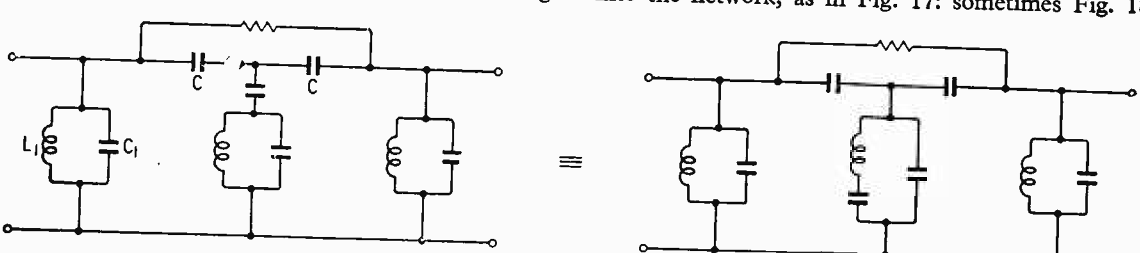


Fig. 19. Two variants of a circuit sometimes used. In practice the compensation resistance must not be allowed to leak anode voltage to the following grid.

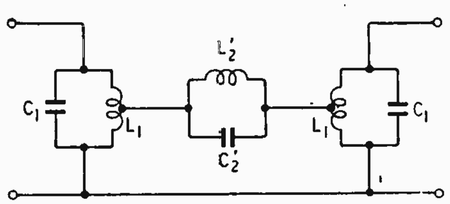


Fig. 20. The circuit of Fig. 15 (a) may give awkwardly high values of L_2. This is one way of getting a lower value.

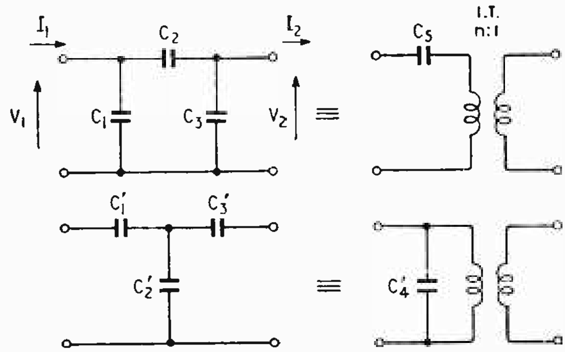


Fig. 21. These two equivalences may often be used to provide more easily realized elements.

gives more convenient values. The arrangement shown in Fig. 18 is slightly more convenient for adjustment, since L'_2 can be tuned with C'_3 to the centre of the pass-band, which is also the anti-resonant frequency of L_1C_1, and then C'_2 is tuned to give the correct peak frequency. In Fig. 17 we must either alter C_3 or dodge backwards and forwards between L_2 and C_2, each of these affecting both band-centre and peak frequencies. All the design formulæ are in the standard reference books.

There is a considerable temptation at this point to discuss those natty little shunt absorber circuits which some designers like. The two variants shown in Fig. 19 are electrically equivalent. Although they look fairly simple they do take slightly longer in computation, still using the standard books, than the network of Fig. 17, though I do not think there is much to choose in performance. The reason for the extra work is that you must first consider L_1C_1 and part of C as a half-section of a filter, then treat the middle bit with the rest of each C and the shunt arm as a full section of a different kind of filter, and then put the whole lot together. Mind you, it is nothing to the time you could spend messing about measuring characteristics with lots of different coils if you did no calculations at all. Time spent in reconnaissance, the manual says, is seldom wasted, and nowhere is that more true than in circuit design.

There are, no doubt, other ingenious notch circuits which may be considered, but I cannot offhand think what they are. In ordinary i.f. use they will all be connected between tuned anode and tuned grid circuits and I shall be very surprised if they do not all turn out to be quite conventional filter networks. In audio-frequency work we sometimes wish to put a notch into a system of such a large bandwidth that this approach is not appropriate. Frequently, too, we are actually working between resistive terminations. Here we have the case of a first order filter designed to provide a stop band and I have already covered the theory of this, the simple first order filters and the frequency transformations, in "Filters Without Tears" (August, September, November and December issues, 1954).

Sometimes one hears the objection that the design of these interstage networks by conventional filter theory leads to impossible values of components. The objector is usually a man who has muddled up a circuit by trial and error and has then declared himself happy with a much poorer performance than the one he specified for his calculations. If we take the circuit of Fig. 15(a) as an example, there is rarely any trouble about L_1 because this is just the usual anode or grid inductance we have in any ordinary amplifier. It is always L_2 which causes the trouble. One way in which the value of L_2 may be reduced is shown in Fig. 20. For example we might centre-tap L_1: the impedance level would be reduced to one quarter, so that $L'_2 = L_2/4$ and $C'_2 = 4C_2$.

The other way which can sometimes be used to make component values more convenient is to use a capacitance transformation. It was obvious in Fig. 20 that what we really did was introduce an ideal transformer in parallel at a different impedance level from the ends. If we consider the first pair of networks in Fig. 21 we can write

$$V_1 = (1+C_3/C_2)\,V_2 + 1/j\omega C_2\,I_2$$
$$I_1 = j\omega\,(C_1(1 + C_3/C_2) + C_3)\,V_2 + (1+ C_1/C_2)I_2$$

and
$$V_1 = nV_2 + 1/j\omega nC_5\,I_2$$
$$I_1 = 1/n\,I_2$$

There are several ways of arriving at these equa-

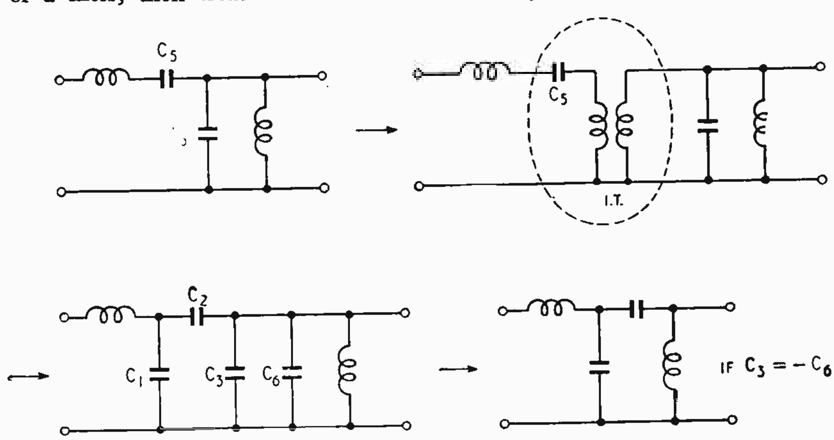


Fig. 22. An ideal transformer is introduced into the middle of a conventional half-section band-pass filter.

tions and I do not want to use up space on such a straightforward operation. If now we put $C_2/C_3 = \kappa_3$ and $C_2/C_1 = \kappa_1$ we can go on to demand that both pairs of equations should be identical. Again I skip the algebra to tell you that the answer in first stage of boiling down is:

$$nC_5 = C_2$$

$$\frac{\kappa_1}{\kappa_3}\,\frac{1+\kappa_3}{1+\kappa_1} = n^2$$

$$\text{and } 1 + \kappa_1 + \kappa_3 = 0$$

This last equation implies that either C_1 or C_3 must be negative. In fact

$$\kappa_1 = n/(1-n) = -n/(n-1)$$
$$\kappa_3 = -1/(1-n) = 1/(n-1)$$

Thus if n is greater than unity C_1 is negative, and if n is less than unity C_3 is negative. The equations for the other transformation are obtained in the same way and you will find them in Shea's book. The negative capacitance is rather a nuisance though it should not cause any more alarm than does the $-M$ in a conventional transformer. But you do have to find a positive capacitance to marry it in with. In the sequence shown in Fig. 22 an ideal transformer is put into the middle of a constant -κ half-section band-pass filter. Ideal transformer plus C_5 is equivalent to the π of capacitors $C_1C_2C_3$ shown in the third diagram. If we have a step-up in the transformer C_3 will be negative, because n will be less than unity. We can choose the value of n to make $C_3 = -C_6$, so that the parallel end capacitance vanishes and we are left with the very simple network you see in Fig. 22. In one particular design this gave a ten-to-one step-up and was terminated in the losses of the end inductance.

The other topic which arises from consideration of the bifilar-T is the general use of coil-pairs in filter networks. I propose to treat this as the subject for a separate article because I have to meet a man in a glacier to morrow, and anyway I do want my notes.

In this study of the bifilar-T trap and matters which arise from it I hope I have conveyed to some readers at least the importance of making full use of the elementary filter theory which is in every book. The transformations used for twisting the circuits around are not difficult and once you have twisted the circuit into a standard form you can always find equations for the values in the standard references. If you want a superior design there is a great deal of superior filter theory available. Certainly you will not do any better by just using coils you have handy and hoping for the best, and if you cannot put numbers into a simple formula you just ought to give up design work.

An Interim Statement on the International Geophysical Year

By T. W. BENNINGTON*

IN a booklet published by the Royal Society† an interim statement is made concerning some of the I.G.Y. achievements. The main impression one gathers from this is that, during a period of record high sunspot activity which provided a unique opportunity for the study of solar-terrestrial relationships, a vast programme of observational work was satisfactorily accomplished, but that it is much too early yet to attempt to discern even the outstanding results of this work. Nevertheless matters of interest have arisen in each of the 15 scientific subjects studied in this country, and among them are some closely connected with radio.

The arrival in the earth's atmosphere of ultraviolet rays, X-rays and charged particles from the sun is of importance in radio because of the effects of these radiations upon the ionosphere, both in maintaining the structure of the ionized layers and in disrupting it. The latter aspect was studied by means of special observations made when it seemed likely that exceptional outbursts of solar radiation would occur. To ensure this 38 sequences of "alerts" were issued on a world-wide basis, and these culminated in 43 "special world intervals", during which the observations were made. Not all of these did, in fact, coincide with unusual solar activity, though it seems likely that a few exceptional outbursts were fully observed.

A vast measurement programme has been carried out upon the ionosphere, which included vertical sounding by pulsed radio signals, studies of absorption using radio waves from radio stars and reflections from meteor trails, and measurements of atmospheric noise produced by lightning flashes. At Halley Bay, Antartica it was observed that in winter, despite the fact that at the layer height the sun never rises, the F_2 electron densities at noon are ten times greater than those at midnight, whilst in summer, when the sun never sets, the maximum density at noon is less than that at midnight. The maximum density at noon is, in fact, greater in winter than in summer, whilst at the equinoxes there is a sudden change from winter to summer conditions. It is concluded that, since the direct ionizing action of the sun is small, these variations in ionization are mainly due to movements in the ionosphere, and that in winter the layer is replenished by horizontal movements of ionization.

Studies of solar activity made in the U.S.A. and U.S.S.R. appear to indicate that when a solar flare occurs—such as may give rise to a sudden ionospheric disturbance—there is a sudden conversion of magnetic energy in the sun into wave and particle energy, for the magnetic lines of force undergo a sudden redistribution.

Many data on the earth's magnetic field have been obtained, the main use of which will begin when they can be correlated with simultaneous observations of aurora, the ionosphere and activity on the sun, and some of which may help to define the position of the electric currents in the high atmosphere which are responsible for geomagnetic—and ionospheric—disturbances. The auroral observations appear to indicate that displays of aurora australis and aurora borealis progress very similarly, and that the aurora penerates farthest towards the equator in the "summer" hemisphere.

* Research Department, British Broadcasting Corporation.

† "Some International Geophysical Year Achievements", The Royal Society, December, 1958.

News from the Industry

Thorn-Philco—Under an agreement with Philco International Corp., of New York, all its "radio and monochrome television engineering knowledge, designs and developments will become available through a licence to Thorn Electrical for manufacture and sale of these products in the United Kingdom." Thorn also acquires all the issued capital stock of Philco (Overseas), Ltd., Philco's manufacturing unit in this country, which also owns the U.K. sales company Philco (Great Britain), Ltd. Thorn Electrical will manufacture export receivers under the Philco trademark for Philco International's overseas distribution. Thorn will also manufacture and sell sound and television receivers and radiogramophones, under the Philco trademark in the U.K. Philco is now added to the names of Ferguson, H.M.V., Marconiphone, Champion and Avantic, already in the Thorn group.

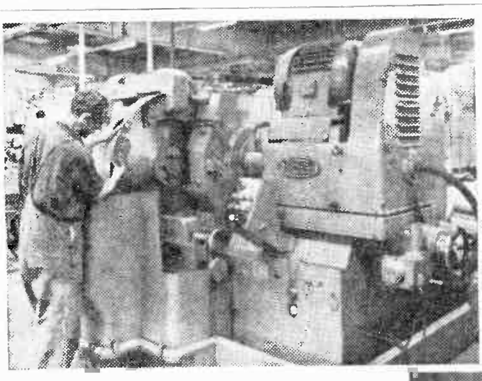
Cossor Radar and Electronics, Ltd., have moved from Highbury, London, to new premises in Harlow New Town, Essex. The company has for some time occupied two small factories in the New Town, and to these has been added a large third factory. The site covers some nine acres and the factory, which has a floor-space of 95,000 square feet, houses the principal research and development laboratories and workshops, the main production unit, and the administrative and sales offices.

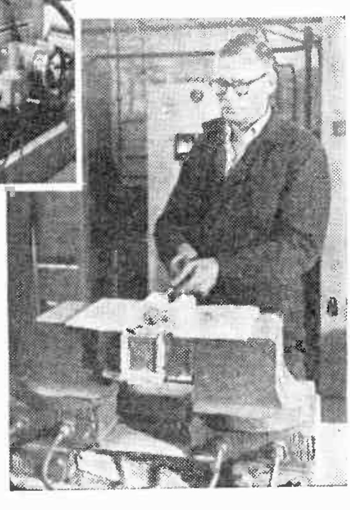
International Computers & Tabulators, Ltd., is the title under which the recently merged British Tabulating Machine Co. and Powers-Samas Accounting Machines will trade. In the field of electronic calculators and computers both of the original companies are associated with concerns specializing in electronic developments. B.T.M. are associated with the G.E.C. (they jointly own Computer Developments, Ltd.) and Powers-Samas with Ferranti. B.T.M. also have a link with Laboratory for Electronics, of Boston, U.S.A. I.C.T.'s main manufacturing establishments are at Letchworth, Croydon and Castlereagh (N. Ireland).

Ferranti-designed klystrons are to be manufactured in the U.S.A. under an agreement concluded between Raytheon Corporation, Ltd., of Boston, Mass, and Ferranti, Ltd. A sum of $250,000 is involved in this sale of British "know-how" to the United States of America. The agreement involves two tubes used in Doppler radar systems. They are intended for use in military equipment and production in the U.S.A. is expected to begin early in 1960.

Marconi's have received a contract from the Ministry of Supply for v.h.f. direction finders for a number of civil airports and airfields in the U.K. The type ordered is AD210C, the first of a new series of automatic d.f. equipment developed by Marconi's.

Permanent Magnet Production





Plant for the production of permanent magnets by the English Steel Magnet Corporation, Ltd. (a subsidiary of the English Steel Corporation) has now been concentrated at North Street Works, Openshaw, Manchester, where the latest equipment for heat treatment and grinding has been installed. The pictures show (top, left) a Roland duplex grinder and (bottom, right) the cooling of magnets in a magnetic field to induce anisotropic properties.

Sperry Gyroscope Co., of Brentford, Middlesex, announce a substantial re-organization. The main objective is a de-centralization of management and the establishment of three separate operating divisions each with its own sales, design and manufacturing organization. These three divisions will be known as the Brentford, Bracknell and Industrial Divisions. The Brentford Division will be responsible for the company's aeronautical, marine and naval activities, the Bracknell Division will concentrate on Government contract work for guided weapons and inertial navigation, and the company's interests in industrial control engineering will be concentrated in the Industrial Division. M. L. Jofeh, formerly the company's chief engineer, is manager of the Industrial Division, Wing Commander J. C. G. Bell, manager of the Brentford Division, and H. B. Sedgfield, manager of the Bracknell Division.

Radio Rentals.—The net profit of the Radio Rentals Group for the year ended last August, after deducting £911,947 for taxation, totalled £824,940—an increase of £219,221 on the previous year. The group's manufacturing subsidiary is Mains Radio Gramophones, Ltd., of Bradford, Yorks.

Burnhope.—All the main transmitting equipment, including the aerial system, for the recently opened I.T.A. station at Burnhope, near Durham, was supplied by Marconi's. The Burnhope transmitters (two 4-kW vision and two 1-kW sound) are identical to those used at Chilterton Down.

E.M.I. Vidicon film-scanning equipment to the value of over £30,000 has been supplied to Tyne Tees Television, the programme contractors for the Burnhope station.

20th Century Electronics, Ltd., of King Henry's Drive, New Addington, Surrey, have appointed Peter Holton to take charge of their Photomultiplier Applications Advisory Service. Mr. Holton was until recently in charge of testing and application of photomultiplier tubes in the E.M.I. Photomultiplier Production Group at Ruislip.

Griffin & George (Research and Development), Ltd., has been formed by the Griffin & George Group to conduct research into, and the development of, new and improved scientific instruments and apparatus for laboratory use and process control.

Redifon have received an order from the G.P.O. for a number of i.s.b. drive units valued at £30,000.

Printed Circuits, Ltd., of Borehamwood, Herts., which recently became associated with the London Electric Wire Co. & Smiths, Ltd., are establishing an information service in the form of a series of technical bulletins. Those wishing to receive these brochures are asked to write stating their particular interest.

Consoles. — R. H. Minns has resigned his technical directorship of Hatfield Instruments, and, with J. S. Jordan, has formed Consoles. The company, which has premises at Hersham Trading Estate, Walton-on-Thames, will produce metal cabinets and control consoles, and a range of measuring instruments, transformers and aerial equipment.

A new plastics factory to make equipment for the radio industry has been opened at Reading by Resinoid and Mica Products, Ltd., which was formerly a subsidiary of Southern Areas Electricity Corp., Ltd.

Stella.—The head office and showroom of Stella Radio and Television Co. is now at Astra House, 121/3, Shaftesbury Avenue, London, W.C.2. The telephone number (Gerrard 7086) is unchanged.

Amos of Exeter are moving on March 2nd to larger premises at Weircliffe Court, Exwick, Exeter. The telephone number (Exeter 72132) is unchanged.

Kelvin Hughes Survey Department offers a world-wide service for hydrographic surveys, in the sounding and sampling of river, coastal and sea areas, tide and tide stream studies, together with the necessary land surveys. All preliminary marine survey work for the proposed sixth nuclear power station at Sizewell, Suffolk, was undertaken by the department.

CQ Audio, Ltd., have arranged with Technical Suppliers, Ltd., of 63, Goldhawk Road, London, W.12, to act as sole distributors for their complete range of equipment.

EXPORTS

Trunk Radio-telephones.—Recent orders for the Murphy MR851 trunk radio-telephone equipment include 42 terminal installations—each comprising output unit, modulator, demodulator, r.f. unit and supply units—for British Guiana's first trunk telephone network. A second order for MR851 equipment for Australia's Snowy Mountains Hydro Electric Authority has also been received. The equipment provides 24 traffic channels.

India. — Solartron Electronic Group, who had a stand at the exhibition held in association with the recent Indian Science Congress, are in the course of forming, with Indian interests, a company in India.

V.H.F. communications equipment valued at more than £600,000 has been ordered from Plessey for the Australian Army. The equipment comprises the latest frequency-modulated v.h.f. multi-channel radio-telephone transmitter/receivers to have been proved in armoured fighting vehicles under field conditions. Three sets are involved, these being known to the British Army as the C42, the B47 and the B48.

Hanover Trade Fair.—Electronic Components Centre (Great Britain), Ltd., which represents a number of component manufacturers, have concluded a 10-year agreement with the Hanover Fair Authorities to exhibit as the British Electronic Centre. Among the firms associated with the organization, which has offices at 31 Morden Road, London, S.E.3, are Ardente, Geo. Bray, British Electric Resistance, Cosmocord, E.M.I. Electronics, Hunt, London Electric Wire Co., Painton, and Telcon.

Norwegian Navy has ordered Decca true-motion radar, type TM909, for its new "Nasty" class of motor torpedo-boats.

Denmark.—The display of British products, including domestic sound and television equipment, announced in our last issue (page 98) as taking place in Copenhagen in May, has been postponed until November.

MARCH MEETINGS

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

LONDON

2nd. British Computer Society.—"Pseudo-random elements for computers—a survey of methods" by Dr. E. S. Page at 2.30 at Northampton College of Advanced Technology, St. John's Street, E.C.1.

3rd. Association of Supervising Electrical Engineers.—"Wired television systems—installation and maintenance problems" by L. A. Isaacson (E.M.I.) at 7.30 at Windsor Castle Hotel, 134 King Street, Hammersmith, W.6.

4th. Association of Supervising Electrical Engineers. — "High - frequency heating" by a representative of Philips Electrical at 7.45 at Wood Green Town Hall, N.22.

5th. I.E.E.—"The reliability and life of impregnated paper capacitors" by J. P. Pitts at 5.30 at Savoy Place, W.C.2.

10th. I.E.E.—Discussion on "The Laplace transform—a tool for the electrical engineer" opened by A. C. Sim at 6.0 at Savoy Place, W.C.2.

10th. Association of Supervising Electrical Engineers. — "Radio - frequency heating" by P. W. Ainscow (G.E.C.) at 7.45 at Eltham Green School, Queenscroft Road, S.E.9.

12th. Armed Forces Communications and Electronics Association.—Visit to M.O. Valve Co.'s works at Hammersmith.

13th. Television Society.—"Training in television servicing" by G. C. Barker (Murphy) at 7.0 at the Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, W.C.2.

13th. Radar and Electronics Association, Student Section.—"Radar data handling" by Dr. L. C. Payne (Decca Radar), at 7.0 at Norwood Technical College, Knight's Hill, S.E.27.

18th. I.E.E.—"New amplifying techniques" by C. W. Oatley at 5.30 at Savoy Place, W.C.2.

18th. British Computer Society.—"An approach to learning and teaching machines" by C. E. G. Bailey at 6.15 at the Northampton College of Advanced Technology, St. John's Street, E.C.1.

18th. British Kinematograph Society.—Film and demonstration of stereophony at 7.30 at Mullards Theatre, Mullard House, Torrington Place, W.C.1.

19th. Brit.I.R.E. Medical Electronics Group.—"Instrumentation in field physiology" by Dr. H. Wolff at 6.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

19th-20th.—I.E.E.—Radio and Telecommunication Section convention on stereophonic sound recording, reproduction and broadcasting.

20th. Institute of Navigation.—"The impact of radar on the rules of the road at sea" by Capt. F. J. Wylie, R.N. (president), at 5.15 at the Royal Geographical Society, 1 Kensington Gore, S.W.7

20th. R.S.G.B.—"Single sideband techniques" by B. J. Rogers, G3ILI, (Bush) at 6.30 at the I.E.E. Savoy Place, W.C.2.

20th. B.S.R.A.—"F.M. feeder units" by R. S. Roberts at 7.15 at the Royal Society of Arts, John Adam Street, W.C.2.

23rd. I.E.E.—"High-quality microphones" by M. L. Gayford at 5.30 in the Lecture Theatre at Savoy Place, W.C.2.

23rd. I.E.E.—"Effects of argon content on the characteristics of neon-argon glow-discharge reference tubes" by Dr. F. A. Benson and P. M. Chalmers at 5.30 in the Tea Room at Savoy Place, W.C.2.

25th. Brit.I.R.E.—Papers on radio telemetry including "Engineering aspects of a 24-channel f.m.-a.m. telemetry system" by W. M. Rae and "A six-channel high-frequency telemetry system" by T. C. R. S. Fowler at 6.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

ABERDEEN

13th I.E.E.—"The relation between picture size, viewing distance and picture quality with special reference to colour television and to spot-wobble techniques" by L. C. Jesty at 7.30 at Robert Gordon's Technical College.

BELFAST

3rd. I.E.E.—Faraday lecture on "Automation" by Dr. H. A. Thomas at 7.30 at the Sir William Whitla Hall, Queen's University, Stranmillis Road.

10th. I.E.E.—"The B.B.C. sound broadcasting service on very-high frequencies" by E. W. Hayes and H. Page at 6.30 at the David Keir Building, Queen's University.

BIRMINGHAM
23rd. I.E.E.—"The history of B.B.C. television" by R. T. B. Wynn at 6.0 at the James Watt Memorial Institute.

BRISTOL
10th. Television Society.—"Industrial television" by J. G. M. Downs (Pye) at 7.30 at the Hawthornes Hotel, Clifton.
24th. Brit.I.R.E.—"Recent advances in travelling-wave tubes" by P. F. C. Burke at 7.0 at the School of Management Studies, Unity Street.

CAMBRIDGE
2nd. I.E.E.—"The recognition of moving vehicles by electronic means" by T. S. Pick and A. Readman at 8.0 at the Cavendish Laboratory, Free School Lane.
17th. I.E.E.—"Reliability of electronic components" by G. W. A. Dummer at 8.0 at the Cavendish Laboratory, Free School Lane.

CARDIFF
10th. Association of Supervising Electrical Engineers. — "High-quality sound reproduction" by a representative of G.E.C. at 7.30 at the Angel Hotel.
11th. Brit.I.R.E.—"Applications of photo-electric cells" by Dr. F. A. Benson at 6.30 at the College of Advanced Technology.

CHATHAM
2nd. I.E.E.—"Domestic high-fidelity reproduction" by J. Moir at 7.0 at the Medway College of Technology.

CHESTER
25th. Society of Instrument Technology.—"Industrial applications of transistors" by D. G. Holloway at 7.0 at the Grosvenor Museum, Grosvenor Street.

CHRISTCHURCH
25th. I.E.E.—"The application of transistors to line communication equipment" by H. T. Prior, D. J. R. Chapman and A. A. M. Whitehead at 6.30 at the Kings Arms Hotel.

DUNDEE
12th. I.E.E.—"The relation between picture size, viewing distance and picture quality with special reference to colour television and to spot-wobble techniques" at 7.0 at the Electrical Engineering Department, Queen's College.

EDINBURGH
17th. I.E.E.—"The application of transistors to line communication equipment" by H. T. Prior, D. J. R. Chapman and A. A. M. Whitehead at 7.0 at the Carlton Hotel, North Bridge.
20th. Brit.I.R.E.—"Application of magnetic amplifiers to electrical switching" by J. A. Purdie at 7.0 at the Department of Natural Philosophy, The University, Drummond Street.
24th. I.E.E.—Faraday lecture on "Automation" by Dr. H. A. Thomas at 7.0 at the Usher Hall.

EXETER
12th. I.E.E.—"Germanium and silicon power rectifiers" by T. H. Kinman, G. A. Carrick, R. G. Hibberd and A. J. Blundell at 3.0 at S.W.E.B. Showrooms, Bedford Street.

FARNBOROUGH
24th. I.E.E.—"Space research" by Dr. R. L. F. Boyd at 6.0 at Farnborough Technical College, Boundary Road.

FAWLEY
6th. Society of Instrument Technology.—"Swartwout electronic instrument system" by M. V. Needham at 5.30 at Copthorne House.

GLASGOW
19th. Brit.I.R.E.—"Application of magnetic amplifiers to electrical switching" by J. A. Purdie at 7.0 at the Institution of Engineers and Shipbuilders, 39 Elmbank Crescent.

LEEDS
16th. I.E.E.—Faraday lecture on "Automation" by Dr. H. A. Thomas at 7.0 at the Town Hall.

LIVERPOOL
11th. Institution of Production Engineers.—"Electronic control of machine tools" by J. A. Stokes at 7.30 at the Exchange Hotel, Tithebarn Street.

MANCHESTER
5th. Brit.I.R.E.—"Closed circuit television equipment" by R. E. Blythe at 6.30 at Reynolds Hall, College of Technology, Sackville Street.
18th. I.E.E.—"Bridging the Atlantic" by A. H. Mumford at 6.15 at the Engineers' Club, Albert Square.

NEWCASTLE UPON TYNE
2nd. I.E.E.—"High-quality microphones" by M. L. Gayford at 6.15 at King's College.
11th. Brit.I.R.E.—"Microwave stripline circuits for radar equipment" by K. Foster at 6.0 at the Institution of Mining and Mechanical Engineers, Neville Hall, Westgate Road.
19th. I.E.E.—Faraday lecture on "Automation" by Dr. H. A. Thomas at 7.0 at the City Hall.

PRESTON
11th. I.E.E.—"Computers" by Dr. R. L. Grimsdale at 7.15 at the North-Western Electricity Board Demonstration Theatre, Friargate.

READING
10th. I.E.E. Graduate & Student Section.—"Stereophonic sound" by E. W. Berth-Jones at 7.0 at Reading Technical College.

SHEFFIELD
6th. I.E.E.—Faraday lecture on "Automation" by Dr. H. A. Thomas at 7.0 at the City Hall.

WOLVERHAMPTON
11th. Brit.I.R.E.—"The development of high-frequency tape recording" by P. J. Guy at 7.15 at the Wolverhampton and Staffordshire College of Technology, Wulfruna Street.

WORCESTER
25th. Institution of Production Engineers.—Annual general meeting at 7.0 followed by "Numerical control of machine tools" by O. S. Puckle at the Star Hotel.

LATE-FEBRUARY MEETINGS
23rd. B.S.R.A.—"The application of transistors to low noise pre-amplifiers" by J. Somerset Murray at 7.0 at the Royal Society of Arts, John Adam Street, W.C.2.
27th. R.S.G.B.—"Recent developments in the microwave field" by K. W. Drummond (Mullard) at 6.30 at the I.E.E., Savoy Place, W.C.2.

RANDOM RADIATIONS

By "DIALLIST"

Long-lived C.R.T.s

MY request for information about old television c.r.t.s which are still going strong after years of use produced some quite amazing figures not only for the tubes themselves, but also for valves and other components working in the same sets. The oldest c.r.t. reported still at work belongs to a Horley reader. The set was bought in 1948 and it has averaged not less than three hours' use an evening ever since. During all that time the only bits and pieces replaced have been one EF50, five EB41s and one auto-transformer. Though still unboosted, the 9-in tube is claimed to give an excellent picture. From Washington, D.C., comes an account of an R.C.A. 16AP4 tube which has been in use from late afternoon till bedtime every day since 1949. About four years ago the emission fell off so the heater voltage was raised permanently to 7.5V and it has needed no further attention. My correspondent, who is an electrical engineer, puts its service life so far at 17,000 hours *plus*, for it gets some very hard work at the week-ends and during the children's school holidays.

Can You Say?

Several readers ask whether I can suggest reasons for the longevity of some c.r.t.s. I only wish I could! If you take a batch of well-made and well-pumped c.r.t.s of the same type, a few (a very few) will fall by the way in the first six months of use; the great majority will have the about average service life for their class—some a little above and some a little below the mean figure. But just the odd one here and there will turn out to be a long-lived prodigy. I suppose, really, that that's only to be expected, for the same sort of thing seems to be true not only of most electrical and mechanical appliances, but also of human beings and other animals. Incidentally, my American reader asks why in this country we use c.r.t. and not c.r.v. as the abbreviation for the cathode-ray tube; in other words, why do we call it a tube and not a valve? The answer to that one is that the c.r.t. was developed (wasn't it by Crookes?) years before the electronic valve was even thought of.

The Sun Does Its Best

DURING the International Geophysical Year, which recently ended its eighteen-months span, the sun played its part in a way which exceeded all expectations. It's some 200 years since records of sunspot activity began to be kept and never in the whole of that time has solar activity been so marked as in the present maximum period. Many of the I.G.Y. programmes were concerned with such activity and some remarkable discoveries will no doubt come to light when all the results have been fully digested. Two have already been disclosed. The first is that of the Van Allen belt of intense radiation, which surrounds the whole of the Earth, except for those regions which are near the magnetic poles. It was data from Explorer satellites which led to the knowledge of this belt's existence. Then, we seem now to have found the reason—or at any rate one of the reasons—why large "flares" in the sun are followed by wireless blackouts. Whenever such a flare occurred the U.S. authorities sent up special rockets and from the data received from these it was found that these activities are accompanied by a tremendous emission of X-rays, one of whose effects is to cause the wireless blackouts.

Some Bed!

ON the whole, I don't think I'll go in for one of the super-beds on show at the recent Furniture Exhibition in London. I use my bed for sleeping purposes. There are doubtless those who like to go abed and watch the "tele" or listen to the "wireless" and I've no doubt that there'll be quite a run on Slumberland's masterpieces, even of the variety with mink coverlets, which is to sell for a mere £2,500. I might be tempted to do something about it if the TV set were equipped to deal with tape recordings of single-file processions of sheep jumping one after another over a gate. That would indeed be a luxury beyond price to those who like myself sometimes have bouts of insomnia. But I don't think I need push-button curtain opening or shutting gadgets and I'm sure I don't want a bed fitted with an intercom. telephone—unless this is so arranged that it can be used only for outgoing calls. No, I think I'll remain content with my present simple, but very comfortable couch.

Non-detachable Backs

WHAT a blessing it would be if the television sets sold to the ordinary viewer could be made with backs that couldn't be taken off except by the use of a key or a special tool. Like me, I expect you've met with instances of the damage that can be done when someone who knows nothing about the works gets poking about in them with a screwdriver. And then there's the question of the risk of accidents. By the law of averages about half the TV sets used with 2-pin mains plugs are at any time so connected that their chassis are live. Yet people will get fiddling about with adjustments which can be made only if the set is switched on and working. One way of making backs non-detachable except by the serviceman would be to mount one side of the back on pintles like those used for rudders and to have a lock or a sealed fastening between the other side and the cabinet. Probably the seal would be the simplest. The dealer would fix it when he had installed the set and would impress his own mark on it.

CLUB NEWS

Barnet.—F. J. H. Charman (G6CJ) will give a lecture-demonstration on aerials to members of the Barnet & District Radio Club on March 31st. The club's lecture-meetings are held at 7.30 on the last Tuesday of each month at the Red Lion Hotel, High Barnet. Morse and instructional meetings are held on the second Tuesday.

Battersea.—The London Short-wave Club meets every Friday at 7.30 at the L.C.C. Men's Institute, Latchmere Road, London, S.W.11. Lecture-demonstration meetings are arranged for alternate Friday evenings and the club station (G2CLR) is "on the air" on the intermediate Fridays between 7.30 and 9.30.

Birmingham.—The March programme of the Slade Radio Society includes a Mullard film show on the 6th at the Y.M.C.A., Snow Hill; a talk on the 13th by J. F. Moseley, of Pye, on v.h.f. business radio, illustrated by a film; and on the 27th two members, T. J. Hayward (G3HHD) and G. Nicholson (G3HKC) will deal with the construction and use of test equipment. Except where otherwise stated, meetings are held at the Church House, High Street, Erdington, at 7.45.

Brighton.—Meetings of the Brighton and District Radio Club (G3EVE) are held at 8.0 on Tuesdays at the Eagle Inn, Gloucester Road, 1.

Bury.—B. P. Clear, of the Jodrell Bank Research Station, will talk on some aspects of the station's work at the March 10th meeting of the Bury Radio Society. The club meets at 8.0 at the George Hotel, Kay Gardens. On the 24th members are visiting the Mullard works at Simonstone.

Halifax.—High-quality recordings will be demonstrated by Fane Electronics to members of the Halifax & District Amateur Radio Society on March 3rd. The club meets on the first Tuesday of each month at the Sportsman Inn, Bradshaw.

South Kensington.—D. E. A. Harvey, of Siemens, will speak on the manufacture and use of transistors at the March 10th meeting of the Civil Service Radio Society. Meetings are held at 6.0 in the Science Museum, South Kensington, London, S.W.7.

UNBIASED

By FREE GRID

Extra-spatial Electrons

NOT long after the Russians launched their circumsolar satellite, I attended a lecture at the London Planetarium in which this man-made planet was shown, together with the other planets in their respective orbits, travelling around the sun. The lecturer must have been an electronics fan—which is not quite the same thing as an electric fan—as he was at pains to explain what a great part electronics played in space navigation.

In my opinion the next step will obviously be to launch a satellite at a high enough velocity for it to escape from the sun's gravitational field, and go into orbit around the nearest star, Proxima Centauri, which is only $4\frac{1}{3}$ light years away. Then will come the day when a spaceship escapes out of our own Milky Way, and journeys towards another galactic system such as the giant nebula in Andromeda which is one of the nearer ones, only a matter of a million light years distant.

When that day dawns will there be no other fields to conquer? To the unthinking materialist it might seem so, but to the more intelligent members of the community who read *W.W.* it will be clear that the ultimate triumph will not come until a "spaceship" breaks out of this universe of space and time into the timeless and non-spatial one which seems to be inhabited by poltergeists and other clammy entities who, if the ghost hunters are to be believed, not only pass freely through brick walls, without let or hindrance, but have the ability to be in two or more places at once.

Now I have never actually seen a ghost, although I once mistakenly thought I did, as you will see by the accompanying 20-year-old sketch. It may surprise you, therefore, when I say that I do believe in them, and I think I can see the way in which we may eventually be able to launch a psychic sputnik.

Actually it was "Cathode Ray" who gave me the idea when he told us in the November issue that an electron seemed to consist of an uncancelled ψ wave, which, as he explained, is a wave in nobody knows what. Now obviously these ψ waves must possess the various attributes which we associate with waves such as length, amplitude and what-have-you.

We all know that radio waves of various lengths and amplitude are constantly passing through our receivers and through each other without difficulty. Working on this analogy I have the idea that ghosts are built of atoms made up of ψ waves having a different length or other dimension from those which we call electrons.

It therefore follows that if we can find means to change the length or other dimension of the electronic ψ (psi) waves, we shall turn them into what I will call psychic electrons of which ghosts and ghostly walls are built. In other words if we change the wavelength of electrons or ψ wave in, say, a lump of sugar, it will disappear from our world into the fourth dimension, like the Time Machine in H. G. Wells's famous science-fiction novel.

Challenge Accepted

IN the January issue Mr. James M. Hoy in a letter to the Editor invites me to visit the Institution of Civil Engineers for the purpose of reading a certain paper in the Proceedings of this learned society, after which I am further invited to give a definition of the phrase "common usage". All this, because I stated in *W.W.* that the word "valve" had, by common usage, come to mean a one-way device.

Well, I have no need to accept the invitation to visit the HQ of the I.C.E. to study the paper mentioned, for I will freely concede that in civil engineering circles a valve obviously does not mean a one-way device. I will, however, gladly accept the invitation to define what I mean by "common usage".

On the face of it, the phrase would seem to mean "as universally used by all ordinary folk". That is not my view at all nor can it be the view of Mr. Hoy, otherwise he would not talk in his letter about the "ball valve in the cistern in the attic", for he must know that the term "ball cock" is used by most ordinary folk, who also ignorantly talk of a lavatory cistern when they mean a "water-waste preventer".

No, when I said that the word "valve" had, by common usage come to mean a one-way device, I meant among the people I was addressing, namely, regular readers of *Wireless World*, and also other people having a serious interest in matters covered by this journal.

If I were writing for a cycling journal I think I should also be justified in thinking that among its readers a valve meant a one-way device.

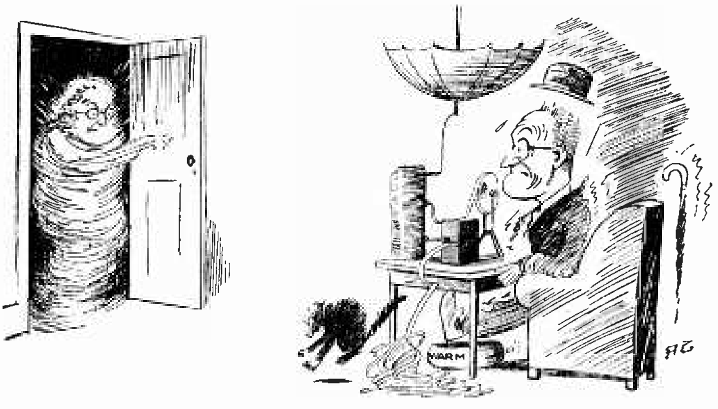
But if I were writing for a journal like the *Radio Times* which caters for the millions who *use* radio valves, then I should remember that among the majority of its readers the word valve meant neither a one-way device nor a regulating device. To the ordinary listening and viewing public the word valve simply means a "small glass thing" inside the receiver.

Satis-Fi Tapes

I POINTED out in the February issue that most commercial tapes are recorded at $7\frac{1}{2}$ in/sec whereas many tape recorders are designed for $3\frac{3}{4}$ in/sec only. I asked companies to let us have some $3\frac{3}{4}$ in/sec records even if it meant sacrificing a bit of hi-fi so that the tapes became lo-fi ones.

I have now heard from Technical Suppliers Ltd., that such tape records, having a frequency range of 30-16,000 c/s, are already available from them.

The makers say that, in their opinion, with the ever-increasing performance of modern tape recorders, these slower-speed tapes will eventually replace those of $7\frac{1}{2}$ in/sec. Maybe they will, just as the "$7\frac{1}{2}$" hi-fi recordings appear to have ousted the early 15 in/sec tapes. I don't suppose that those who have already paid good money for "$7\frac{1}{2}$" hi-fi tapes will agree that the new ones can be as good. But I feel sure they will satisfy most of us, and perhaps we can compromise, therefore, and instead of talking of lo-fi tapes as I suggested, call them satis-fi tapes.



I once mistakenly thought I saw a ghost